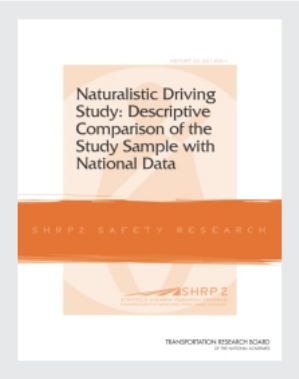


Naturalistic Driving Study: Descriptive Comparison of the Study Sample with National Data

DETAILS

44 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-43273-3 | DOI 10.17226/22196

AUTHORS

Jon Antin, Kelly Stulce, Lisa Eichelberger, and Jon Hankey; Strategic Highway Research Program Safety Focus Area; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

The Second
STRATEGIC HIGHWAY RESEARCH PROGRAM

SHRP 2 REPORT S2-S31-RW-1

Naturalistic Driving Study: Descriptive Comparison of the Study Sample with National Data

Jon Antin, Kelly Stulce, Lisa Eichelberger, and Jon Hankey
Virginia Tech Transportation Institute
Blacksburg, Virginia

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2015
www.TRB.org

Subject Areas

Data and Information Technology
Highways
Safety and Human Factors
Vehicles and Equipment

The Second Strategic Highway Research Program

America's highway system is critical to meeting the mobility and economic needs of local communities, regions, and the nation. Developments in research and technology—such as advanced materials, communications technology, new data collection technologies, and human factors science—offer a new opportunity to improve the safety and reliability of this important national resource. Breakthrough resolution of significant transportation problems, however, requires concentrated resources over a short time frame. Reflecting this need, the second Strategic Highway Research Program (SHRP 2) has an intense, large-scale focus, integrates multiple fields of research and technology, and is fundamentally different from the broad, mission-oriented, discipline-based research programs that have been the mainstay of the highway research industry for half a century.

The need for SHRP 2 was identified in *TRB Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life,* published in 2001 and based on a study sponsored by Congress through the Transportation Equity Act for the 21st Century (TEA-21). SHRP 2, modeled after the first Strategic Highway Research Program, is a focused, time-constrained, management-driven program designed to complement existing highway research programs. SHRP 2 focuses on applied research in four areas: Safety, to prevent or reduce the severity of highway crashes by understanding driver behavior; Renewal, to address the aging infrastructure through rapid design and construction methods that cause minimal disruptions and produce lasting facilities; Reliability, to reduce congestion through incident reduction, management, response, and mitigation; and Capacity, to integrate mobility, economic, environmental, and community needs in the planning and designing of new transportation capacity.

SHRP 2 was authorized in August 2005 as part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The program is managed by the Transportation Research Board (TRB) on behalf of the National Research Council (NRC). SHRP 2 is conducted under a memorandum of understanding among the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the National Academy of Sciences, parent organization of TRB and NRC. The program provides for competitive, merit-based selection of research contractors; independent research project oversight; and dissemination of research results.

SHRP 2 Report S2-S31-RW-1

ISBN: 978-0-309-31491-6

Copyright Information

Note: SHRP 2 report numbers convey the program, focus area, project number, and publication format. Report numbers ending in "w" are published as web documents only.

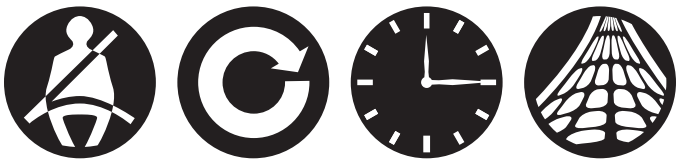
Notice

The project that is the subject of this report was a part of the second Strategic Highway Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical committee and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

The Transportation Research Board of the National Academies, the National Research Council, and the sponsors of the second Strategic Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the report.



SHRP 2 Reports

Available by subscription and through the TRB online bookstore:

www.mytrb.org/store

Contact the TRB Business Office:
202-334-3213

More information about SHRP 2:

www.TRB.org/SHRP2

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. C. D. (Dan) Mote, Jr., is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Victor J. Dzau is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. C. D. (Dan) Mote, Jr., are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

SHRP 2 STAFF

Ann M. Brach, *Director*
Stephen J. Andrle, *Deputy Director*
Cynthia Allen, *Editor*
Kenneth Campbell, *Chief Program Officer, Safety*
Jared Cazel, *Editorial Assistant*
JoAnn Coleman, *Senior Program Assistant, Capacity and Reliability*
Eduardo Cusicanqui, *Financial Officer*
Richard Deering, *Special Consultant, Safety Data Phase 1 Planning*
Shantia Douglas, *Senior Financial Assistant*
Charles Fay, *Senior Program Officer, Safety*
Carol Ford, *Senior Program Assistant, Renewal and Safety*
James Hedlund, *Special Consultant, Safety Coordination*
Alyssa Hernandez, *Reports Coordinator*
Ralph Hessian, *Special Consultant, Capacity and Reliability*
Andy Horosko, *Special Consultant, Safety Field Data Collection*
William Hyman, *Senior Program Officer, Reliability*
Linda Mason, *Communications Officer*
David Plazak, *Senior Program Officer, Capacity and Reliability*
Rachel Taylor, *Senior Editorial Assistant*
Dean Trackman, *Managing Editor*
Connie Woldu, *Administrative Coordinator*

ACKNOWLEDGMENTS

This work was sponsored by the Federal Highway Administration in cooperation with the American Association of State Highway and Transportation Officials. It was conducted in the second Strategic Highway Research Program (SHRP 2), which is administered by the Transportation Research Board of the National Academies. The project was managed by Kenneth L. Campbell, Chief Program Officer for SHRP 2 Safety. James H. Hedlund, SHRP 2 Consultant for Safety Coordination, also contributed to the project.

The research reported in this document was performed by the Virginia Tech Transportation Institute (VTTI). The authors acknowledge the contributions of VTTI Director Thomas Dingus, who served as principal investigator, and Feng Guo and Jeremy Sudweeks of VTTI, who made valuable contributions to the early conceptualization and structuring of the analyses supporting this effort.

FOREWORD

Kenneth L. Campbell, *SHRP 2 Chief Program Officer, Safety*

This report provides a descriptive comparison of data from the SHRP 2 Naturalistic Driving Study (NDS) sample and national data. The primary objective of the SHRP 2 NDS is to support analyses relating crash risk to driver, vehicle, roadway, and environmental characteristics. Since age is one of the most important driver characteristics, this objective is best supported by adequate sample sizes across all age groups. The national population of drivers has the greatest number of drivers in the middle age groups and progressively fewer in the younger and older ages. In contrast, the NDS oversampled younger and older drivers. In addition, the NDS oversampled newer-model-year vehicles because these vehicles provided useful data through their vehicle networks. It is important for users of the NDS data to have information on the relationship of the NDS sample to the national population. In general, many statistics taken directly from the NDS sample will not be nationally representative unless they are adjusted to account for relevant characteristics of the NDS sample.

The SHRP 2 NDS is the first large-scale study focused on collision prevention (as opposed to injury prevention once a collision occurs) since the Indiana Tri-Level Study (*Tri-Level Study of the Causes of Traffic Accidents: Final Report,* Report DOT HS-805 085, U.S. Department of Transportation, May 1979). Vehicle use was recorded continuously in the SHRP 2 NDS. Information on vehicle travel, or exposure, can be extracted at the same level of detail as for safety-related events like crashes and near crashes. Hence, the SHRP 2 NDS is the first large-scale study to support detailed estimates of collision risk. Moreover, crashes are a leading cause of nonrecurring congestion. Collision prevention has added benefits in terms of reduced delay, fuel consumption, and emissions. The focus of the NDS is to provide objective information on the role of driver behavior and performance in traffic collisions and the interrelationship of the driver with vehicle, roadway, and environmental factors.

The SHRP 2 Safety research program was carried out under the guidance of the Safety Technical Coordinating Committee (TCC), which was composed of volunteer experts. The Safety TCC developed and approved all project descriptions and budgets and met semiannually to review progress and approve any program modifications. The Oversight Committee approved all budget allocations and contract awards. Assistance was provided by expert task groups, which developed requests for proposals, evaluated proposals and recommended contractors, and provided expert guidance on many issues, such as data access policies and procedures. The decisions and recommendations of the governing committees were implemented by SHRP 2 staff as they carried out day-to-day management of the research projects.

CONTENTS

Executive Summary

Data from Project S31, Naturalistic Driving Study (NDS) User Support and Data Dissemination, of the second Strategic Highway Research Program (SHRP 2) are meaningful only if the relation of the drivers, vehicles, roads, and crashes in the data to the drivers, vehicles, roads, and crashes in the United States is understood. However, this relation may vary for different research questions. This report illustrates how the data relate to the country as a whole across several key dimensions.

SHRP 2 data are fairly inclusive of the nation in many respects. The counties from which participants were drawn, when aggregated, include a wide range of geographical features, roadways, and climates. Similarly, the SHRP 2 vehicle fleet includes all the national fleet's light vehicle types and most of its light vehicle makes, although it is biased toward recent model years. SHRP 2 drivers range in age from 16 to 95, with younger and older drivers oversampled. Two SHRP 2 crash rates were calculated: a lower "confirmed" estimate, using the crashes known to have been reported, and an upper "possible" estimate, using the crashes judged to meet the police-reportable threshold. The confirmed SHRP 2 crash rate is slightly below the national police-reported crash rate, and the possible SHRP 2 rate is substantially above the national rate.

However, the SHRP 2 NDS sample is not representative of the national driving population. Analysts who wish to use Project S31 data to make comparisons with a national population of some characteristic, such as driver age, will need to weight the SHRP 2 data to match the national distribution of that characteristic. This report provides an example of weighting by driver age and gender.

The information presented in this report should be helpful in using and interpreting SHRP 2 NDS data to illuminate how drivers behave in real-world settings, especially those moments leading up to and during crash-related events.

CHAPTER 1

Introduction

The second Strategic Highway Research Program (SHRP 2) naturalistic driving study (NDS) comprises the largest set of naturalistic driving data ever collected in a single study, with more than 3,100 participants from six geographically dispersed sites across the United States. Volunteer participants were observed for more than three years in all, producing some 50 million miles of naturalistic driving data from kinematic and other sensors, as well as from four-channel video (Dingus et al. 2014). The combined video is illustrated in Figure 1.1. Sensors included accelerometers in three dimensions, a global positioning system, forward radar, and others.

The SHRP 2 data set is expected to help a generation of researchers address a myriad of crucial transportation safety and other questions. However, to properly analyze these data and meaningfully interpret results, one must first understand the degree to which the data sample can be used to study the target population of interest: all drivers in the United States.

Simply stated, the primary goal of the SHRP 2 NDS was to collect and archive the largest set of naturalistic driving data in history. More specifically, adequate samples of key driver, vehicle, and environmental characteristics were identified as integral to a thoughtful examination of driver behaviors, particularly those associated with crash-related events. Additional layers of challenge were presented by the study's financial and operational constraints, all of which necessitated savvy strategic planning in the precollection phase. In addition, nimble management of the ongoing study was required as novel challenges continually emerged as the study progressed.

Specifically, study objectives had to be attained within the confines of a budget that allowed for recruitment and data collection at only six sites, each of which had to be selected carefully to maximize sample quality and variety while minimizing operational obstacles. In addition, budgetary limitations, along with the naturalistic essence of the study, precluded the provision of study vehicles to participants. The resulting reliance on volunteer drivers using their own vehicles introduced the primary impediment to both fulfilling original sample design goals and maintaining optimal operational efficiency, particularly with regard to successful instrumentation of 2,000 eligible vehicles with data acquisition equipment. That is, attracting interested male and female participants across the driving age spectrum with vehicles well suited for the study (i.e., in terms of facilitating the collection of vehicle network data) required numerous midstudy modifications, both to study equipment and to the way in which sampling goals were undertaken.

Representativeness

A *representative* sample is one from which results can be generalized to the larger population (Spence et al. 1976). One method of obtaining a representative sample is to select the sample at random from the population of interest (i.e., so that every member of the population has an equal chance of being chosen [Spence et al. 1976]). However, a truly random selection is extremely difficult to achieve in an actual study involving human subjects, and it was not possible in Project S31 for several reasons. First, participants had to live in one of the six preselected data collection sites, illustrated in Chapter 2, so all other drivers in the United States—the vast majority of the nation's drivers—did not have a chance to participate. Second, SHRP 2 NDS participants, similar to participants in virtually all ethically conducted studies, were required to grant their informed consent before data could be collected from them. As a result, SHRP 2 participants could not be selected at random. Instead, they were selected only from drivers living in the six data collection sites who were willing to grant their informed consent to participate. Thus, SHRP 2 data constitute a convenience sample.

It has been argued that it is not possible to determine the representativeness of such a convenience sample (Anderson et al. 2003). But it is still instructive to compare the sample with the target population on as many relevant parameters as are available. Equipped with such comparison data, the analyst may be better able to judge whether the sample is adequately

Figure 1.1. Quad-video image.

characteristic of the population of interest for any specific purpose and whether any reweighting of the data is appropriate for specific research applications. Indeed, the degree to which a sample is characteristic of the population of interest may vary widely according to the particular research question being addressed and the exact subset of data being extracted from the larger data set for analysis (Ramsey and Hewitt 2005).

Goal of This Report

The goal of this report is to help researchers and other consumers of the data better understand from a variety of perspectives the relation of the SHRP 2 NDS data to the main population of interest, that is, all drivers, vehicles, and driving conditions in the United States. More specifically, this report addresses four questions:

1. How do the selected sites in aggregate compare to the United States as a whole?
2. How do the participants sampled compare to all drivers in the United States?
3. How do the vehicles sampled compare to the entire U.S. fleet?
4. How do police-reported crash rates observed in the study compare to crash rates in the United States as a whole?

Data from the SHRP 2 NDS sample are also compared, when possible, with other geographical areas of interest, including the aggregated SHRP 2 recruitment counties and the SHRP 2 states.

Approach

First, the report recapitulates at a high level the original sample design, including how the six data collection sites were selected, as well as how recruitment and screening progressed throughout the study. Second, information is presented about each of the data collection sites. Third, three categories of study data—participant characteristics, vehicle fleet composition, and crash rates—are compared with local or national comparison data sets, each from as many perspectives as feasible. Taken together, this information should provide the reader with sufficient information to assess how SHRP 2 data can be used for analyzing a variety of research questions.

CHAPTER 2

Data Collection Site Selection

It was considered important to sample from as broad a range of environmental and geographical conditions as feasible to better understand how these elements interact with driver, vehicle, and roadway factors and to sample from as broad an array of these conditions found in the United States as possible. However, considering the nation's vast area, it would be impossible for any six sites to adequately represent its entirety. Further complicating the situation was the inability to choose study sites simply based on key environmental and geographical considerations; instead, sites had to be selected from among those organizations that responded to SHRP 2 solicitations, as detailed below.

