

DOT HS 811 181 August 2009

# **The Crash Outcome Data Evaluation System (CODES) And Applications to Improve Traffic Safety Decision- Making**

This document is available to the public from the National Technical Information Service, Springfield, Virginia 22161

**CONTRIBUTING AUTHORS** Alabama: Glenn Cummings, Center for the Study of Rural Vehicular Trauma Connecticut: Justin Peng and Marian Storch, Connecticut Department of Public Health Delaware: Steven Blessing and Laurie Lin, Delaware Office of EMS Georgia: Denise Yeager, Georgia Dept. of Human Resources./Div. of Public Health/Injury Prevention Illinois: Mehdi Nassirpour, Illinois DOT Division of Traffic Safety Indiana: Jose Eduardo Thomaz, Center for Road Safety, Purdue University Iowa: Suning Cao, Iowa Dept. of Public health/Center for Vital Records and Health Statistics; Scott Falb, Office of Driver Services/Iowa Dept. of Transportation Kentucky: Huifang (Jenny) Qin and Michael Singleton, Kentucky Injury Prevention and Research Center Maine: Karl Finison, Maine Health Information Center Maryland: Timothy Kerns, University of Maryland/National Study Center for Trauma and EMS Massachusetts: Heather Rothenberg, University of Massachusetts Minnesota: Tina Folch and Scott Hedger, Minnesota Dept. of Public Safety/Office of Traffic Safety; Anna Gaichas and Mark Kinde, Minnesota Dept. of Health Missouri: Mark Van Tuinen, Missouri Department of Health and Senior Services Nebraska: Ming Qu, Nebraska Department of Health and Human Services New York: Motao Zhu and Susan Hardman, New York State Department of Health Ohio: Kristen Conner and Dr. Gary Smith, Children’s Research Institute/Ohio State University Rhode Island: Ted Donnelly, Rhode Island Department of Health South Carolina: Mary Tyrell and Tracy Joyce, South Carolina State Budget and Control Board Utah: Larry Cook, Intermountain Injury Control Research Center, University of Utah Virginia: Michael Lundberg and Kathleen Bernard, Virginia Health Information From NHTSA’s National Center for Statistics and Analysis: Augustus “Chip” Chidester, Director, Office of Data Acquisitions Barbara Rhea, Chief, State Data Reporting Systems Division John Kindelberger, Team Leader, State Data and Quality Assurance Xuemei Pan, Advanced Systems Technology and Management, Inc., for NHTSA/NCSA Morrie O’Neil, Advance Systems Technology and Management, Inc. Governors Highway Safety Association for NHTSA/NCSA: Sandra Johnson Michael McGlinicy, Ph.D., Strategic Matching Inc.

TABLE OF CONTENTS EXECUTIVE

SUMMARY.....1 I. THE CRASH  
OUTCOME DATA EVALUATION SYSTEM.....3 Introduction and  
Background.....3 Implementation and  
Data Enhancement.....3 Federal Use of CODES  
Data.....4 Document Purpose and  
Structure.....4 CODES State-Level  
Applications Summarized.....5 Table 1: State CODES  
Applications Supporting Traffic Safety Problem Identification.....6 Table 2: State CODES  
Applications Supporting Traffic Safety Decision-Makers.....7 Table 3: State CODES  
Applications Supporting Traffic Safety Legislation.....8 Table 4: State CODES  
Applications Supporting Public Educations.....9 Table 5: Web Sites of CODES  
Programs in the NHTSA CODES Network.....10 II. APPLICATIONS TO IMPROVE  
TRAFFIC-SAFETY DECISION-MAKING.....11 Alabama  
CODES.....12 Connecticut  
CODES.....13 Delaware  
CODES.....17 Georgia  
CODES.....19 Illinois  
CODES.....21 Indiana  
CODES.....22 Iowa  
CODES.....23 Kentucky  
CODES.....26 Maine  
CODES.....28 Maryland  
CODES.....31 Massachusetts  
CODES.....33 Minnesota  
CODES.....37 Missouri  
CODES.....40 Nebraska  
CODES.....43 New York  
CODES.....45 Ohio  
CODES.....47 Rhode Island  
CODES.....49 South Carolina  
CODES.....51 Utah  
CODES.....53 Virginia  
CODES.....55 III.  
APPENDICES.....57  
Appendix 1: Frequently Asked Questions Regarding CODES.....57  
Appendix 2: Probabilistic Linkage Using Multiple Imputation.....60  
References.....62 ii

