HEI

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Assessing Health Impact of Air Quality Regulations: Concepts and Methods for Accountability Research

HEI Accountability Working Group

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Contributors

This Communication is the work of a multidisciplinary group, chaired by Dr Jonathan M Samet of the Johns Hopkins Bloomberg School of Public Health, that included participants from the Health Effects Institute's Health Research and Review Committees, HEI staff, and other invited experts. An iterative workshop process was used to develop the Communication's novel concepts and subject matter. For the first workshop in March 2002, HEI convened a multidisciplinary group of experts, several of whom were asked to draft text in advance. At the workshop, participants met in plenary and in small groups, revising draft text on the basis of their discussions. A subset of the workshop participants was then asked by HEI to join the Accountability Working Group responsible for drafting specific chapters. This group met in June 2002 to review and revise the draft chapters and prepare a final draft. The draft was sent for peer review to a broad range of experts and stakeholders, several of whom presented their views at the 2003 HEI Annual Conference. This final document was then prepared by Dr Samet and HEI staff.

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APPENDIX 1.A. Case Study: Airbags and Front-Seat Motor Vehicle Occupant Safety in the United States

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The introduction of motor vehicles to the United States has been both beneficial and detrimental. Motor vehicles led to increased mobility and improved the economy, but they also increased the risks of death or injury in crashes. As the numbers of vehicles on the road and miles traveled increased, so did the number of individuals suffering temporary or permanent health losses. Toward the end of the 1960s, some 52,000 US residents died each year because of cars; many more sustained temporal or permanent physical impairments (Bonnie et al 1999). Motor vehicle crashes became the leading cause of death between the ages of 1 and 44 years and the leading cause of years of potential life lost.

By the late 1960s, a group of physicians, public health professionals, and engineers had introduced the concept of crash and injury preventability and established the field of research called *injury control*. As part of their efforts to reduce the burden of motor-vehicle crashes, they advocated for a federal agency to be responsible for motor-vehicle safety, a regulatory body to increase the safety of motor vehicles, and legislation to establish surveillance systems.

SURVEILLANCE SYSTEMS AND DATABASES

As a result, a number of surveillance systems were developed. One of the first, the Special Crash Investigation, was established in 1972 to provide in-depth engineering data on specific crashes. Population-based surveillance systems were the next development, starting with the Fatality Analysis Sampling System in 1975, which generated a census of all police-reported crashes in the United States for which one or more people died within 30 days. This data system comprises some 50 data elements: mainly data from accident reports completed by police at the scenes of crashes, with supplementary vehicle registration and drivers' license data.

The National Automotive Sampling System was established in 1978 as a probability sample of police-reported crashes after which at least one vehicle was towed. A subset system, the General Estimates System, involves annual sampling of some 50,000 crashes, for which data from police accident records only are included (for a total of 90 data elements). A second subset, the Crashworthiness Data System, focuses on crashes involving passenger vehicles. An in-depth investigation is conducted for each of 5000 crashes sampled annually. Detailed crash, vehicle, and medical information are collected in the approximately 400-element database.

All these databases are publicly available (US National Highway Traffic Safety Administration 2003). They have enabled researchers to track the magnitude of the motor vehicle crash problem, investigate possible risk factors, and evaluate preventive measures.

AIRBAGS VERSUS SAFETY BELTS

Research conducted with the help of these national databases and others confirmed that head injuries due to contact with the windshield and frontal panel, including the steering wheel, during frontal crashes are the most dangerous types of crash injury in terms of their lethal and severe nonlethal consequences (Graham 1989). Safety belts and airbags were the most helpful devices available to minimize these injuries. Safety belts had been introduced into motor vehicles in the early 1960s, but their efficacy was hampered in the real world by their low use rates: at the time, fewer than 10% of motor vehicle front seat occupants used their safety belts (US Department of Transportation 1997).