Study sites were selected by a SHRP 2 expert technical group formed for this purpose. The expert technical group used a two-stage process. First, two requests for qualifications were released; this stage produced 11 qualified sites. Second, a request for proposal was sent to those contractors who responded to and passed the initial qualification stage. The SHRP 2 NDS site selection expert technical group, with guidance from the technical coordinating committee, was then faced with the responsibility of narrowing down the request for proposal respondents to the final six organizations (and their respective sites) determined to be best suited for the study (with maximal geographical and environmental diversity being key factors under consideration). The request for proposal stage resulted in the final selection of the six SHRP 2 NDS sites (Antin et al. 2011). Site selection was not based solely on a desire to have geographic diversity or dispersion. Instead, each site had to be supported by a qualified and vetted research organization that proposed to support a site of a particular size at one or more defined locations, and only six such sites could be supported within the scope and budgetary constraints of the program. Figure 2.1 shows that, in terms of number of data acquisition system (DAS) kits (and thus, roughly, number of participants) managed, the three largest sites were associated with Buffalo, New York; Seattle, Washington; and Tampa, Florida. Durham, North Carolina, housed the moderately sized site, and the smallest two sites were located in Bloomington, Indiana, and State College, Pennsylvania.

Data Collection Site Comparisons

This section provides further information about the geography and climate of the data collection sites. In addition, comparisons are drawn with their respective states and the nation as a whole when possible. In this way the reader can begin to determine the degree to which the aggregated data collection sites match national point estimates on important characteristics and how well they encompass the great diversity of the nation. The most current complete set of comparison data available at the time of the compilation of this report was 2010 U.S. Census data, which are used in this chapter, as well as the demographic comparisons presented in Chapter 4. Data collection for Project S31 commenced in late 2010.

Figure 2.2 through Figure 2.7, taken from Blatt et al. (2014), show a detailed view of each site's geographical recruitment area.

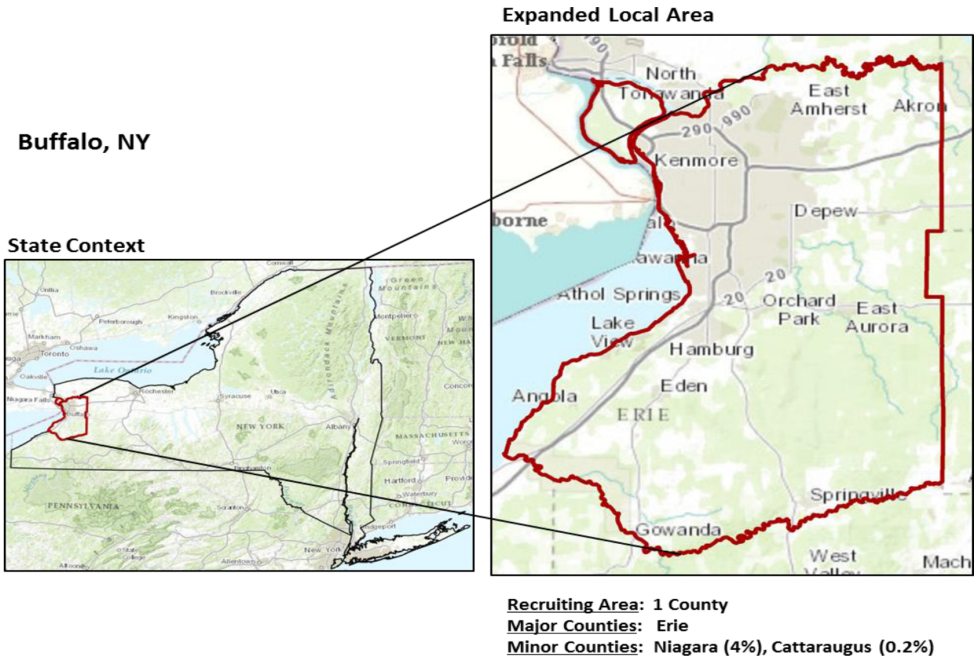
Table 2.1 shows the population, land area, and resulting population density for each of the six recruitment sites. The numbers represented in the following tables and figures reflect only the primary counties where recruitment took place (and each of those primary counties in their entirety); however, at some sites a relatively small proportion of the participants were recruited from nearby counties. Four sites recruited participants only from their primary counties. The largest percentage of recruits from the nonprimary counties at a single site was 4%. Overall, 1% of all participants were recruited from nonprimary counties.

Figure 2.8 shows the population and land area across the six recruitment sites.

Figure 2.9 shows the population density of each of the six recruitment sites. Note that population density roughly

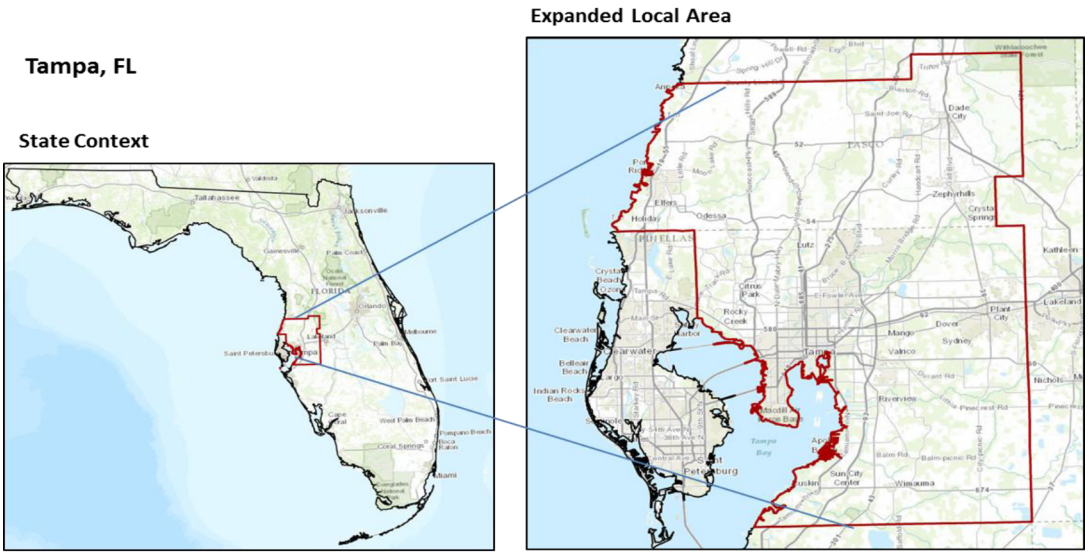
(text continues on page 9)

Figure 2.1. Six data collection sites and nominal distribution of the DAS kits.



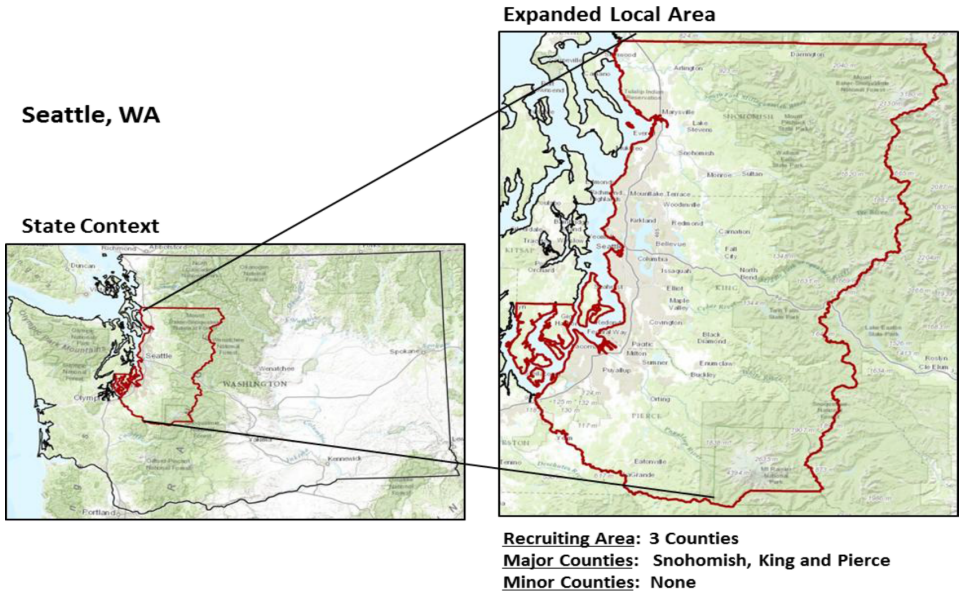
Source: Blatt et al. 2014.

Figure 2.2. New York recruitment area and expanded view.



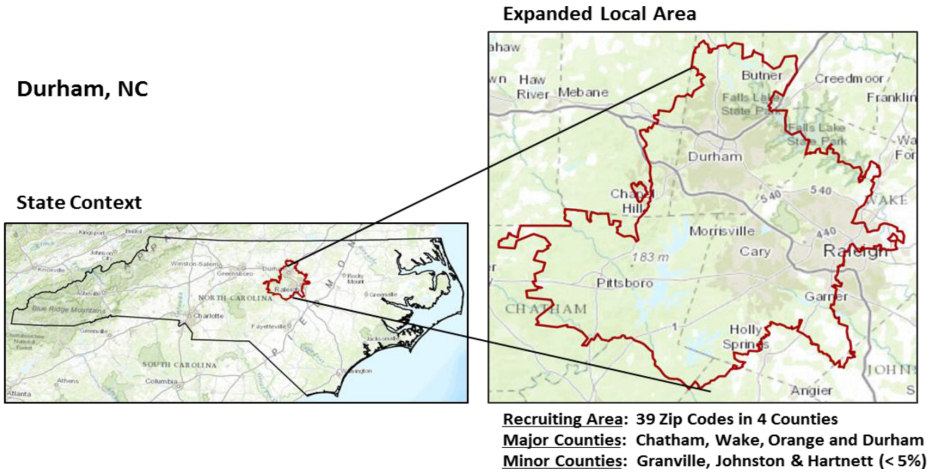
Source: Blatt et al. 2014.

Figure 2.3. Florida recruitment area and expanded view.



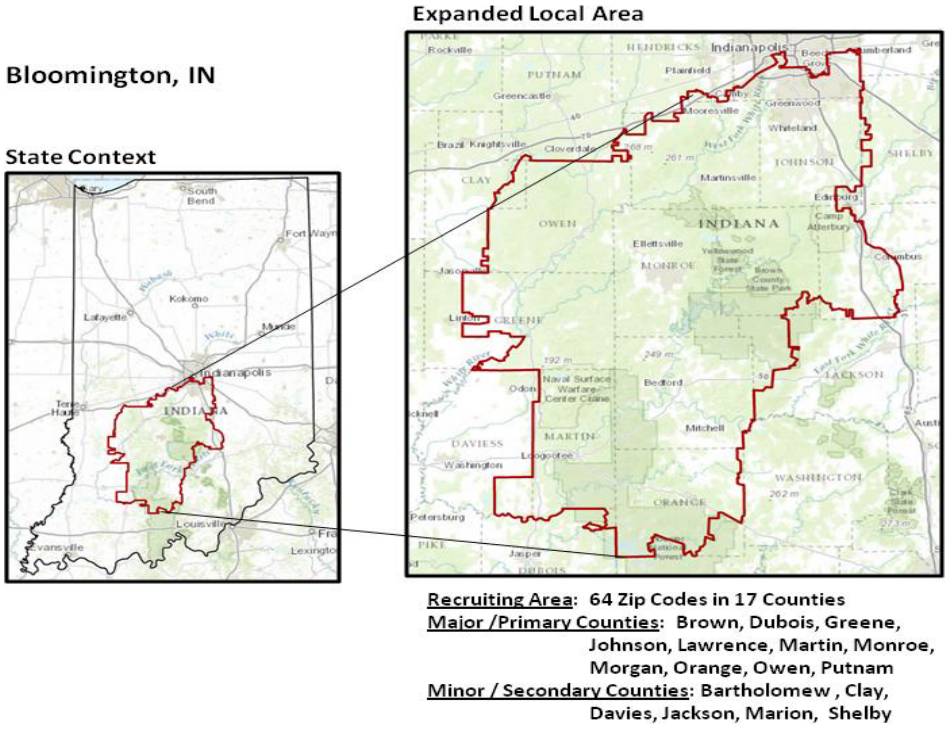
Source: Blatt et al. 2014.

Figure 2.4. Washington recruitment area and expanded view.



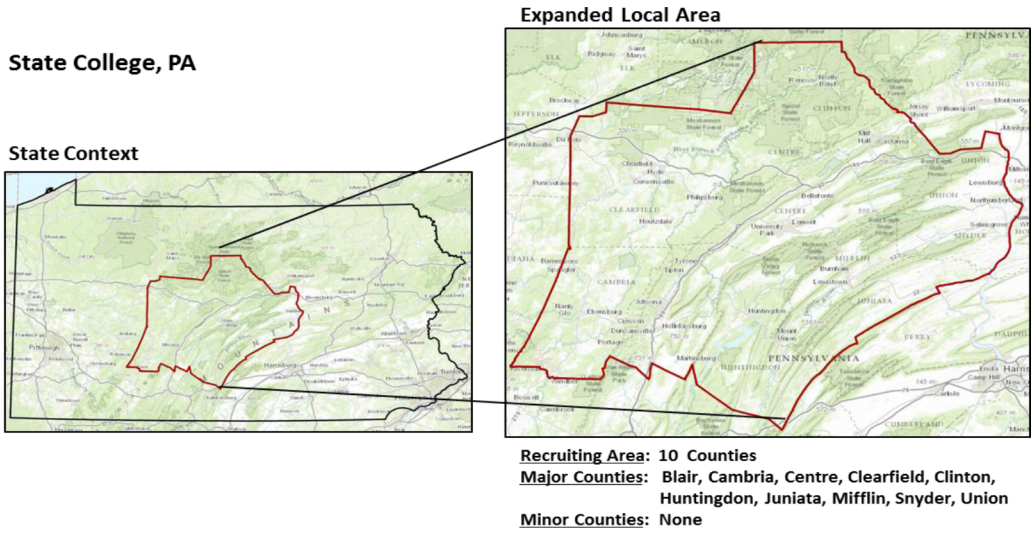
Source: Blatt et al. 2014.

Figure 2.5. North Carolina recruitment area and expanded view.



Source: Blatt et al. 2014.

Figure 2.6. Indiana recruitment area and expanded view.



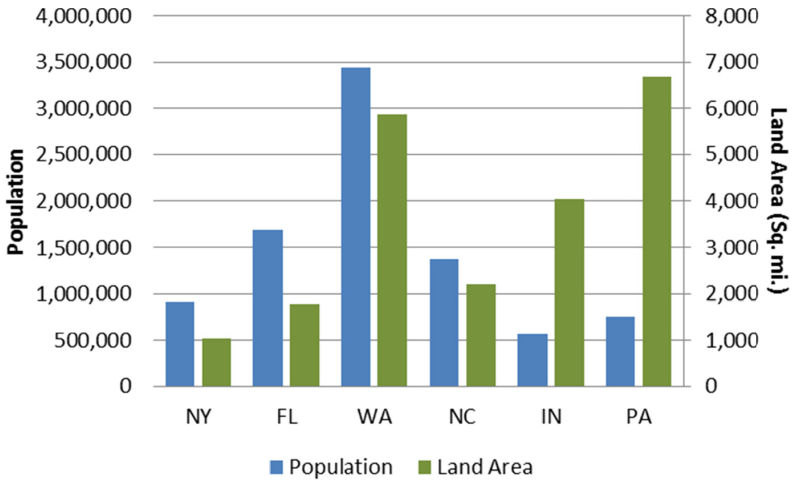
Source: Blatt et al. 2014.

