Automotive Safety Research Institute

1334 Pendleton Ct.
Charlottesville, VA. 22901

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Docket Management Facility
US Department of Transportation
1200 New Jersey Ave. SE,
West Building, Room W12-140
Washington DC 20590

Submission to: Docket No. NHTSA-2018-0056 Request for Information: Improving Prehospital Trauma Care

Response to Question 18. What is the potential role of vehicle telematics in improving prehospital care outcomes?

The purpose of this docket submission is to outline the body of research initially funded by NHTSA and subsequently by BMW that led to the development and application of the URGENCY Algorithm that predicts the risk of serious injury, based on crash variables. A second purpose is to suggest research and initiatives to enhance the predictive capability of the algorithm and to remove impediments to its wide application in the field.

Numerous analyses have shown the benefits of correctly identifying crash victims with serious time critical injuries and providing immediate acute care [Champion 2003 and 2005]. The Automatic Crash Notification (ACN) systems on many of the newer vehicles are useful in guiding rescue units to the crash site. However, the majority of crashes with air bag deployment do not have occupants with time critical injuries. Consequently, the small numbers of crashes that require time critical medical attention cannot be determined and prioritized for rapid EMS response. There is a body of research that provides a foundation for assessing the risk of serious injury, which, when implemented, could save lives by predicting crashes with time critical injuries that need urgent response. However, the accuracy of current predictions is limited by the deficiencies in the available data set used to train the algorithm. To date NASS/CDS has been used for that purpose. The accuracy and availability of the NASS/CDS deltaV is not as good as the same data from the vehicle crash recorder. In addition, there are properties that can be obtained from the crash recorder such as acceleration-time histories and the character of multiple impacts that would improve the prediction capability. Research is needed to permit better utilization of the crash recorder data in training the algorithm. Finally, there are impediments to deploying URGENCY predictions caused by the lack of standards for interpreting and transmitting the injury risk assessment to the first responders and the trauma centers. Government involvement is needed for standardization of date transmission from the vehicle to the response units and trauma centers.

In the discussion to follow, the publications that summarize the development and application of the URGENCY Algorithm are outlined. Copies of all the referenced publications are supplied with this submission.

At the direction of Administrator, Dr. Ricardo Martinez, NHTSA initiated a research project in 1996 to explore ways to reduce motor vehicle casualties by improving emergency response. The research team was made up of the following: Howard R. Champion, Research Professor of Surgery, Uniformed Services University of the Health Sciences (Principal Investigator), Augenstein JS, Professor of Surgery, University of Miami; Blatt AJ, V.P., Veridian; Cushing B, Surgeon, Maine Medical Center; Digges KH, Research Professor of Engineering, George Washington University; Hunt RC, Emergency Physician, State University of NY, Syracuse, and Siegel JH, Professor of Surgery, University of Medicine and Dentistry of New Jersey. Louis V. Lombardo, Physical Scientist, NHTSA was the Project Manager for the Research. Under a contract with George Washington University, Dr. Malliaris developed 15 monthly briefings on the relationship between Crash Attributes and Casualties. The first public results of this NHTSA funded research were published in SAE Paper 97093, February 1997 [(1) Malliaris et.al. 1997]. That paper showed relationships between 21 crash variables and the resulting serious injury risk. The final briefing of the Research Project to Dr. Martinez occurred on March 27, 1997. Prof. Digges, with the assistance of Graduate Student Ana Eigen, programmed an Excel sheet to display a thermometer that registered serious injury risk in response to variations of the Malliaris input variables [(2) Digges et. al. 1997]. The formulas that related vehicle telemetry and crash scene variables to serious injury risk became known as the URGENCY Algorithm. The overall results of the research project are contained in a two ESV Papers [(8, 11) Champion et. al. 2003 and 2005].

NHTSA included an evaluation of the URGENCY Algorithm in their Field Operational Test of Vehicles with ACN systems and demonstrated how injury risk could be incorporated in the ACN response [(3) Funke et. al. 2000].