Airbags had the potential to be more protective than safety belts because they do not require any action on the part of occupants. Designed in the late 1940s, airbags are inflatable cushions that automatically deploy during collision. Whereas safety belts protect by restraining the occupant and reducing their likelihood of hitting the dashboard, steering wheel, or windshield during the deceleration associated with a crash, frontal airbags protect by providing a soft cushion against which the occupant comes to rest. However, the necessarily quick deployment of the bags releases large amounts of energy, which could injure vehicle occupants.

Whether vehicles in the United States should have airbags (instead of, or in addition to, safety belts) became one of the longest and most intense debates among professionals concerned with motor vehicles. Consumer protection organizations and injury control specialists, including agents of the National Highway Traffic Safety Administration, favored the passive protection of airbags because they were skeptical of the potential to considerably increase safety belt use. In contrast, manufacturers were concerned about the added costs associated with airbags. In addition, they and some safety experts expressed concerns about possible airbag-related injuries (Graham 1989).

The 20-year debate culminated in 1991 with legislation requiring all cars sold in the United States to be equipped with frontal airbags for drivers and front-seat passengers, effective model year 1997 (US Department of Transportation 2001). (To date, the United States is the only country

to have passed such legislation.) This legislation was passed in spite of some experimental evidence presented by manufacturers that confirmed possible damage to out-of-position or smaller occupants. After enactment, manufacturers introduced frontal airbags very rapidly into the fleet. The percentage of passenger cars with driver-side airbag systems increased from 23% in model year 1990 to 100% in model year 1995.

AIRBAG DESIGN AND PERFORMANCE

Airbags had to be designed to protect potential occupants from sustaining forces greater than a prespecified level when exposed to a frontal crash of specified severity. Performance standards were developed early in the debate on the basis of experimental and real-world crash data. By 1991, frontal airbag systems were expected to reduce the probability of death for a driver by 22% (US Department of Transportation 1996). The effects on nonfatal injuries and front-seat passengers were assumed to be similar.

Soon after airbag systems were implemented, however, the need for performance monitoring became clear. Numerous researchers began monitoring performance primarily by using the databases created in the 1970s. In mid 1996, several children died from airbag deployment during otherwise minor crashes. Even before these highly publicized accidents occurred, several reports of airbag-induced injuries had already been published in the medical literature, showing that certain specific injuries (ie, blunt or hyperextension-related) occur when an occupant interacts with an inflating bag. By the end of 1996, the Special Crash Investigations system confirmed that 39 child passengers, 2 adult passengers, and 31 drivers (mostly female, several more than 60 years old) died from these injuries (US National Center for Statistics and Analysis 2003).

Concurrent statistical evaluations of airbag performance reported mixed results. Fatalities were reduced by 34% among drivers without safety belts in frontal crashes, by 11% for drivers and front seat passengers in all crashes, regardless of safety belt use, and by 16% in cases of serious head injuries among drivers in all types of crashes (US Department of Transportation 2001). Less favorable were reports of a net 63% increase in child fatalities (Graham et al 1998) and a 14% increase in serious upper-extremity injuries among drivers (US Department of Transportation 2001). Passenger-side airbags were less cost effective than driver-side airbags, even when adult occupants only were included in the analyses (Graham et al 1997; Larkin et al 1998).

These unintended negative consequences of airbags reignited the debate about their use, which involved motor vehicle manufacturers, airbag system manufacturers, consumer representatives, government safety officials, lawyers, victims' associations, and others. Because airbags were inducing some injuries, had they been introduced carelessly? Had the airbags been designed to perform too aggressively or to deploy too frequently or in crash conditions that were not sufficiently severe? On the other hand, because overall airbags were protective, had they not been introduced soon enough?

AIRBAG IMPROVEMENTS

The renewed debate led to remedial measures. Manufacturers were requested to send letters to owners of airbag-equipped vehicles, warning them of the dangers of airbags, and to add three warning stickers in the interior of new vehicles. Permission was granted to install a switch to turn off the airbag systems, which was an illegal operation prior to this time. Legislation requiring proper restraint of child passengers was strengthened throughout the country; some states started to require children below certain ages to occupy rear seats only. In 1997, a final rule on depowering, or allowing less powerful frontal airbags to be used, was introduced. Lastly, performance standards required for approval of the systems were revised in 2000.