Figure 2.7. Pennsylvania recruitment area and expanded view.

Table 2.1. Population, Land Area, and Population Density of Six Recruitment Site Counties

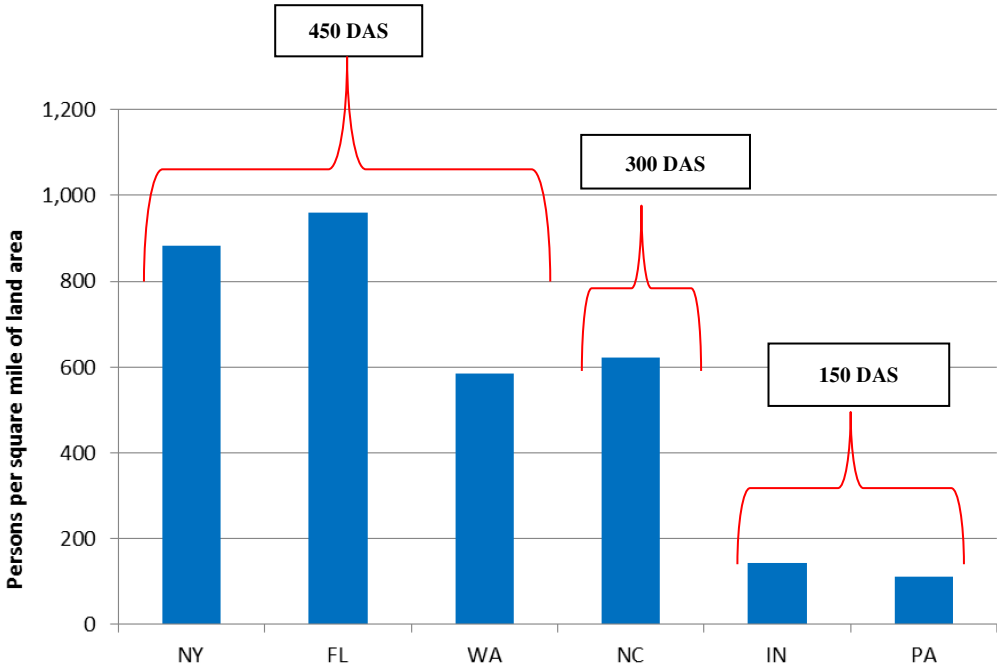
Location of Recruitment Site Counties	Population	Land Area (mi²)	Population Density (persons/mi²)
New York	919,040	1,042.69	881.41
Florida	1,693,923	1,767.10	958.59
Washington	3,439,809	5,872.35	585.76
North Carolina	1,368,273	2,201.35	621.56
Indiana	572,664	4,045.80	141.55
Pennsylvania	747,515	6,678.48	111.93

Source: U.S. Census Bureau 2010b.



Source: U.S. Census Bureau 2010b.

Figure 2.8. Population and land area across recruitment site counties.



Source: U.S. Census Bureau 2010b.

Figure 2.9. Population density across recruitment site counties with nominal number of DAS kits managed at each site.

(continued from page 4)

corresponds to the number of DAS kits allocated to each site. Two of the three sites with the greatest number of kits, New York and Florida, were also the two highest in population density. The other large site, Washington, was just slightly less densely populated than the moderately sized North Carolina site. The two smallest sites in terms of DAS allocations, Indiana and Pennsylvania, were also by far the lowest in population density. According to the 2010 U.S. Census Bureau's listing of urbanized areas, all the primary cities within the areas from which SHRP 2 NDS participants were recruited are designated as urban (U.S. Census Bureau 2010a).

Figures depicting comparisons between study recruitment areas, their respective states, and the nation as a whole include a series labeled "Recruitment Site Counties Weighted by Nominal Site Size." Data in these series are weighted based on each site's size, as determined by the number of DAS kits nominally allocated to that site as outlined in Figure 2.1 and calculated as in Appendix A.

Figure 2.10 shows the population densities of the aggregated recruitment site counties, the aggregated SHRP 2 states, and the United States as a whole. The higher population density of the SHRP 2 recruitment sites, when considered as a weighted aggregate, exceeds both state and national concentrations.

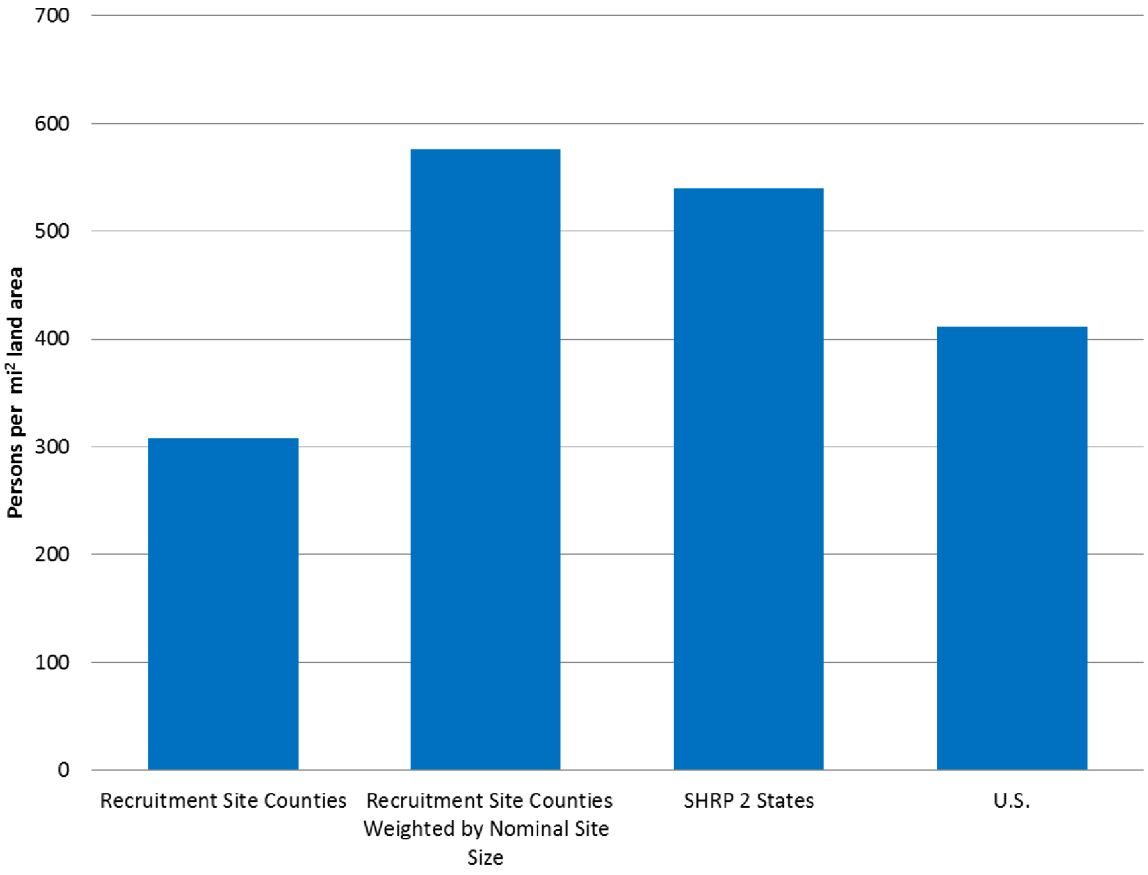
Figure 2.11 shows the data collection sites with their respective latitudes, longitudes, and altitudes.

Table 2.2 shows average January and July temperatures from 1981 through 2010 for each SHRP 2 state.

Figure 2.12 shows average January and July temperatures for all recruitment sites, SHRP 2 states, and the nation from 1981 through 2010. The figure reflects that the recruitment site counties were slightly warmer in January than the SHRP 2 states as a whole, which were in turn slightly warmer than the U.S. average. In contrast, the average July temperatures for these three geographical groupings were nearly identical.

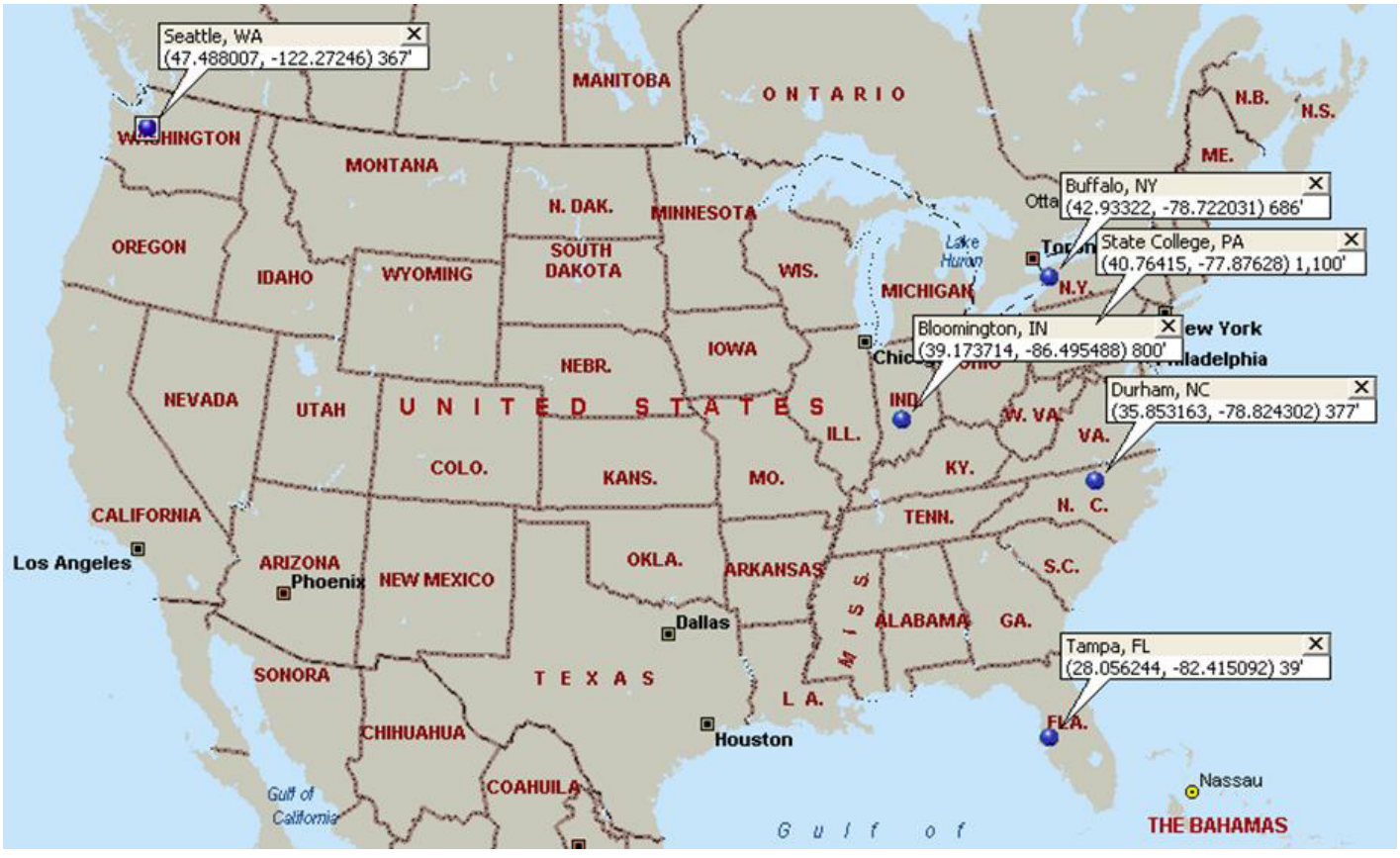
Table 2.3 shows average annual rainfall in inches for the recruitment site counties from 1981 through 2010.

Figure 2.13 shows average rainfall in inches across all recruitment site counties, SHRP 2 states, and the nation as a whole from 1981 through 2010. This figure demonstrates that rainfall amounts were similar for these three geographical groupings, with the recruitment sites and SHRP 2 states receiving somewhat greater amounts of rainfall on average than the nation as a whole.



Source: U.S. Census Bureau 2010b.

Figure 2.10. Population density.



Source: The Weather Channel 2014; Google 2014.

Figure 2.11. Site latitudes, longitudes, and altitudes (in feet above sea level).

Table 2.2. Average January and July Temperatures for Recruitment Site Counties, 1981–2010

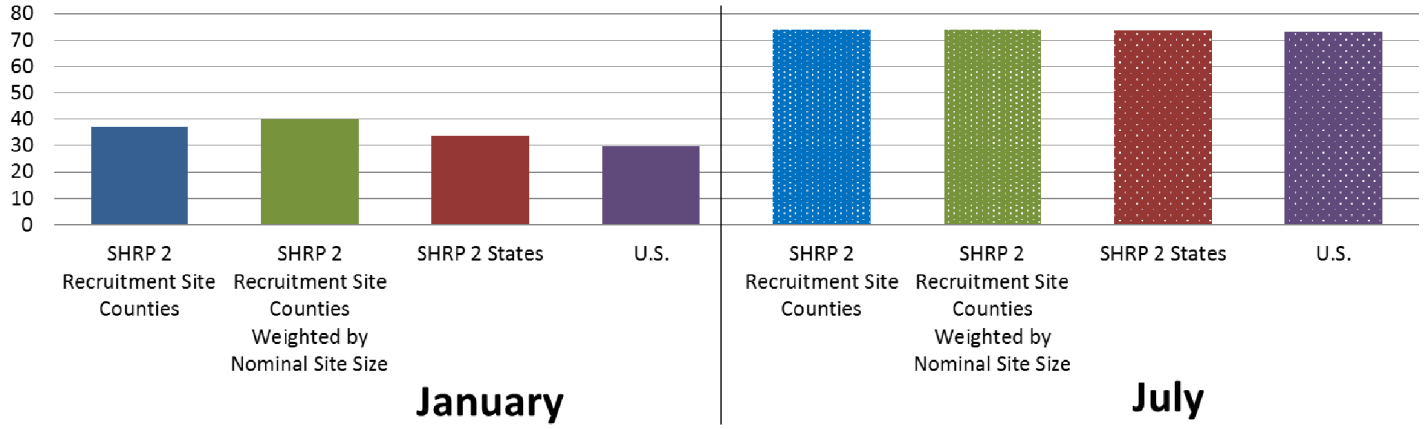
Location of Recruitment Site Counties	Average Temperature (°F)	
	January	July
New York	24.85	71.10
Florida	60.20	82.50
Washington	41.72	64.50
North Carolina	40.34	78.64
Indiana	28.86	74.79
Pennsylvania	26.91	71.66

Source: National Oceanic and Atmospheric Administration 2014.