**EXECUTIVE SUMMARY** The Crash Outcome Data Evaluation System (CODES) is a program facilitated by the National Highway Traffic Safety Administration as a component of its State Data Program. CODES uniquely uses probabilistic methodology to link crash records to injury outcome records collected at the scene and en route by emergency medical services, by hospital personnel after arrival at the emergency department or admission as an inpatient and/or, at the time of death, on the death certificate. CODES is designed to foster and cultivate crash-outcome data linkage for highway safety applications at the State level, supporting State Highway Safety Offices, State Public Health and Injury Prevention Departments, State Emergency Medical Services Agencies, State transportation departments, and other such agencies; and to facilitate participation in NHTSA-coordinated multistate studies using linked data at the Federal level. This document is intended to inform traffic safety professionals, from those in CODES programs to those in the agencies they support, as well as all others interested in traffic safety, on best-practice applications available through linked CODES data. To support CODES program objectives, NHTSA sponsors cooperative agreements that provide software access, technical assistance, and program assistance to CODES State programs to link information about State-reported crashes and their consequences, and to analyze and disseminate the information. Analyses of linked data help inform State traffic safety professionals and coalitions to determine and implement data-driven traffic safety priorities. CODES evolved from a need to quantify and report on the benefits of safety equipment and legislation in terms of mortality, morbidity, injury severity, and health care costs, and has built proactive partnerships between the traffic safety and public health agencies, which own the State data, and NHTSA, which provides access to the software and training resources that make the linkage feasible. NHTSA maintains a CODES facilitating infrastructure to provide technical support and assistance to sites while also encouraging each site to build State-level collaborations and perform relevant analyses within their States. Topics of interest addressed by CODES have included pre-hospital, emergency department, inpatient, rehabilitation, and other health care charges by payer source (private, workers' compensation, Medicare, Medicaid, etc.), and associations with the consequences of motor vehicle crashes; crash injury patterns by type and severity, and hospital charges, by such variables as safety equipment use, vehicle type, geographical location, and others. In recent years, as outlined in abstracts in this paper, such information has been used to: □ **Identify Traffic Safety Problems:** CODES data has been used to identify traffic safety issues in numerous ways, which include examining whether the increased crash rates for teen drivers is accompanied by an increased injury to their passengers (New York and Minnesota); determining hospital charges and length of hospital stay for motorcycle-related injuries (Georgia); identifying the effect of seat belt usage in preventing injuries and fatalities (Kentucky, New York, Ohio, and Utah); studying injury patterns among children riding with unbuckled adults 1