As a follow-on to the NHTSA research that originated the URGENCY Algorithm, grants to the GW University and George Bahouth from the Motor Vehicle Fire Research Institute in 2002, funded dissertation level research to advance the URGENCY Algorithm. The Bahouth dissertation included refinements that separated the risk functions by crash direction. It also examined the risk functions for four different groups of variables that included from 3 to 12 crash factors [(7) Bahouth 2003].

BMW’s extensive and continuous support of the development and application of the URGENCY Algorithm at the William Lehman Injury Research Center (WLIRC) at the Ryder Trauma Center, University of Miami School of Medicine began in 2001 and continues in 2018. The WLIRC gathered both crashed vehicle and injured occupant data for NHTSA, and subsequently for BMW. In 2001, BMW sponsored the introduction of the URGENCY concept to European auto suppliers [(5) Digges 2001]. A summary of an initial URGENCY validation study was published in a 2001 ESV Paper [(4) Augenstein et. al. 2001]. That study applied the URGENCY Algorithm their entire population of 30 frontal impact cases that contained data on both the crashed vehicle and the occupant injuries. The authors found that URGENCY could differentiate cases with serious vs non-serious injuries. However, the authors recommended the inclusion of additional variables to better identify injuries in cases of collisions involving narrow impacts and multiple impacts. Some additional findings were published in a 2003 ESV Paper [(10) Augenstein et. al. 2003 ESV]. A subsequent paper reported the use of NASS/CDS data years 1997-2001 to train the model and years 2003-2004 to evaluate its sensitive and specificity [(9) Augenstein et. al. 2003 AAAM]. This paper illustrated graphically the effect on injury risk of several crash variables and how the important variables change for different crash directions. A follow-on paper examined the sensitivity and specify for groups of variables that would be available from the Automatic Crash Notification System. The incremental benefit of adding each variable was shown [(12) Augenstein et. al. 2005]. A 2006 SAE paper presented an overview of the research conducted to date to improve the accuracy of the URGENCY Algorithm and its application to Automatic Crash Notification. [(13) Augenstein et. al. 2006]. A 2007 ESV paper described how URGENCY would be used in conjunction with the BMW Automatic Crash Notification System and showed how the system can be used to evaluate pre-crash and post-crash safety [(14) Augenstein et. al. 2007].

A 2009 ESV paper reported the first field experiences with BMW's enhanced AACN systems where vehicles not only provide an initial notification and location of a crash but also transmit data describing the nature and severity of the collision [(15) Rauscher et. al. 2009]. The paper presented an analysis of populations who could benefit from the enhanced data now transmitted and identified how the application of URGENCY to estimate likelihood of serious injuries could help improve rescue care. URGENCY would be useful in at least three types of events. (1) when no voice communication is established (2) to supplement verbal communications (3) to identify occult injuries that are time critical. Based on the initial field experience, in 10% to 12% of the cases voice communication was not established. No injury was identified by the in the majority of the crashes. However, 13% who said they were not injured were transported to a hospital. The number with occult injuries could not be determined from the data.

Finally, a 2012 AAAM paper employs NASS/CDS data years 1998 to 2009 to evaluate the selectivity and specificity when of varying the injury risk threshold used to predict serious injuries [(18) Bahouth et. al. 2012].

Overall summaries of the URGENCY research and applications were provided in briefings at a Symposium that dealt with ACN and URGENCY on August 3, 2011 in Tokyo [(16, 17) Digges 2011; Augenstein et. al. 2011].

Although manufacturers like BMW are now equipping vehicles with technology capable of transmitting valuable crash information to TSPs, the remaining rescue system must be enhanced to most effectively utilize the data. Mechanisms for the transfer of telematics data from one entity to another along the rescue chain are needed. This transfer may occur verbally or in electronic form as the system develops. Protocols must be enhanced so that the injury severity data is consistently treated by all involved and actionable. Currently, no consistent criteria exists within dispatch or trauma triage protocols to process specific data elements known to effect the risk of serious injury including crash (deltaV), impact direction, number of impacts, restraint status (i.e. airbag deployment regime and belt use) and occupant age. In our opinion and those of others, a synthesized estimate of injury severity would be most useful. Finally, education is required so that 911 operators, EMS and treating physicians understand the value and correctly interpret the information to allow for real improvements in patient.