Table 2.3. Average Annual Rainfall for Recruitment Site Counties, 1981–2010

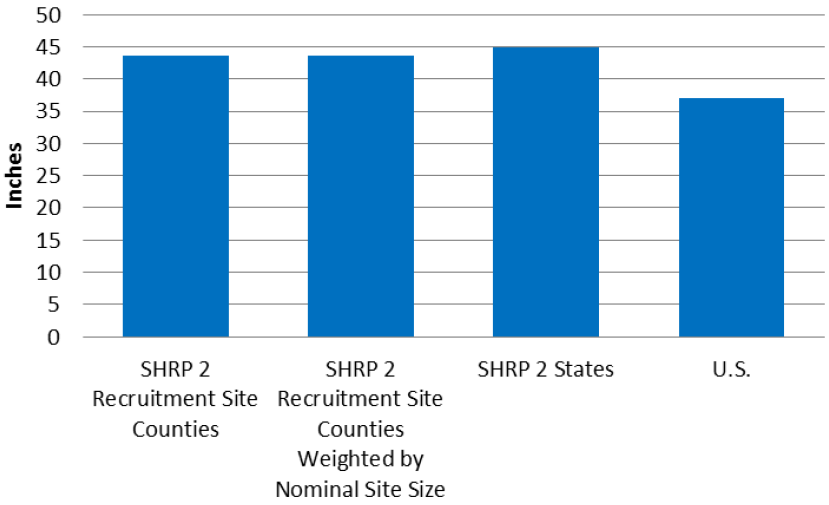
Location of Recruitment Site Counties	Average Annual Rainfall (in.)
New York	40.48
Florida	49.46
Washington	38.85
North Carolina	46.27
Indiana	46.40
Pennsylvania	40.57

Source: National Oceanic and Atmospheric Administration 2014.



Source: National Oceanic and Atmospheric Administration 2014.

Figure 2.12. Average January and July temperatures (°F), 1981–2010.



Source: National Oceanic and Atmospheric Administration 2014.

Figure 2.13. Average annual rainfall.

CHAPTER 3

Participant Sample Design and Operations

The guiding principle of the original SHRP 2 NDS sampling plan was to recruit an equal number of male and female licensed drivers in each of several carefully selected age ranges. These age ranges were designed to sample across the full breadth of the driver age spectrum, oversampling the youngest and oldest segments of the study population. This oversampling was done in light of the elevated crash risk expected for these youngest and eldest of the driving age groups (Stutts et al. 2009) in support of one of the major goals of the study: to observe and learn how best to prevent crash-related events. The original sample design is presented in Table 3.1. A secondary intention of the sample design was to collect data from 350 vehicles featuring any of several advanced vehicle technologies (AVTs), without respect to participant age or gender for those AVT vehicles. Such technologies included crash warning/avoidance technology, integrated communication and infotainment technology, or brake assist applications.

Participant Recruitment and Screening

As reflected in Table 3.1, the initial study design called for drivers of vehicles eligible for inclusion in the study (according to criteria to be elucidated later in this chapter) to enroll for either one or two years. The enrollment period was later made more flexible, allowing participants the opportunity to extend existing enrollment periods beyond their originally planned dates of exit and allowing researchers to enroll new participants for shorter durations of time to maximize use of study equipment and data collection near the end of the study. In addition, as a result of participant attrition for a wide variety of reasons (e.g., moving out of the area, needing to sell the instrumented vehicle), some participants were enrolled for less time than would have been expected based on Table 3.1.

Recruitment

More than 18,000 individuals were recruited (i.e., were contacted using a variety of approaches and agreed to participate in the study), though only 3,100 were fully enrolled. The first recruitment approach, random cold calling to households, was initiated approximately one month in advance of the first anticipated installation in October 2010 and continued until early 2011. This approach was based on guidance from statisticians that a subject pool recruited in this quasi-random fashion would provide the least biased and most representative participant sample. Unfortunately, success rates using this approach were disappointingly low (i.e., on the order of less than 2%), as few people contacted in this way were interested in participating, the nature of a household sample made targeting older and younger drivers problematic, and the vast majority of those who were interested did not have a vehicle that met the initial set of eligibility criteria. In the earliest study stages, vehicle eligibility was based on access to data via the onboard vehicle network (details on this topic are expanded below).

When it became obvious that a purely random cold calling approach would not be suitably efficient, operational efficiency and budgetary constraints dictated implementation of a more focused cold calling approach in which calls were made only to households believed to own an eligible vehicle (based on household data purchased from R. L. Polk & Company and other similar organizations, as well as on customer lists received from some original equipment manufacturers). At the same time, site contractors were authorized to pursue recruitment via convenience methods, including using social media, posting ads in local newspapers or other media, distributing flyers, and making personal appearances at a wide variety of venues. Development of a web-based screening tool allowed interested recruits a convenient and highly efficient means of expressing interest in the study and providing the necessary contact information.

Table 3.1. Original Sample Design

Gender and Age Range	Age Group Description	Period of Enrollment		No. of Participants	DAS Units	Vehicle-Years
		One Year	Two Years			
M 16–17	Minor teen	72	28	172	100	200
M 18–20	Adult teen	72	28	172	100	200
M 21–25	Young adult	72	28	172	100	200
M 26–35	Adult	72	28	172	100	200
M 36–50	Middle adult	72	28	172	100	200
M 51–65	Mature adult	72	28	172	100	200
M 66–75	Younger older adult	72	28	172	100	200
M 76+	Older older adult	72	28	172	100	200
F 16–17	Minor teen	72	28	172	100	200
F 18–20	Adult teen	72	28	172	100	200
F 21–25	Young adult	72	28	172	100	200
F 26–35	Adult	72	28	172	100	200
F 36–50	Middle adult	72	28	172	100	200
F 51–65	Mature adult	72	28	172	100	200
F 66–75	Younger older adult	72	28	172	100	200
F 76+	Older older adult	72	28	172	100	200
Any	AVT	0	350	350	350	700
Total		1,152	798	3,102	1,950	3,900

Note: M = male; F = female.
Source: Dingus et al. 2014.

Figure 3.1 illustrates the overwhelming success of convenience methods as opposed to random or focused calling approaches, particularly among individuals aged 35 and younger. Although at first glance the 16- to 17-year-old subgroup appears to be an exception to this characterization, it is important to note that many of the teen drivers included in the study who identified as coming into the program through the call center did so as additional primary drivers of parents recruited via that method.

Goal-Oriented Recruiting

As the study progressed, recruitment priorities shifted from fulfillment of the original sample design of the number of participants in each age–gender cell toward a more goal-driven approach of number of vehicle-months in each age–gender cell. Midway through the study, targets for recruitment of drivers aged 26 to 65 were reduced, and targets for younger and older drivers were increased to accentuate even further the oversampling already built into the original study design. During the study's final months, if no potential participants were available in undersubscribed age–gender cells, participants in oversubscribed cells were enrolled so that available DAS units would collect additional data rather than sitting on a shelf. Figure 3.2 depicts the number of primary participants enrolled in the study for at least four months relative to the original sample design targets (as represented by the horizontal bar). Figure 3.2 illuminates the success of the study in reaching recruitment targets for most cells. Drivers aged 16 to 17 represent a notable exception, primarily due to parental consent issues and lower driver populations from which to draw relative to other cells.

Concurrent with the shift to a more goal-oriented approach to recruitment was the cessation of targeted recruitment of drivers of AVT-equipped vehicles. Challenges in the recruiting process for drivers of these vehicles were similar to the obstacles confronted in attracting younger and older drivers. Specifically, the random cold calling approach initially implemented, by its nature, made it problematic to target drivers of such vehicles. The focused calling approach pursued later in the study failed

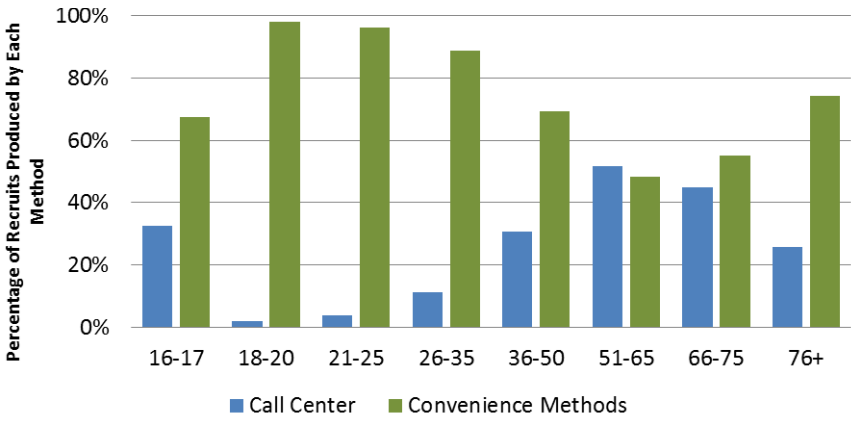


Figure 3.1. Success of call center recruiting versus recruiting via convenience by age group (years).

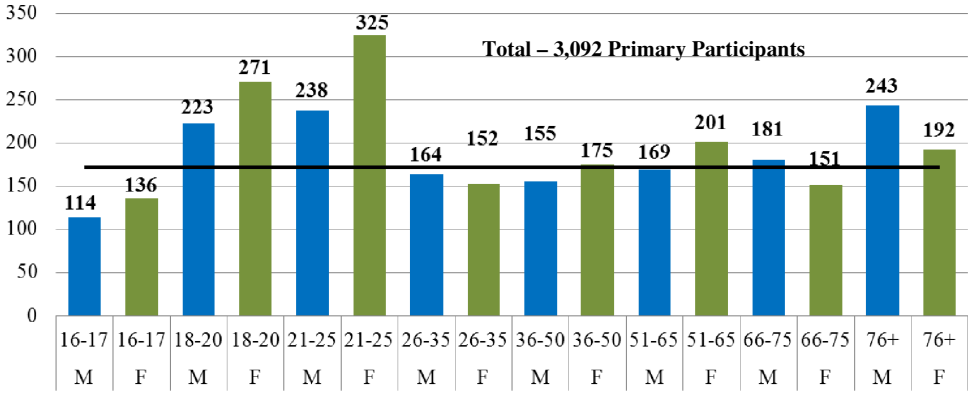
to produce the anticipated number of drivers of AVT vehicles, despite the procurement of household data from R. L. Polk & Co. and customer lists from original equipment manufacturers. In the final analysis, the operational goal of maximizing efficient use of DAS units to collect as much data as possible superseded the original secondary and ultimately unattainable goal of including a substantive AVT subset in the study cohort. A total of 135 vehicles identified as being equipped with AVT were included in the SHRP 2 NDS vehicle fleet. Figure 3.3 presents a breakdown of these vehicles by technology. The discrepancy between the total number of AVT vehicles in the fleet and the numbers presented in Figure 3.3 can be attributed to the presence of multiple AVTs on some vehicles.

Participant and Vehicle Eligibility Screening

In the early stages of the study, a potential participant was required to satisfy the criteria listed below. The first three were basic eligibility criteria, and the other two criteria were established in the interest of operational efficiency:

1. Is a licensed driver;
2. Is competent to grant informed consent (or for minors, informed assent with consent granted by a parent or guardian);
3. Has an eligible vehicle (the list of eligible vehicles grew as the study progressed);
4. Drives at least three days per week; and
5. Plans to keep the vehicle for the duration of anticipated study participation (i.e., one or two years for most participants).

Participants were initially required to own a vehicle for which the coordination contractor had acquired parameter IDs, which were needed to interpret the data generated by the vehicle's onboard network (the third criterion above). Later



Source: Dingus et al. 2014.

Figure 3.2. Primary participants enrolled in NDS for at least four months relative to original sample design goals. (Blue = male; green = female.)

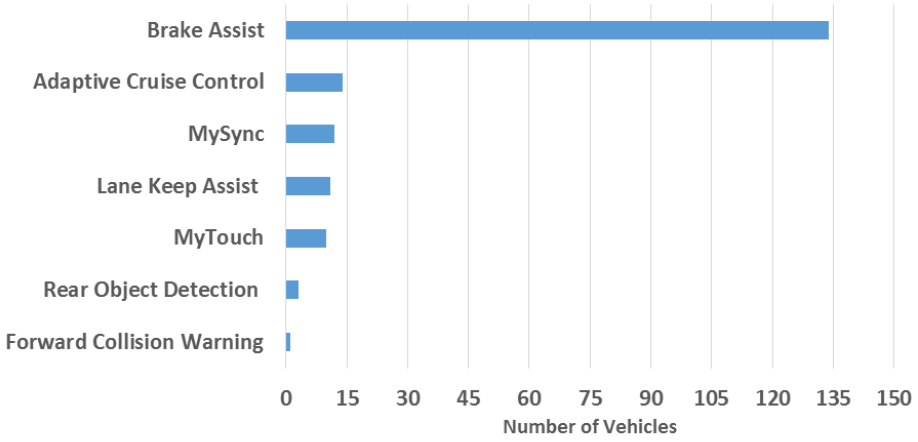


Figure 3.3. AVT vehicles by technology.

in the study, vehicle eligibility criteria were expanded to permit a greater proportion of recruits to become actual study participants. In particular, the addition of older model years attracted more drivers in the younger age groups. The resulting expansion of the vehicle fleet to include some newly manufactured model years, as well as older vehicle-years, for both of which a less robust set of vehicle network data was available, produced four distinct vehicle classes in terms of the collection of vehicle network data. These vehicle classes are presented in descending order of data richness in Table 3.2.

A set of guiding principles was used to shape ongoing recruitment strategy and installation priorities. These goals focused on allocating recruitment, inventory, and human resources in a manner aimed at increasing the number and time-in-study of participants in the 16 to 25 and 76+ age groups, with males being prioritized over females in each age group due to their higher relative risk (NHTSA 2012). Further, site contractors were asked to prioritize, whenever possible, the installation of participants with vehicles in classes that maximized data richness. These principles continued to steer recruitment and installation until the final months of the installation period, when the goal of maximizing use of DAS equipment to collect study data became paramount.

The transition from cold calling to a more goal-oriented approach, the cessation of targeted recruiting in the AVT sector of the study cohort, and the adjustment of eligibility criteria to produce a sample more inclusive of the primary populations of interest (i.e., younger and older drivers) are illustrative of the manner in which real-world considerations intersected with study design. Any assessment of the degree to which the resulting sample compares to the target population must take such necessary fine-tuning into account.

Table 3.2. SHRP 2 NDS Vehicle Classes

Class	Vehicles Included	Vehicle Network Information Collected	Vehicle Count	Percentage of Fleet
Prime	Vehicles for which parameter IDs were available and included on the original eligible vehicle list.	Speed, plus wiper activation, brake actuation, headlight activation, turn signal activation, and steering data, as available	1,717	51%
Subprime	Generally, vehicles manufactured after 2009 for which parameter IDs were not available.	Speed and accelerator position	488	14%
Legacy	Vehicles manufactured between 1996 and 2008.	Speed and accelerator position	736	22%
Basic	Vehicles manufactured prior to 1996; no vehicle network.	None	421	13%
All			3,362	100%

Source: Dingus et al. 2014.

CHAPTER 4

Data Comparisons

Chapter 3 documents how the SHRP 2 NDS data came from a convenience sample of drivers. Analysts using the data must keep this sampling method firmly in mind. Analysis methods must account for the extent to which the aggregated SHRP 2 data differ substantially from the national distribution of characteristics that influence the subject being analyzed. For example, if driver age is important to the analysis, then the analyst must account for the fact that the SHRP 2 data contain a relatively greater proportion of younger and older drivers than the national driver population. As a first step, the SHRP 2 data could be weighted to match the national driver age distribution, as illustrated in this chapter.