compared to buckled adults (Utah); researching the types and frequency of injuries to children in passenger motor vehicles (Connecticut and Missouri); and analyzing the characteristics and outcomes of crashes involving teen drivers (Delaware and Minnesota). □ **Support Traffic Safety Decision-Makers:** CODES data has been used to inform and educate traffic safety decision-makers at the State and local level. Examples of CODES activities being used to support decision-makers include providing State legislators with the CODES report on the effectiveness of seat belt use in preventing injuries and fatalities (Kentucky); delivering data and expertise to the State Highway Administration to assist in the development of a long-term, statewide strategic plan to guide the future direction of traffic records and highway safety (Maryland); presenting CODES-related fact sheets and reports to the State Traffic Records Coordinating Committee (TRCC) (Massachusetts, Virginia); using CODES data to present a report to the Governor's Highway Safety Office and State legislators on the effect that enacting a standard enforcement seat belt law would have on hospital charges, direct medical costs, and the impact to the State's Medicaid system (Ohio); and developing media products on the medical and financial consequences of the under-the-influence drivers involved in crashes (South Carolina). □ **Support Traffic Safety Legislation:** CODES research has been used at the State level to inform legislators about traffic safety issues in their State and traffic safety legislation. These activities included providing legislators with information in support of upgrading existing graduated driver's license (GDL) laws (Delaware and Minnesota); using CODES data to expand a mandatory seat belt law to include back-seat passengers (Indiana); creating a fact sheet to help support legislation for motorcycle helmet use (Iowa); and providing data to a children's safety advocacy group to help convince legislators to change child passenger safety (CPS) laws (Connecticut). □ **Educate the Public:** As a means to informing the public about traffic safety issues, CODES data has been used to give a presentation to a State TRCC about the length of hospital stay, injury body region, and nature of injury for older vehicle occupants (Massachusetts); post a fact sheet comparing the crash rate severity of State drivers against non-State drivers on the State's Health and Human Services Department Web site (Nebraska); publish a paper on backseat seat belt use in the *Journal of Safety Research* (New York); and launch a Web site that contains five years of CODES data from which the user can select standard reports or create online queries based on selected criteria (Virginia). NHTSA is also using CODES multi-State data in a variety of studies as CODES States enable submission of standardized, non-identifiable data for research purposes. Through streamlining of programs and continuing methodological innovations, CODES is expected to continue leadership on traffic safety research in the 21st century. 2

## **I. THE CRASH OUTCOME DATA EVALUATION SYSTEM Introduction and Background**

Evolving from a need to quantify and report on the benefits of safety equipment and legislation in terms of mortality, morbidity, injury severity, and health care costs at State and national levels, the Crash Outcome Data Evaluation System has built proactive partnerships between the traffic safety and public health agencies, which own the State data, and NHTSA, which provides access to the software and training resources that make the linkage feasible. NHTSA maintains a CODES facilitating infrastructure to provide technical support and assistance to sites while also encouraging each site to build State-level collaborations and perform relevant analyses within their States. The intent of CODES data linkages is to ensure that traffic safety coalitions have access to crash outcome analyses to help determine and implement data-driven traffic safety priorities. As a result of these linkages, the availability of population-based, comprehensive, and representative crash outcome data is maintained to assist existing traffic safety coalitions in the selection and implementation of data-driven traffic safety priorities. A properly implemented State CODES program supports State Highway Safety Offices, State Public Health and Injury Prevention departments, State EMS Agencies, State transportation departments, and other such agencies to target their resources and evaluate the potential impact on preventing mortality and morbidity, reducing injury severity, and lowering health care costs. **Implementation and Data Enhancement** Through NHTSA-sponsored cooperative agreements, CODES provides access to linkage software and technical assistance in the form of software support, linkage training, and analysis training to State CODES programs. Technical assistance is disseminated through means such as software documentation, Web seminars, individual assistance, and periodic technical assistance meetings. Once trained, State CODES programs add to the available knowledge about State-reported crashes and their consequences by linking crash data to data systems such as EMS records and statewide hospital discharge records. The CODES program links crash records to injury outcome records collected at the scene and en route by emergency medical services, by hospital personnel after arrival at the emergency department or admission as an inpatient and/or, at the time of death, on the death certificate. Although crash data indicate the occurrence of injury, they include only limited information about type and severity and no information about health care costs or International Classification of Diseases (ICD) coding. Similarly, hospital injury datasets with ICD codes and billing charges do not include information about the characteristics of the crash or vehicles involved. CODES linkage integrates the two subject matters, and as a result, CODES provides statewide, real-world crash outcome data that can provide population-based information on crash outcomes in terms of deaths, specific injury type/region/severity, and costs. As linkage expands into other data systems, as it has in some States, it can enhance other participating data systems in a variety of ways. For example, EMS and hospitals obtain information about the time of onset to evaluate the responsiveness of the trauma system; 3