To further support emergency response using ACN, in 2005 NHTSA developed the Atlas and Database of Air Medical Services (ADAMS) to reduce the time between the ACN call and the notification and response of the rescue aircraft [(6) Flanigan et. al 2005]. ADAMS is a web-based, password-protected, geographic information system on data on air medical service main and satellite base helipads, communication centers, rotor- wing aircraft, and major receiving hospitals for trauma in the United States. ADAMS initially was developed to provide the geographic information needed to support real time, wireless routing of automatic crash notification (ACN) alerts from a crashed motor vehicle to the nearest air medical transport service and trauma center. This coupling of ADAMS and ACN technology to enhance emergency communications will speed delivery of emergency medical care to crash victims and thereby reduce the deaths and disabilities caused each year.

Issues associated with the use of voice communication with crash occupants (when available) and data from vehicle crash sensors to predict the risk of crash injuries that require time critical emergency care (URGENCY Algorithm).

- Standardized risk thresholds for predicting time critical injuries.

- Data available from vehicle crash recorder has not been used to train the algorithm
- Accuracy of time critical injury prediction using all available data at the time of crash
- Integrity of the communication system between vehicle and person making risk assessment.
- Skill of the person using voice, vehicle and other data to make accurate risk assessment.
- Promptness and clarity of communications between risk assessor and 911 operator
- Skill of the 911 operator in transmitting risk and location information to rescue & care facilities
- Response appropriateness of Police, EMS, and Trauma Center to information from 911 operator

Research and Development Needed

Risk threshold for predicting time critical injuries and Accuracy of time critical injury prediction:
Need to create database like NASS/CDS that includes a standard set of crash recorder variables
Need to refine and test injury risk algorithms using expanded databases that include all the variables measured by the vehicle crash sensors
Integrity of the communication system between vehicle and person making risk assessment.
Need to provide vehicle standards for the post-crash variables to be transmitted and for communication integrity
Need to determine and resolve communication impediments between the vehicle and the communications network throughout the USA
Need to consider machine learning capability to update the algorithm and provide automatic communication of time critical injury crashes from the vehicle to all units that need the injury risk assessment
Skill of the person using voice, vehicle and other data to make accurate risk assessments.
Need to develop training sessions and materials on interpreting injury risk to 911 operator
Promptness and clarity of communications between risk assessor and 911 operator
Need to develop a standard communication vocabulary for communications between all parties
Need to develop an automated system that places the risk assessment call to the proper 911 operator, the response teams and the trauma hospital closest to the vehicle crash
Skill of the 911 operator in transmitting risk and location information to rescue & care facilities
Need to develop and apply training for 911 operators and associated instruction manuals for response to high injury risk calls
Response of Police, EMS, and Trauma Center to data from 911 operator
Need to develop and apply training to all parties on interpreting and responding to time critical injuries predicted by information from the crashes vehicle.
Need to develop and apply an assessment program to identify benefits and deficiencies associated with the use of vehicle telematics data.

Conclusions

Government initiatives are needed to promote wider use of ACN calls to identify crashes with time critical injuries. The impediments to classifying and transmitting the injury presence and vehicle location of the small fraction of crashes that require rapid response need to be removed. Most of the impediments are associated with the interpretation and transmission of information between the vehicle and the response groups. The use of machine learning and of the internet to provide information and communication should be considered.

Continuing improvement of the predictive capability of the algorithms is needed, including the use of all the information available from the vehicle crash sensors.

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Kennerly H. Digges, PhD, PE
President Automotive Safety Research Institute
1334 Pendleton Ct
Charlottesville VA 22901