This chapter compares a variety of SHRP 2 data elements with local and national distributions on key driver, vehicle, and crash variables. These comparisons should help data users understand some of the biases in the aggregated SHRP 2 data.

Participant Characteristics

This section describes the SHRP 2 sample in terms of a variety of participant and socioeconomic factors: age, race, ethnicity, household income, employment/work status, marital status, and education level. The SHRP 2 sample on these factors is compared with individuals living within the SHRP 2 recruitment counties, the SHRP 2 states, and the nation as a whole. The comparisons include a series labeled "SHRP 2 Sample Weighted According to Age/Gender" that was derived by weighting the SHRP 2 data according to the distribution of licensed drivers across the United States, as presented in Figure 4.1 and more explicitly defined in Appendix A. The series labeled "SHRP 2 Recruitment Site Counties Weighted by Nominal Site Size" is derived according to the method described in Appendix A.

The gender distribution in the study compares favorably with that of the U.S. driving population in 2012: 0.48 male in SHRP 2 compared with 0.50 male in the U.S. driving population (FHWA 2014).

The distribution of participants across age groups is compared with the U.S. driving population in 2012 (the latest full year of data collection in the SHRP 2 NDS) in Figure 4.1. As noted in the sampling discussion, participants in the youngest and oldest age groups were intentionally oversampled to capture the best information possible for those individuals with an elevated crash risk.

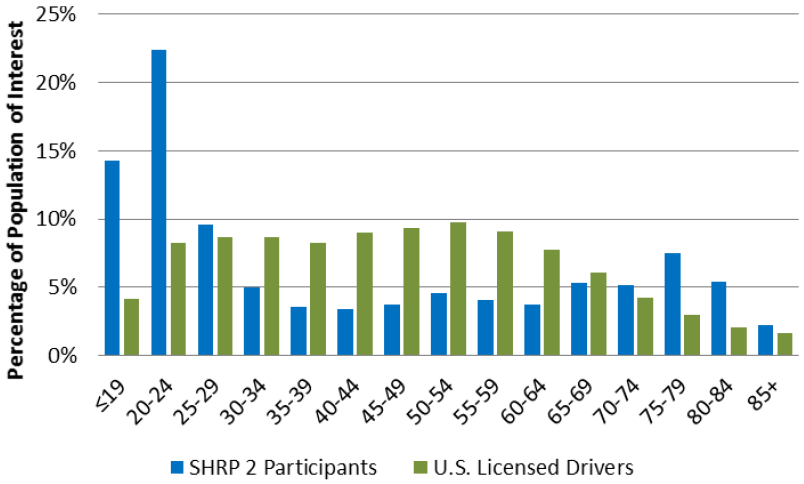
Table 4.1 shows the percentage of the SHRP 2 participant pool self-identifying as Hispanic across the data collection sites. (The U.S. Census Bureau recognizes only two ethnicities: Hispanic and non-Hispanic.)

Figure 4.2 shows the percentage of Hispanic participants in the SHRP 2 sample compared with the aggregate of the recruitment areas, the SHRP 2 states aggregated, and the nation. The figure shows that the SHRP 2 sample was notably less Hispanic than would have been expected within the recruitment areas, the SHRP 2 states, and the nation at large. In fact, nationally the Hispanic percentage of the population is on the order of four times that of the SHRP 2 sample.

Figure 4.3 compares the racial distribution of the SHRP 2 sample with that of the SHRP 2 recruitment sites, the SHRP 2 states, and the nation. All are generally very similar, with the SHRP 2 sample including a notably greater proportion of individuals who identify themselves as white and, in turn, a notably smaller proportion who identify themselves as black or African-American. Respondents to the 2010 U.S. Census identified either as single race (97%) or multirace (3%). For the purposes of this representation, the two groups have been combined with the designation indicating the predominant race identified for multiracial respondents.

Socioeconomic Factors

Figure 4.4 shows participant responses indicating annual household income. The majority of the SHRP 2 sample (56%) had an annual household income lower than the average household income of each of the following comparison groups: the



Source: Dingus et al. 2014.

Figure 4.1. SHRP 2 participant versus U.S. driving population percentages by age group (years).

aggregated geographic areas from which the sample was drawn ($63,419), data collection sites weighted according to nominal DAS allocation ($65,384), and the national average ($70,883).

Figure 4.5 shows the work status of the SHRP 2 sample. To achieve consistency with Census data, students are included in the employed population. A majority of SHRP 2 participants were employed in some capacity. Further, many participants who self-identified as not working outside the home were found on deeper analysis to be engaged in gainful labor on a full-time or part-time basis.

Figure 4.6 shows the percentage of the SHRP 2 sample employed compared with the aggregate of the recruitment areas, the SHRP 2 states aggregated, and the nation. Consistent with Census data, the percentage of the SHRP 2 sample identified as employed comprises those identifying as employed full time or part time and as students. Due to lack of availability of Census data on individuals aged 65 and older and in the interest of providing a meaningful comparison between the study sample and the Census data, only data from study participants between the ages of 16 and 64 are presented in Figure 4.6. Although the percentages are all very similar, the employed percentage of the SHRP 2 sample was slightly greater than in the comparison areas.

Figure 4.7 shows the percentage of the SHRP 2 sample employed full time compared with the aggregate of the recruitment areas, the SHRP 2 states aggregated, and the nation. Due to lack of availability of Census data on individuals aged 65 and older and in the interest of providing a meaningful comparison between study sample and Census data, only data from study participants between the ages of 16 and 64 are presented in Figure 4.7. Approximately 60% of SHRP 2 participants aged 16 to 64 were employed full time, but the percentage was lower (40%) when the entire sample was considered, as is the case in Figure 4.5. The percentages associated with the comparison data are all nearly identical.

Figure 4.8 shows the marital status of the SHRP 2 sample.

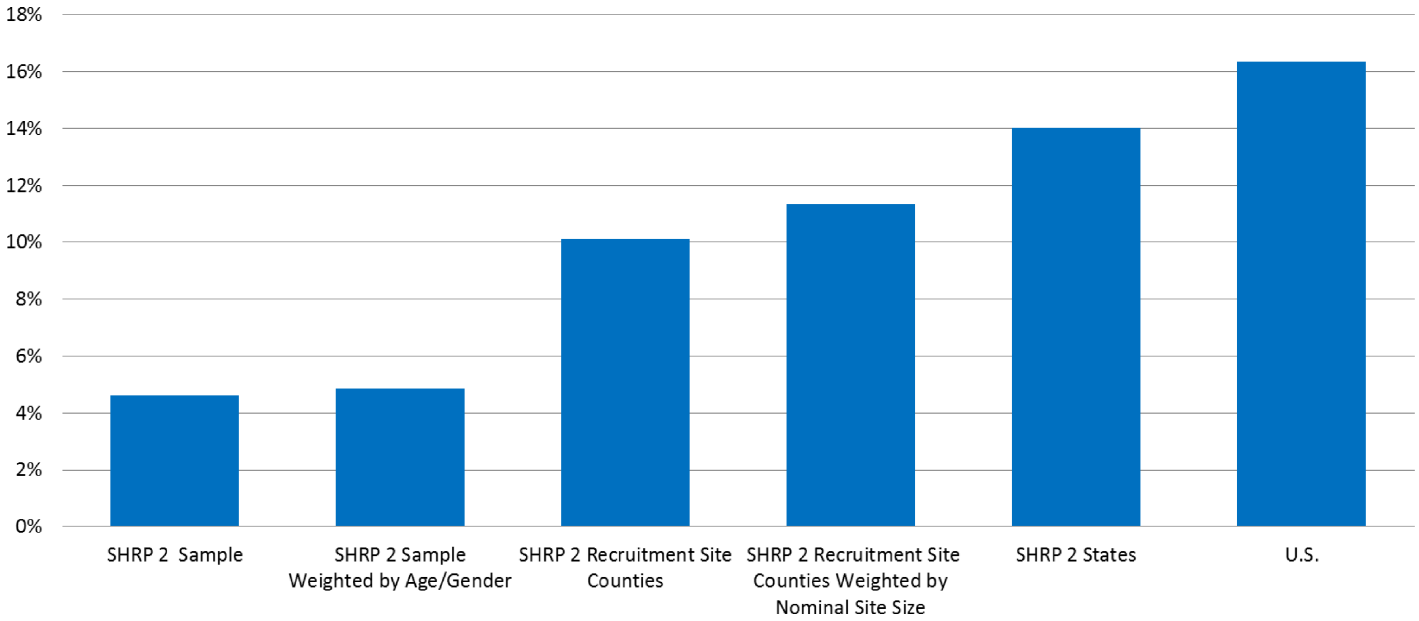
Figure 4.9 compares the two largest groups from Figure 4.8, single and married, with the aggregate of the recruitment areas, the SHRP 2 states aggregated, and the nation. Although the percentages are nearly identical for the comparison areas, the SHRP 2 sample has a notably higher percentage of single and a notably lower percentage of married individuals relative to the comparison data.

Figure 4.10 shows the level of education attained by the SHRP 2 sample compared with that of the aggregate of the recruitment areas, the SHRP 2 states aggregated, and the nation. In the interest of accurate comparison with the 2010 Census, which only includes respondents aged 25 and older in its representation of educational attainment, only participants

(text continues on page 22)

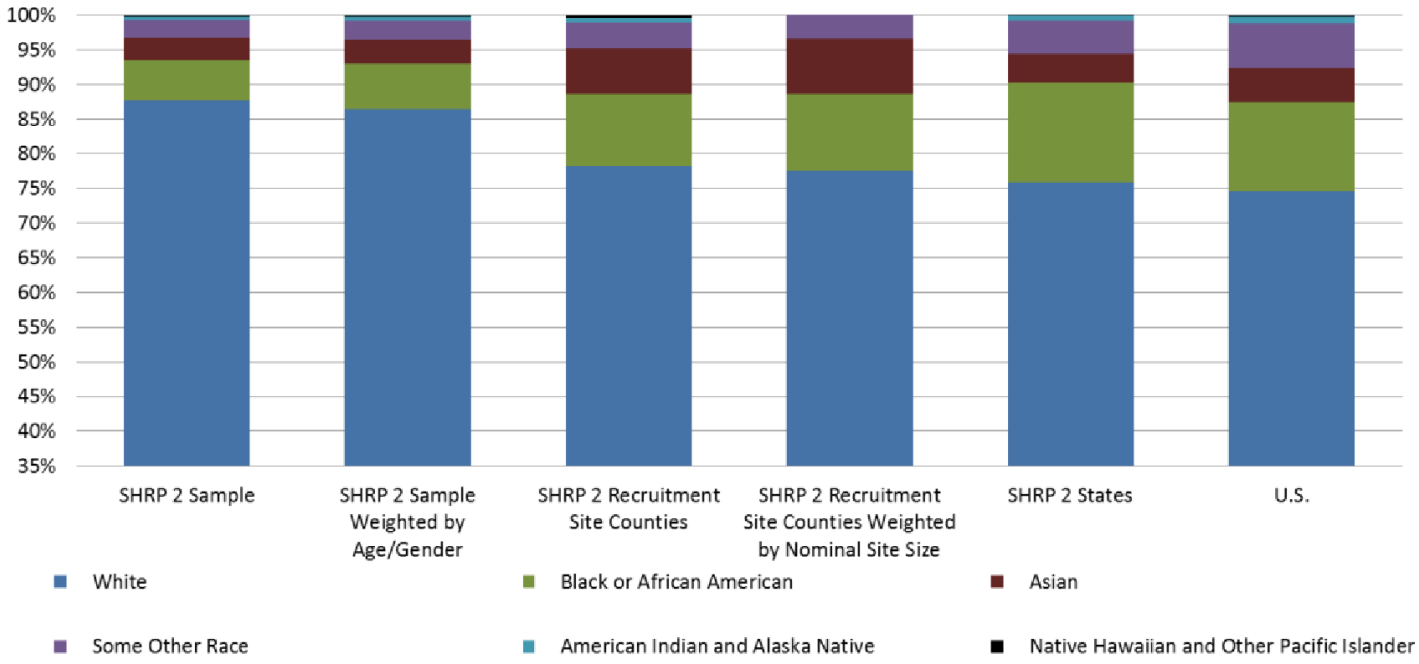
Table 4.1. Characterization of SHRP 2 NDS Sample by Ethnicity

SHRP 2 Sample by Site	Percentage Hispanic
New York	2%
Florida	12%
Washington	4%
North Carolina	2%
Indiana	2%
Pennsylvania	1%



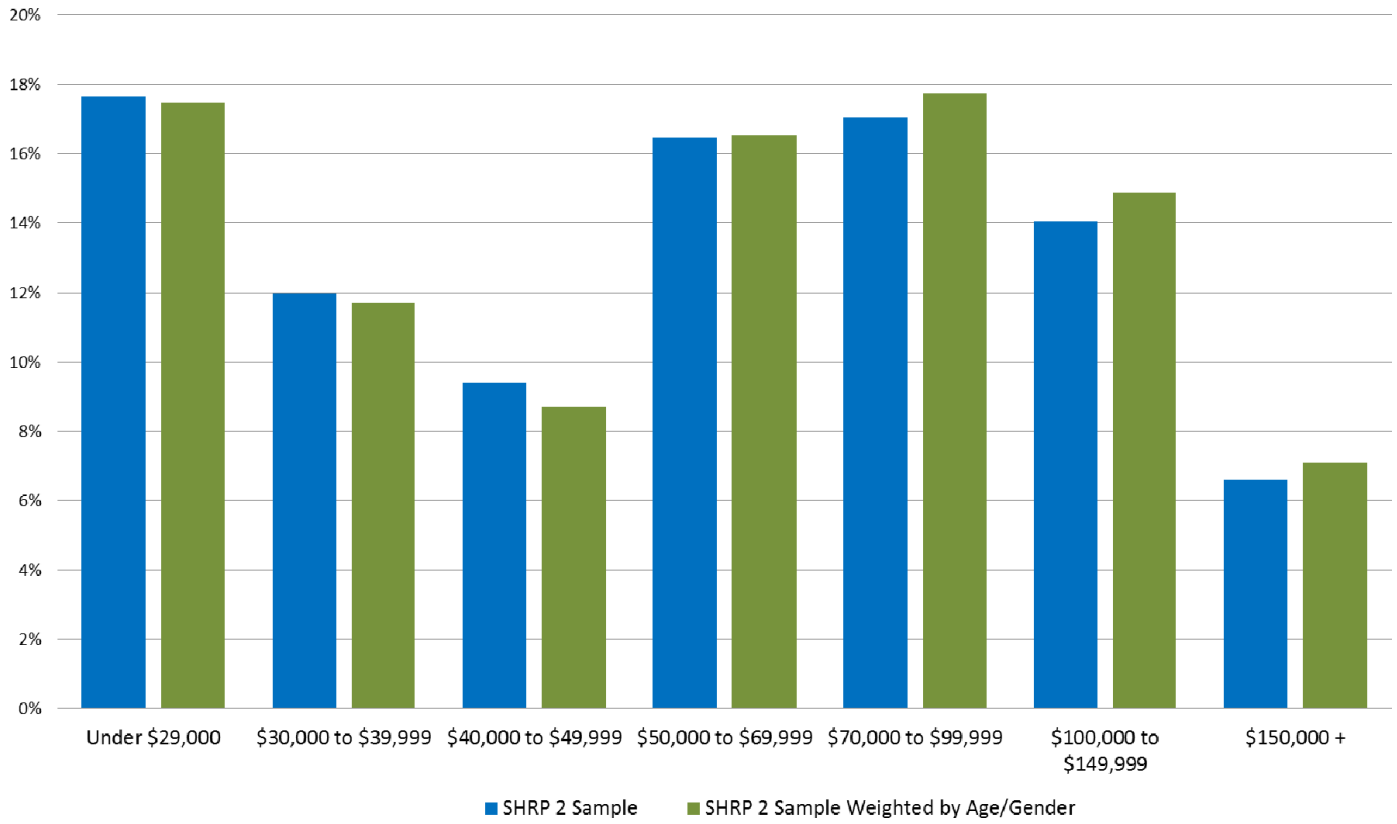
Source: U.S. Census Bureau 2010d.