roadway inventories expand to include injury outcome information by location point; driver licensing information is augmented with the medical and financial consequences caused by drivers who are impaired or repeat offenders; and vehicle characteristics can be related to specific types of injuries and their costs. In addition, data quality can improve as previously undiscovered problems are identified and corrected during linkage. **Federal Use of CODES Data** In the original NHTSA Report to Congress (1996) on the Benefits of Safety Belts and Motorcycle Helmets, data on crashes from seven States was compiled as part of the first CODES program. This report employed probabilistic linkage techniques to combine data gathered from police crash reports, emergency medical services, hospital emergency departments, and hospital discharge files to more fully describe motorcycle crash events and their outcomes. Among other findings, this report revealed an increase in hospital charges for motorcycle operators who were unhelmeted at the time of their crashes, and motorcycle helmet effectiveness of 67 percent in the reduction of brain injuries. Though not catalogued in this report, the Federal-State collaboration that successfully implemented CODES at the State level has led to the planning of new CODES applications at the Federal level. States that have successfully linked at least two years of crash and injury outcome data may receive the benefits of the NHTSA CODES facilitation as part of the CODES Data Network. These projects also share their expertise and, under certain privacy considerations, can contribute specific standardized model variables for multi-State studies. NHTSA is currently working with CODES Data Network States to expand this capability, in order to provide support to NHTSA program needs with multi-State crash data analyzed by crash conditions, safety equipment, and other crash variables in terms of injury types, level of care, discharge status, payer, charges, and other outcome variables not available in unlinked crash data.

**Document Purpose and Structure** This document is designed to well-inform traffic safety professionals, from those in CODES programs to those in the agencies they support, as well as all others interested in traffic safety, on best-practice applications available through linked CODES data. To distribute information on many applications in a compact way, this paper presents abstracts of applications presented by CODES members at CODES annual meetings. Abstracts are presented as prepared for the years 2006 and 2007. Each summarizes the population and traffic safety issue targeted, the format and methodology used, and impacts, actions or follow-ups on the targeted subject matter. Since the State-specific applications presented are limited to those reported at the CODES meetings in 2006 and 2007, they do not represent a complete inventory of all of the applications developed by the States during this period. Thus, for example, not all of the CODES States actively involved in developing and supporting the State TRCC are listed in Table 2. For convenience, abstracts are summarized in four categories, with summary tables allowing reference and page location by category and subject matter. After the summaries, full abstracts are presented in State alphabetical order. Following the abstracts, two appendices offer responses 4

to frequently asked questions regarding the CODES program and a more technical description of the statistical methodologies used to achieve representative linked data statewide. **CODES State-Level Applications Summarized** This section summarizes presented State CODES applications in four broad objectives: (1) traffic safety problem identification, (2) traffic safety decision-making support, (3) safety legislation development and support, and (4) public education. For each grouping, a table summarizes and references State applications in the category. Objective 1: Identify Traffic Safety Problems CODES data is population-based, so the large volume of data generated as the result of annual linkage in most CODES States can help identify safety issues including infrequent but potentially significant crash outcomes. Table 1 provides a reference to traffic-safety problem-identification applications as documented in their abstracts in Part 2 of this report. Objective 2: Support Traffic Safety Decision-Makers With limited resources, decision-makers need to identify and justify priorities assigned to improving traffic safety in relation to other public health issues. CODES data can provide statewide information to support safety efforts initiated by elected officials, and CODES data reported at the county or local level can be used in planning priorities of the coordinating agencies such as the Traffic Records Coordinating Committees (TRCCs), funding/planning agencies such as the State Highway Safety Offices and departments of public health/injury control, or data users such as the members of the CODES advisory committee. Many CODES projects also have played key roles in helping to define the traffic safety agenda of their State TRCC committees. Table 2 summarizes examples of these traffic-safety decision-making support applications as documented in their abstracts in Part 2 of this report. Objective 3: Support Traffic Safety Legislation Traffic safety efforts must be targeted where they will have the most impact on improving crash outcome. When the increase in deaths, injury, severity, and health care costs becomes unacceptable, legislation may be necessary to change public behavior. In these instances, the State-specific medical and financial information generated by CODES can demonstrate the expected savings, in terms of decreased health care costs and injury severity, to taxpayers with the adoption of specific traffic safety legislation. Table 3 summarizes examples of legislation-support applications as documented in their abstracts in Part 2 of this report. Objective 4: Educate the Public If an educated public can help improve traffic safety, then traffic safety information must be readily available in a format that meets the public's needs. In support of public education, State CODES programs often use 1- or 2-page fact sheets to disseminate traffic safety information to the public. In addition, the Internet has increased accessibility to linked crash outcome results while complying with State privacy legislation and regulations. Some States provide online interactive reports or detailed data tables. Table 4 summarizes examples of public education applications as documented in their abstracts in Part 2 of this report, and Table 5 lists the Web sites for the CODES States and NHTSA as of March 2009. 5 6