Effective model year 1998, many US manufacturers introduced changes in their frontal airbag systems (US Department of Transportation 2001). Investigation of Special Crash Investigation data on the performance of these new systems has revealed no new airbag-induced deaths since 2000. Preliminary evaluations using the larger, population-based datasets suggest reductions in airbag-induced injuries and no increases in the types of injuries the airbags were intended to protect against. A recently formed coalition between automotive manufacturers and government has led to an expansion of the National Automotive Sampling System Crashworthiness Data System so that more cases of vehicles with newer airbag systems can be collected and analyses can be done sooner. Even then, it will take a few more years before a formal evaluation can be made.

The history of airbag regulation in the United States illustrates the interaction between political, public health, and private industry forces that occurs during adoption of public health measures. It also illustrates several needs for accountability of such measures: specific monitoring of the measure's performance, appropriate sources of data for monitoring, and vigilance for unexpected outcomes.

REFERENCES FOR APPENDIX 1.A

Bonnie RJ, Fulco CE, Liverman CT, eds. 1999. Reducing the Burden of Injury: Advancing Prevention and Treatment. Committee on Injury Prevention and Control, Division of

Health Promotion and Disease Prevention, Institute of Medicine. National Academy Press, Washington DC.

Department of Transportation (US). 1996. Third Report to Congress: Effectiveness of Occupant Protection Systems and Their Use. National Highway Traffic Safety Administration, Washington DC.

Department of Transportation (US). 1997. America's experience with seat belt and child seat use. In: Presidential Initiative for Increasing Seat Belt Use Nationwide; Recommendations from the Secretary of Transportation. National Highway Traffic Safety Administration, Washington DC. Available from *www.nhtsa.dot.gov/people/injury/airbags/presbelt/america_seatbelt.html.*

Department of Transportation (US). 2001. Fifth/Sixth Report to Congress: Effectiveness of Occupant Protection Systems and Their Use. DOT HS 809 442. National Highway Traffic Safety Administration, Washington DC.

Graham JD. 1989. Auto Safety: Assessing America's Performance. Auburn House Publishing Co, Dover MA.

Graham JD, Goldie SJ, Segui-Gomez M, Thompson KM, Nelson T, Glass R, Simpson A, Woerner LG. 1998. Reducing risks to children in vehicles with passenger airbags. Pediatrics 102:e3. Available from *www.pediatrics.org/cgi/content/full/102/1/e3.*

Graham JD, Thompson KM, Goldie SJ, Segui-Gomez M, Weinstein MC. 1997. The cost-effectiveness of air bags by seating position. JAMA 278:1418–1425.

Larkin GL, Weber JE, Graham JD, Thomson KM, Goldie SJ, Segui-Gomez M, Weinstein MC. 1998. Cost-effectiveness of air bags in motor vehicles. JAMA 279:506–507.

National Center for Statistics and Analysis. Special Crash Investigations (US). 2003. Children fatally injured by PAB, normalized for a 12-month period. *www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/SCI/2Q_2003/HTML/PABChild/NTCC.htm.* Accessed 7/01/03.

National Highway Traffic Safety Administration (US). 2003. National Center for Statistics and Analysis: Available information. *www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/TextVer/index.html.* Accessed 7/01/03.

ABBREVIATIONS AND OTHER TERMS

CO	carbon monoxide
COPD	chronic obstructive pulmonary disease
EPA	Environmental Protection Agency (US)
NAAQS	National Ambient Air Quality Standard(s) (US)
NO_2	nitrogen dioxide
O_3	ozone
PM	particulate matter
$PM_{2.5}$	PM less than 2.5 μm in aerodynamic diameter
SO_2	sulfur dioxide