Figure 4.2. Percentage of Hispanic participants in SHRP 2 compared with the U.S. population.



Source: U.S. Census Bureau 2010e.

Figure 4.3. Racial distribution of SHRP 2 participants compared with the U.S. population.



Source: U.S. Census Bureau 2010f.

Figure 4.4. Annual household income of SHRP 2 sample and mean annual household income of relevant populations.

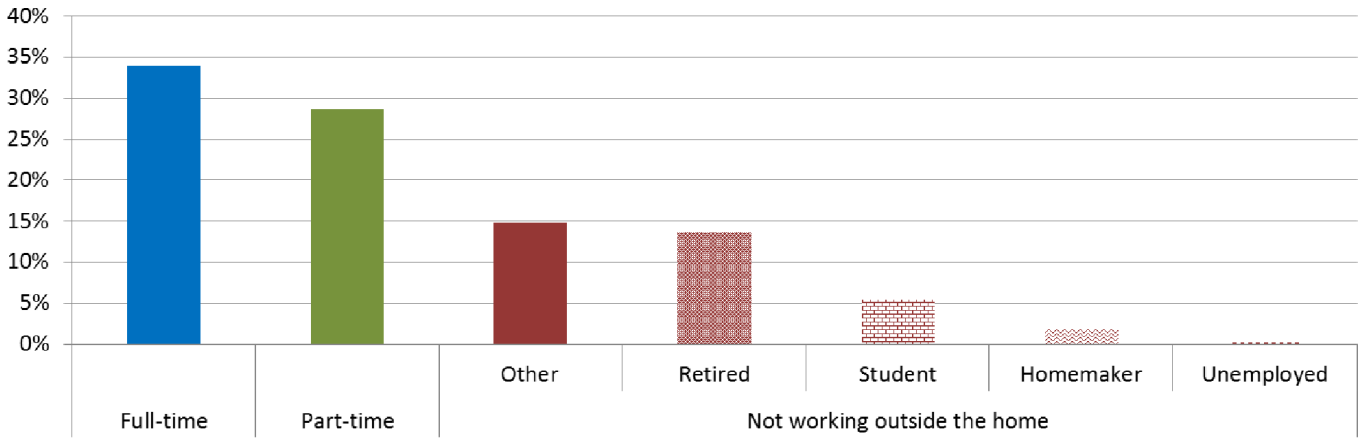
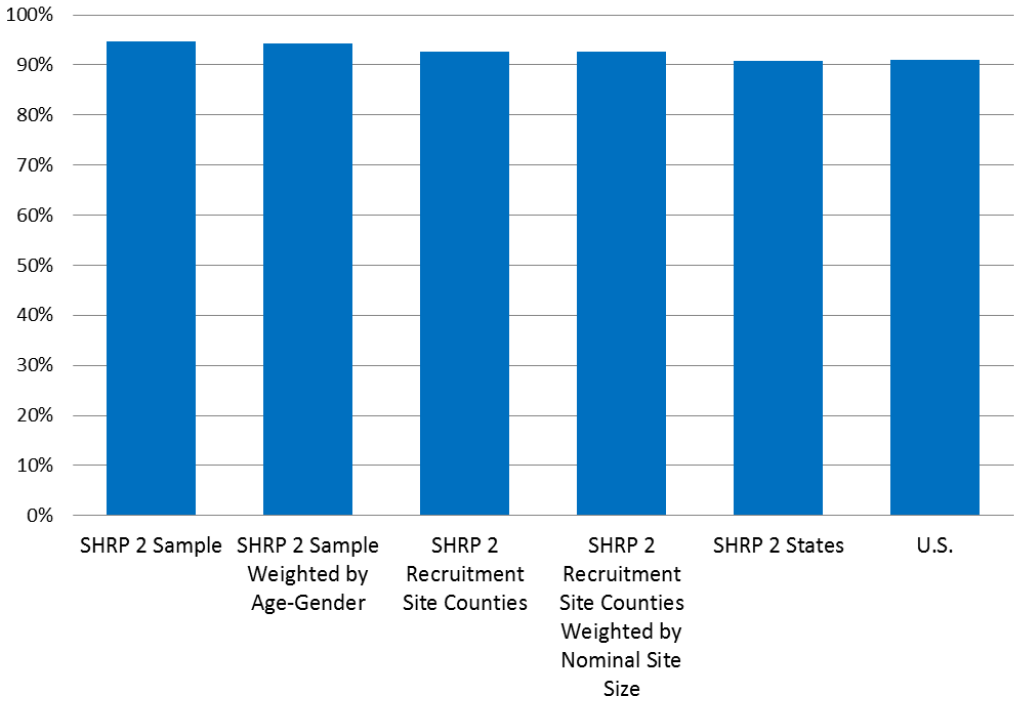


Figure 4.5. SHRP 2 sample work status.



Source: U.S. Census Bureau 2010h.

Figure 4.6. Percentage of employed SHRP 2 participants compared with the U.S. population.

Source: U.S. Census Bureau 2010h.

Figure 4.7. Percentage of SHRP 2 participants employed full time compared with the U.S. population.

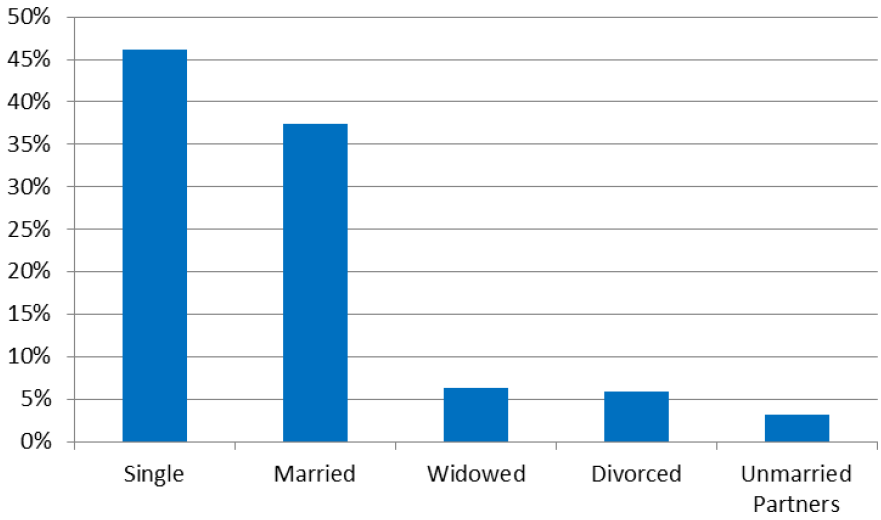


Figure 4.8. SHRP 2 sample marital status.

Source: U.S. Census Bureau 2010g.

Figure 4.9. Percentage of single and married SHRP 2 participants compared with the U.S. population.

Source: U.S. Census Bureau 2010g.

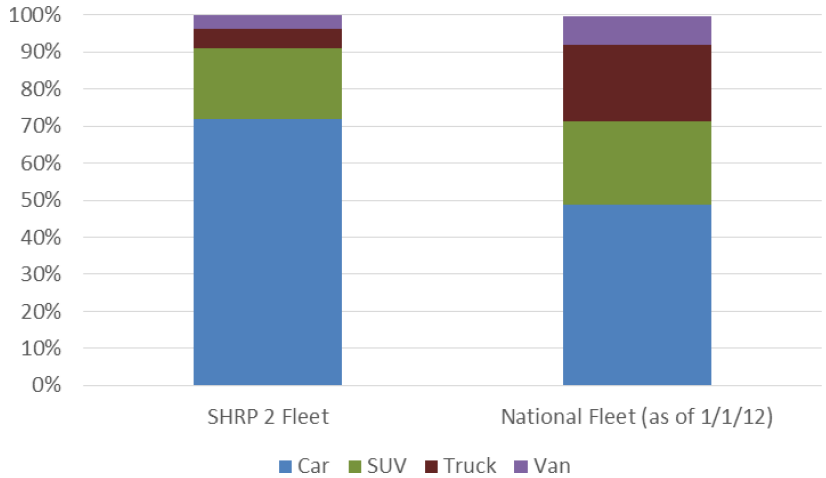
Figure 4.10. Education level of SHRP 2 participants compared with the U.S. population.

(continued from page 17)

aged 25 and older in the SHRP 2 sample are included in Figure 4.10. SHRP 2 participants who did not respond to the question are excluded. The SHRP 2 sample seems relatively well-educated, with a greater percentage holding a college degree than in the SHRP 2 states or the nation.

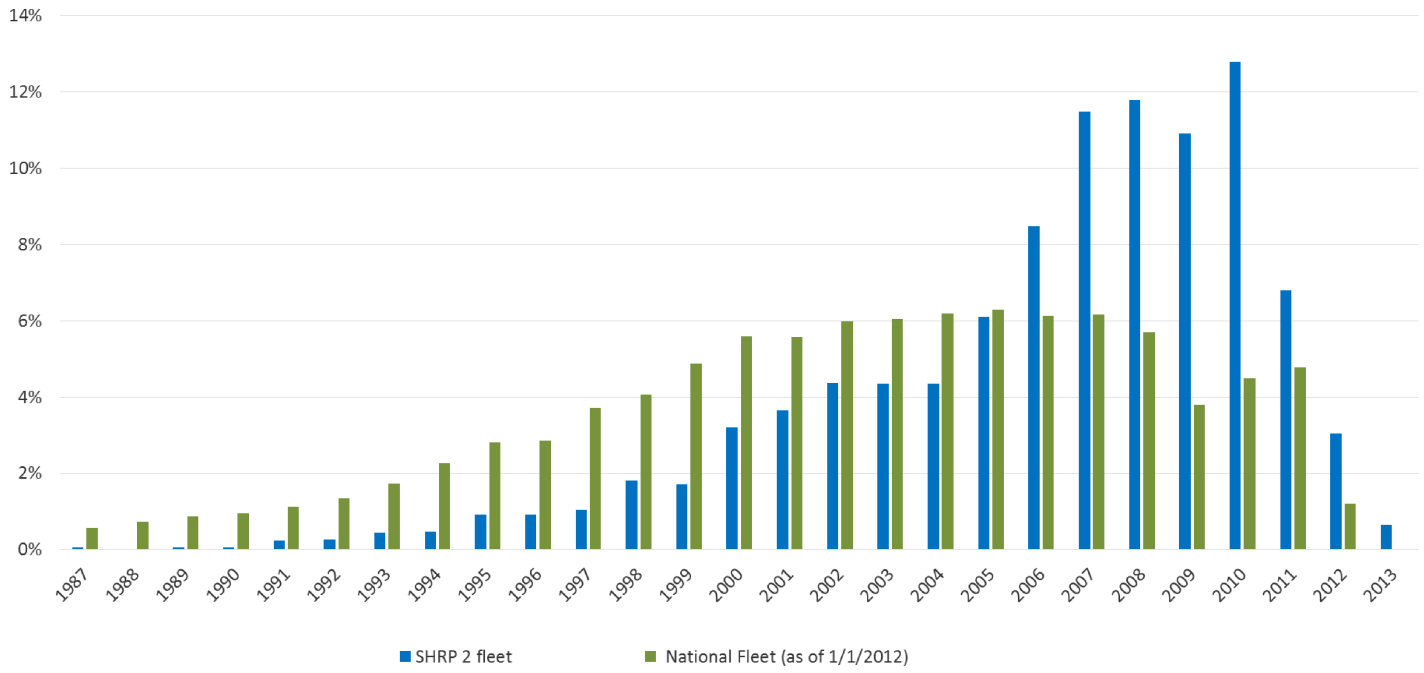
Vehicle Fleet Composition

The SHRP 2 fleet sample was compared with that of the U.S. fleet based on a snapshot of the latter taken as of January 1, 2012. The two fleets were compared in terms of type (Figure 4.11), model year (Figure 4.12), and make (Figure 4.13). The SHRP 2 fleet included cars, trucks, SUVs/crossovers, and vans, with cars being the dominant vehicle type. This distribution contrasts with the national light vehicle fleet, which, as of January 1, 2012, featured a nearly even split between cars and the other three vehicle types combined. The model years of the vehicles included in the SHRP 2 fleet ranged from 1987 to 2013. These model years made up over 95% of the total U.S. fleet on January 1, 2012. Figure 4.12 illustrates a somewhat similar pattern to the U.S. fleet over the model years from 1987 to 2005, but the SHRP 2 fleet starts to spike in model year 2006 due to the study's strong recruitment preference for these and other



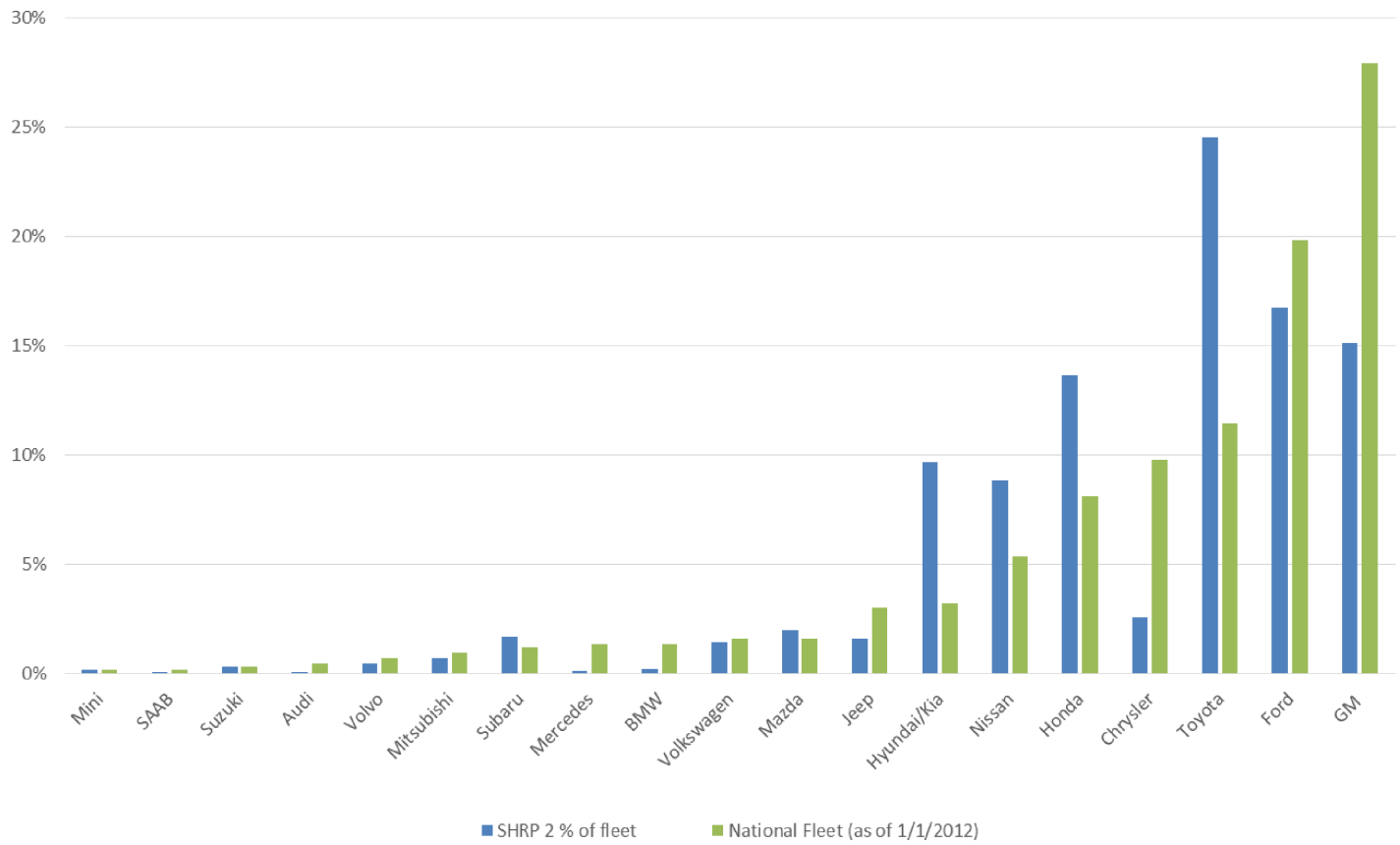
Source: R. L. Polk & Co., personal communication, 2014.