**Table 1: State CODES Applications Supporting Traffic Safety Problem Identification State and Application by Type of Subject Matter Page1. Aggressive Drivers Aggressive Driving**

**Study Delaware** Descriptive statistics and rate ratios (RRs) were used to compare the crash outcomes 18 between 16- and 17-year-old drivers with and without passengers. **2. Older Drivers Elder Occupants in Motor Vehicle Crashes: Forecasting Health Burden Rhode** Statistically, Rhode Island's older occupants are more likely to be hospitalized or fatally 50 Island injured after motor vehicle crashes. CODES data was used to examine the differences and the age distribution of the population to help in developing planning policies on future highway safety interventions. **3. Teen Drivers The Epidemiology of Motor Vehicle Crashes Involving 16- and 17-Year-Old Drivers in Minnesota and Associated Hospital Charges** CODES data were used to determine the per mile rate of teenage driver motor vehicle crash Minnesota 38 involvement and the characteristics of these crashes in Minnesota. Measure medical care charges and the severity of injuries associated with motor vehicle crashes involving teenage drivers. **Using Multiply-Imputed CODES Data to Identify Risk Factors and Reveal Societal Costs in Teen Driving** Police crash reports, emergency department and hospital discharge data were examined to New York 46 determine the risk factors and societal costs for drivers age 16 to 20. Teen drivers and 25- to 49-year-old drivers were compared for traffic crash and injury rates, emergency department visit rates, hospitalization rates, and crash



contributing factors. **4. Non-Resident Drivers Comparing Crashes That Occurred in Nebraska Involving Nebraska and Non-Nebraska Drivers** Comparing the crashes occurring in Nebraska from 1999 to 2003 by the driver's State of Nebraska 44 residence, CODES data explored the patterns and the contributing risks factors of the crashes. Crashes involving non-Nebraska drivers tended to be more severe, resulting in more deaths and serious injuries than crashes involving Nebraska drivers. **5. Roadway Why Is It So Risky to Drive on the Roadways Where the Posted Speed Limit Is 50 Miles Per Hour?** The crashes that occurred on roadways with posted speed limits of 50 mph resulted in severe Nebraska 43 crash outcomes with the highest injury rate and a higher death rate than those crashes that took place on other roadways. This CODES study examines the causes and consequences of crashes occurring on Nebraska roads with posted speed limits of 50 mph. **6. Traumatic Brain Injury Motor Vehicle Crash (MVC) Related to Traumatic Brain Injuries in Iowa** To demonstrate the growing crash and injury rates among motorcycle riders in Iowa from Iowa 2001–2005, CODES data was used to examine the five years' crash rates per 1,000 23 motorcyclist licensed drivers—including fatality and injury rates— and were calculated to demonstrate low rates of helmet use in Iowa. **7. Data Quality Issues Adjusting for Seat Belt Reporting: The Problem of Differential Misclassification** Maine CODES reviewed the problem of differential misclassification of seat belt use in police 30 crash reports and explored a method of correcting for missing data and differential misclassification using CODES linked data.