Figure 4.11. Comparison of SHRP 2 fleet with U.S. light vehicle fleet by vehicle type.



Source: R. L. Polk & Co., personal communication, 2014.

Figure 4.12. SHRP 2 vehicle fleet versus U.S. fleet by vehicle model year.



Source: R. L. Polk & Co., personal communication, 2014.

Figure 4.13. SHRP 2 vehicle fleet versus U.S. fleet by vehicle make.

later-model vehicles due to the generally greater accessibility to network data in these model years. Interestingly, both graphs show a dip for model year 2009, possibly due to the effects of the globally depressed auto industry during that model year's sales period.

The 19 vehicle makes included in the SHRP 2 NDS accounted for almost 98.5% of the U.S. fleet as of January 1, 2012. Further, the top 17 makes in the SHRP 2 study were also the top 17 makes in the national fleet as of that same date. Note that in the data represented in Figure 4.13, certain makes have been logically grouped based on close affiliation, so Ford, Lincoln, and Mercury are all grouped together simply as Ford. Similarly, all GM brands with fundamentally similar vehicles (e.g., Chevrolet, Buick, and Cadillac) have been grouped together under the GM umbrella. However, when one manufacturer owns another, but each continues to produce fundamentally different sets of vehicles, no attempt was made to group them together. For instance, even though Ford Motor Co. owned Volvo's Car Division from 1999 to 2010, these are still counted and listed as two distinct original equipment manufacturers in this report. Figure 4.13 shows that although the same seven makes make up the top percentages in both the SHRP 2 and national fleets, the relative proportions of these seven differ.

There are 275 unique make–model combinations represented in the SHRP 2 data and 1,505 in the national fleet as of January 1, 2012. There is a moderate and highly significant correlation between the ranks of the top 100 SHRP 2 make–model combinations and their corresponding national ranking ($r = .4854$, $p < .0001$). Notably, each of the top seven make–model combinations in the SHRP 2 data are within the top 20 nationally with one exception: the Toyota Prius. It ranked second in SHRP 2, comprising 5.62% of the sample fleet, compared with a national ranking of 63rd, comprising only 0.42% of the national fleet. Due to the overrepresentation of the Toyota Prius among the early participants, a moratorium was established as of June 1, 2012, on further recruitment or instrumentation of this model vehicle.

Crash Rates

Preceding sections of this report describe and compare the characteristics of study participants, their vehicles, and the geographical areas in which the study was primarily conducted with appropriate reference data sets. In contrast, this section compares actual SHRP 2 NDS data to external and comparable sources of information on crashes.

Crashes in the SHRP 2 NDS were classified based on level of severity using the following schema:

- **Level I:** airbag deployment, injury, rollover, high delta-V crashes (virtually all Level I crashes would be police-reported [PR] crashes);
- **Level II:** police-reportable crashes (including PR crashes, as well as other crashes of similar severity that were not reported);
- **Level III:** crashes involving physical contact with another object; and
- **Level IV:** tire strike; low-risk crashes.

The nature of the NDS data collection methods meant that crashes were not always immediately identified by the research team. In fact, a few crashes may continue to be identified during subsequent data reduction and analysis activities months, and sometimes even years, after data collection. Available counts as of June 30, 2014, for SHRP 2 crashes are used in the tables and figures that follow. Figure 4.14 illustrates the number of crashes observed in the SHRP 2 NDS by severity level.

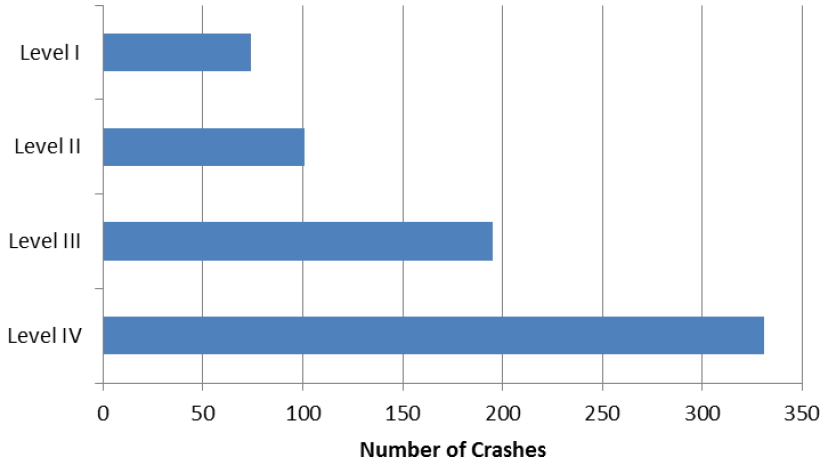


Figure 4.14. SHRP 2 crashes by severity level (confirmed crash evaluations as of June 30, 2014).

Table 4.2. Basic Crash Severity Level Data Across Sites (as of June 30, 2014)

Crash Severity Level	New York	Florida	Washington	North Carolina	Indiana	Pennsylvania	Total
I	15	18	19	16	5	1	74
II	27	25	24	10	8	7	101
III	36	56	36	33	23	11	195
IV	57	108	82	47	20	17	331
Total	135	207	161	106	56	36	701

The number of crashes increased as the crash severity level decreased.

The data represented in Figure 4.14 are shown by data collection site in Table 4.2.

Any publicly available source of data on vehicle crashes deals strictly with PR crashes—obviously, if a crash was never reported to the police, it would be virtually impossible for it to have been counted or otherwise recorded in any formal data collection. This lack of reporting makes data comparisons between public data sources and the SHRP 2 crash database problematic, because it is not always completely clear in the SHRP 2 data set whether a particular crash was reported to the police. If there is a police accident report, then that is an obvious and definitive indication of a PR crash. But if the site contractor indicated that a police report was not filed, then that crash would be counted definitively as not having been reported to the police. However, there are crashes for which it is simply not clear whether the crash was reported to the police. A crash was considered *possibly* police reported (PPR) if it was known to have been reported or if any of the following took place:

- Notable injury;
- Air bag deployment;
- Vehicle rollover;
- Significant property damage;
- Vehicle towed;
- Delta-V of greater than 20 mph or an acceleration on any axis greater than 1.3 g (excluding curb strikes);
- Large animal strike; or
- Sign or roadway furniture strike.

As of July 2014, there were 74 PR crashes (i.e., crashes that had been positively confirmed as having been reported to the police) and a possible total of 224 PPR crashes (i.e., crashes that may or may not have been reported to the police) in the SHRP 2 NDS. To be truly meaningful and comparable across data sets, raw crash numbers must be expressed as rates (e.g., per person, data-year, or miles driven). The comparisons drawn in this instance are PR and PPR crashes per data-year identified through July 2014 in the SHRP 2 data set compared with crashes per licensed driver for a single year from existing data sources. That is, each licensed driver ostensibly contributed one data-year per year, making this a valid comparison. Of course, not everyone listed as a licensed driver in 2012 actually contributed a full year of driving data, as newly licensed drivers could have received their licenses at any point during the year. Similarly, other drivers may have ceased driving for any reason during the year. However, it is also assumed these partial data-year contributors are a small minority. For instance, even if all drivers younger than 20 years of age (approximately 4% of the total) were excluded, presumably the vast majority of even this age group would have still contributed full data-years. Therefore, the overall point estimate for crash rate is considered to be sufficiently accurate for comparison purposes. Table 4.3 and Table 4.4 present 2012 national crash data and data from the SHRP 2 NDS, respectively.

The overall comparison between the crash rates observed in the SHRP 2 data set and the national rate (in 2012) is illustrated in Figure 4.15.

Figure 4.15 shows that the crash rates observed in the SHRP 2 NDS are clearly in the same order of magnitude as the national rate in 2012, with the U.S. rate situated between the low (known PR) and high (PPR) SHRP 2 point estimates. The low SHRP 2 point estimate of the PR crash rate is around 70% of the U.S. rate in 2012; the high SHRP 2

Table 4.3. U.S. Crash Data, 2012

PR crashes	5,615,000[a]
No. of licensed drivers	211,814,830[b]
Crash rate per 1,000 licensed drivers	26.5

[a] NHTSA 2014b.
[b] Federal Highway Administration 2013.

Table 4.4. SHRP 2 NDS Confirmed (PR) and Possible (PPR) Crashes

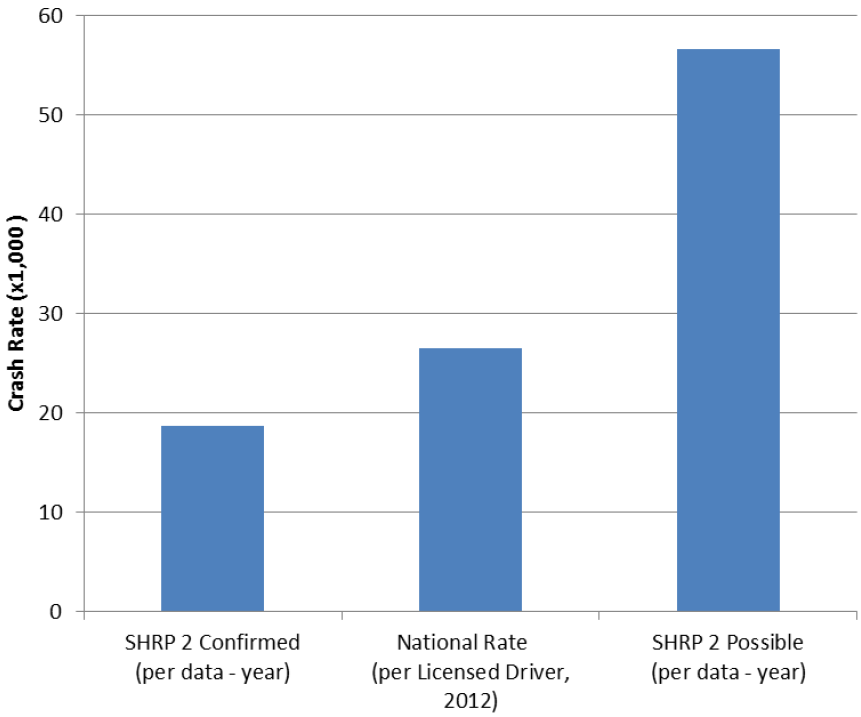
	New York	Florida	Washington	North Carolina	Indiana	Pennsylvania	Total
NDS data-years	878	905	851	660	345	318	3,957
Minimum NDS PR crashes	8	12	25	15	8	6	74
Maximum NDS PPR crashes	48	55	60	31	15	15	224

PPR crash rate point estimate is around twice that of the U.S. rate in 2012.

Figure 4.16 compares the PR and PPR crash rates observed in the SHRP 2 data set with national crash data across age groups. In one NDS series, only those SHRP 2 crashes confirmed as being PR are shown; in the second NDS series, all PPR crashes in the SHRP 2 data set are shown. The national crash data are represented by vehicle crash involvement rates (i.e., vehicles involved in crashes per vehicle-year of exposure). The SHRP 2 crash rates may underestimate national rates as unlicensed drivers were excluded from participation. NHTSA (2014a) noted that 19% of fatal crashes in 2012 involved at least one unlicensed driver.

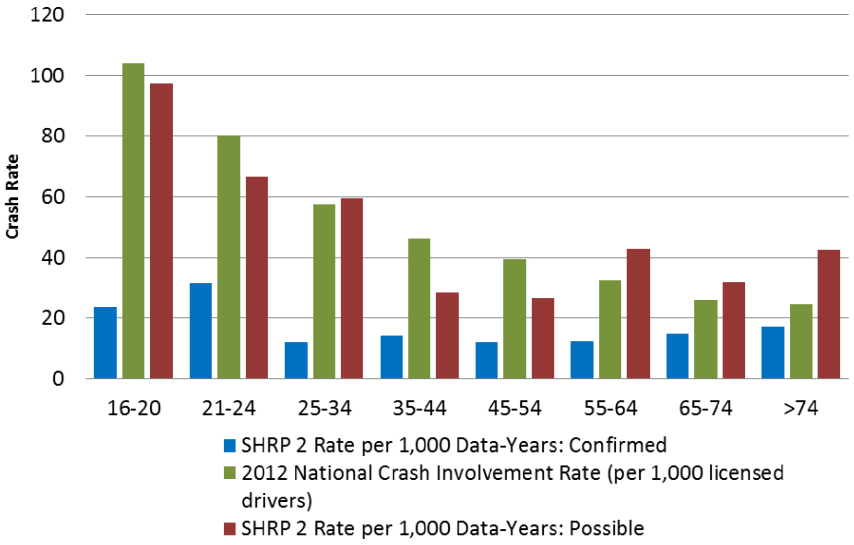
The national data illustrate a clear and monotonically decreasing crash rate with increasing age. There are so few data in each of the age bins that it may be difficult to accurately interpret the SHRP 2 confirmed crash rate data series. The SHRP 2 possible crash rate data series somewhat more closely matches that of the national data, but the pattern is neither clear nor monotonic. Table 4.5 compares crash data for the SHRP 2 sample states to national data.

Figure 4.17 compares the PR and PPR crash rates observed in the SHRP 2 data set with SHRP 2 state and national crash data. The first series presents only those SHRP 2 crashes confirmed as being PR; state crash rate data are depicted in the second series. In the third series, all PPR crashes in the SHRP 2



Source for U.S. rate: NHTSA 2014b.

Figure 4.15. SHRP 2 confirmed (PR) and possible (PPR) crash rates compared with the national rate.



Source: NHTSA 2012.

Figure 4.16. SHRP 2 confirmed (PR) and possible (PPR) crash rates versus 2012 national crash involvement rate by age group.

Table 4.5. 2010 Crash Data by State

State	No. of Crashes	Licensed Drivers (1,000s)	Crash Rate (per 1,000 Licensed Drivers)
New York	315,377	11,286	27.94
Florida	236,528	13,950	16.96
Washington	not available	5,106	not available
North Carolina	not available	6,537	not available
Indiana	193,323	5,550	34.83
Pennsylvania	121,101	8,737	13.86
All 50 states; Washington, D.C.; and Puerto Rico	5,419,000	210,115	25.79

Source: Federal Highway Administration 2014; Volpe National Transportation Systems Center, U.S. DOT, personal communication 2014.

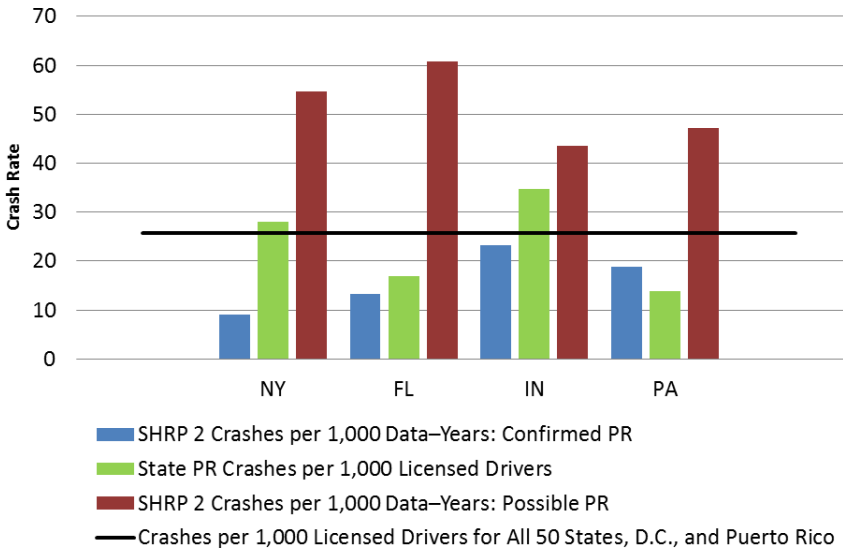


Figure 4.17. Crash rate comparison by state.

data set are displayed. The national crash rate (i.e., from all 50 states; Washington, D.C.; and Puerto Rico) is represented by the horizontal black line. State crash rates were unavailable for Washington and North Carolina, so they are excluded from Figure 4.17.

A primary goal of the SHRP 2 NDS was to amass a sufficiently large data set to study crashes from a naturalistic perspective. By design, this approach facilitates a glimpse into the vehicle to allow for a consideration of the roles that driver distraction, drowsiness, and other nondriving behaviors play in the moments leading up to a crash event. With data analysis still an ongoing effort, the preceding graphs bear out the success of the study in collecting a wealth of such information. Despite the inherent challenges associated with establishing a definitive crash rate for a data set acquired using the naturalistic method to be used as a point of comparison with existing data, overall PR and PPR crash rates observed in the SHRP 2 NDS are clearly in the same order of magnitude as the national crash rate.

Specifically, the lower estimate of the SHRP 2 PR crash rate, representing confirmed PR crashes in the data set, is 70% of the national rate, and the upper estimate, corresponding to all possible PPR crashes in the SHRP 2 data set, is approximately double the national rate. Although neither the confirmed nor the possible crash rates observed in the SHRP 2 data set replicate the trend seen in the national data of a monotonically decreasing crash rate per licensed driver with increasing age, the possible crash rate more closely matches it.

CHAPTER 5

Summary and Conclusion

Summary observations for each of the four report objectives follow.

- How do the selected sites in aggregate compare to the United States as a whole?
- How do the participants sampled compare to all drivers in the United States?
- How do the vehicles sampled compare to the entire U.S. fleet?
- How do police-reported crash rates observed in the study compare to crash rates in the United States as a whole?

How Do the Selected Sites in Aggregate Compare to the United States as a Whole?

The six recruitment sites, when aggregated, are similar to the nation as a whole for summer and winter temperatures (Figure 2.12). The aggregated sites had more annual rainfall (Figure 2.13) and were more urban (Figure 2.10) than the nation. The sites include a wide range of north/south and east/west geographical locations, elevations, temperatures (especially in winter), and primary city population sizes.

The population density comparison illustrates how the SHRP 2 data can be treated when they are analyzed. If population density is irrelevant to the analysis topic, then the data can be used without adjustment or weighting. If population density is relevant, then the data can be adjusted in various ways. Table 2.1 and Figure 2.9 show that population density varied substantially across the six sites, from 112 persons per square mile in Pennsylvania to 959 in Florida. A study wishing to analyze a low-density traffic safety issue could restrict itself to data from the two low-density sites, Indiana and Pennsylvania. A study wishing to consider data from a population density similar to the nation as a whole could use the entire data set but weight data from these two low-density sites more heavily than data from the other four sites.

How Do the Participants Sampled Compare to All Drivers in the United States?

The socioeconomic factors examined were age, gender, ethnicity, race, income, employment, marital status, and level of education. SHRP 2 intentionally oversampled younger and older drivers so that SHRP 2 participants included more of the younger and older driver age groups than the U.S. driving population; the proportion of males and females was about the same. Compared to the total U.S. population, SHRP 2 drivers have a lower proportion identifying themselves as Hispanic (Figure 4.2 and Table 4.1), a higher proportion identifying as white (Figure 4.3), a similar proportion employed (Figure 4.6), a lower proportion employed full-time (Figure 4.7), a lower proportion married (Figure 4.9), and a higher proportion with a college degree (Figure 4.10).

How Do the Vehicles Sampled Compare to the Entire U.S. Fleet?

The SHRP 2 fleet included a greater proportion of cars than other light vehicle types (0.71 and 0.29, respectively), a gap even more pronounced when considered against the national fleet as of January 1, 2012, which features an almost even split between cars and the other three light vehicle categories, namely trucks, vans, and SUVs/crossovers. The 26 model years and 19 makes included in the SHRP 2 study represent more than 95% and 98%, respectively, of the national fleet as of January 1, 2012. The SHRP 2 fleet substantially oversampled model years 2006 to 2011 to collect as much network data as feasible (Figure 4.12). Although the SHRP 2 vehicles include

substantial numbers of the major vehicle makes, SHRP 2 had larger proportions of Hyundai/Kia, Nissan, Honda, and Toyota models and smaller proportions of Chrysler, Ford, and GM models than the national fleet (Figure 4.13).

How Do Police-Reported Crash Rates Observed in the Study Compare to Crash Rates in the United States as a Whole?

Because some SHRP 2 crashes are known to have been reported to the police, but other crashes may or may not have been reported, two SHRP 2 crash rates were calculated: a lower "confirmed" estimate, using the crashes known to have been reported, and an upper "possible" estimate, using crashes known to have been reported or possibly reported. The confirmed SHRP 2 crash rate is slightly below the national PR crash rate, and the possible SHRP 2 crash rate is substantially above the national PR rate (Figure 4.15). When broken out by driver age (Figure 4.16) or by data collection site (Figure 4.17), the same observations generally hold except for middle-aged drivers.

Conclusion

SHRP 2 data are fairly inclusive of the nation in many respects. The counties from which participants were drawn, when aggregated, include a wide range of geographical features, roadways, and climates. Similarly, the SHRP 2 vehicle fleet included most of the national fleet's light vehicle makes and fairly recent model years, but differed from the national fleet with respect to vehicle type. SHRP 2 drivers ranged in age from 16 to 95, with younger and older drivers oversampled. Two SHRP 2 crash rates were calculated: a lower confirmed estimate, using the crashes known to have been reported to the police, and an upper possible estimate, using crashes possibly reported or known to have been reported. The confirmed SHRP 2 crash rate is slightly below the national PR crash rate, and the possible SHRP 2 rate is substantially above the national PR rate.

Analysts who wish to use the SHRP 2 data to make comparisons with a national population of some characteristic, such as driver age, will need to weight the SHRP 2 data to match the national distribution of that characteristic. An example of weighting by driver age and gender is provided in Appendix A.

References

Anderson, D. R., D. J. Sweeney, and T. A. Williams. 2003. *Modern Business Statistics with Microsoft Excel,* 1st ed. South-Western, Cincinnati, Ohio.

Antin, J., S. E. Lee, J. Hankey, and T. A. Dingus. 2011. *SHRP 2 Report S2-S05-RR-1: Design of the In-Vehicle Driving Behavior and Crash Risk Study.* Transportation Research Board of the National Academies, Washington, D.C.

Blatt, A., J. Pierowicz, M. Flanigan, P. Lin, A. Kourtellis, P. Jovanis, J. Jenness, M. Wilaby, J. Campbell, C. Richard, D. Good, N. Czar, and M. Hoover. 2014. *SHRP 2 Draft Final Report of the Field Data Collection Contractors (S07) Revision 1.* Unpublished report. Transportation Research Board of the National Academies, Washington, D.C.

Dingus, T. A., J. M. Hankey, J. F. Antin, S. E. Lee, L. Eichelberger, K. Stulce, D. McGraw, M. Perez, and L. Stowe. 2014. *SHRP 2 Technical Coordination and Quality Control Final Report, Project S06.* Transportation Research Board of the National Academies, Washington, D.C.

Federal Highway Administration. 2013. Highway Statistics 2012. Table DL-22, Highway Statistics Series. http://www.fhwa.dot.gov/policyinformation/statistics/2012/dl22.cfm. Accessed May 28, 2014.

Federal Highway Administration. 2014. Distribution of Licensed Drivers—2012: By Sex and Percentage in Each Age Group and Relation to Population. Table DL-20, Highway Statistics Series. http://www.fhwa.dot.gov/policyinformation/statistics/2012/dl20.cfm. Accessed Apr. 17, 2014.

Google. 2014. Google Maps. http://www.google.com/maps. Accessed May 7, 2014.

National Oceanic and Atmospheric Administration. 2014. *National Climatic Data Center.* http://www.ncdc.noaa.gov. Accessed May 5, 2014.

NHTSA. 2012. *Traffic Safety Facts: 2010 Data.* Report DOT HS 811 659. National Highway Traffic Safety Administration, U.S. Department of Transportation.

NHTSA. 2014a. *Driver License Compliance Status in Fatal Crashes.* Report DOT HS 812 046. National Highway Traffic Safety Administration, U.S. Department of Transportation.

NHTSA. 2014b. *Traffic Safety Facts: 2012 Data.* Report DOT HS 812 016. National Highway Traffic Safety Administration, U.S. Department of Transportation. http://www-nrd.nhtsa.dot.gov/Pubs/812016.pdf. Accessed May 28, 2014.

Ramsey, C. A., and A. D. Hewitt. 2005. A Methodology for Assessing Sample Representativeness. *Environmental Forensics,* Vol. 6, No. 1, pp. 71–75.

Spence, J. T., J. W. Cotton, B. J. Underwood, and C. P. Duncan. 1976. *Elementary Statistics,* 3rd ed. Prentice-Hall, Englewood Cliffs, N.J.

Stutts, J., C. Martell, and L. Staplin. 2009. *Identifying Behaviors and Situations Associated with Increased Crash Risk for Older Drivers.* Report DOT HS 811 093. National Highway Traffic Safety Administration, U.S. Department of Transportation. http://www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811093.pdf. Accessed July 18, 2014.

The Weather Channel, LLC. 2014. Weather Underground. http://www.wunderground.com. Accessed May 8, 2014.

U.S. Census Bureau. 2010a. 2010 Census Urban and Rural Classification and Urban Area Criteria. https://www.census.gov/geo/reference/ua/urban-rural-2010.html. Accessed Sept. 8, 2015.

U.S. Census Bureau. 2010b. Population, Housing Units, Area, and Density: 2010. United States–States and Puerto Rico. 2010 Census Summary File 1. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_GCTPH1.US01PR&prodType=table. Accessed May 5, 2014.

U.S. Census Bureau. 2010c. Profile of General Population and Housing Characteristics: 2010. 2010 Census Summary File 1. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_SF1DP1&prodType=table. Accessed May 2, 2014.

U.S. Census Bureau. 2010d. Race and Hispanic or Latino Origin: 2010. 2010 Census Summary File 1. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_QTP3&prodType=table. Accessed May 2, 2014.

U.S. Census Bureau. 2010e. Race, Combinations of Two Races, and Not Hispanic or Latino: 2010. 2010 Census Summary File 1. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_QTP4&prodType=table. Accessed May 23, 2014.

U.S. Census Bureau. 2010f. Selected Economic Characteristics: 2008–2010 American Community Survey 3-Year Estimates. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_3YR_DP03&prodType=table. Accessed May 16, 2014.

U.S. Census Bureau. 2010g. Selected Social Characteristics in the United States: 2006–2010 American Community Survey 5-Year Estimates. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_5YR_DP02&prodType=table. Accessed May 16, 2014.

U.S. Census Bureau. 2010h. Work Status in the Past 12 Months: 2008–2010 American Community Survey 3-Year Estimates. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_3YR_S2303&prodType=table. Accessed May 16, 2014.

APPENDIX A

Weighting Factors

In Chapter 2 and Chapter 4, figures depicting comparisons between study recruitment areas, their respective states, and the nation as a whole include a series labeled "Recruitment Site Counties Weighted by Nominal Site Size." Data in these series are weighted based on each site's size, as determined by the number of DAS kits nominally allocated to that site, as outlined in Table A.1.

Similarly, figures in Chapter 4 that compare the SHRP 2 NDS sample and other relevant populations include a series labeled "SHRP 2 Sample Weighted According to Age/Gender" derived by weighting the data associated with the study sample according to the distribution of licensed drivers across the United States in 2012, the last full year of data collection. The weighting factors used to derive this series are presented in Table A.2.

Table A.1. Weighting Factor for Each Site Based on Original Nominal Number of DAS Kits Managed

Site	No. of DAS Kits	Site Size–Based Weighting Factor
New York	450	3
Florida	450	3
Washington	450	3
North Carolina	300	2
Indiana	150	1
Pennsylvania	150	1

Table A.2. Weighting Factors for SHRP 2 Sample by Age and Gender

Gender	Age	No. of Licensed Drivers in 2012[a]	2012 Licensed Drivers Weighting Factor for Age and Gender
M	≤19	4,506,199	0.0212742
F	≤19	4,323,609	0.0204122
M	20–24	8,836,224	0.0417167
F	20–24	8,644,805	0.0408130
M	25–29	9,142,229	0.0431614
F	25–29	9,214,424	0.0435023
M	30–34	9,088,323	0.0429069
F	30–34	9,242,363	0.0436342
M	35–39	8,667,787	0.0409215
F	35–39	8,758,112	0.0413480
M	40–44	9,532,858	0.0450056
F	40–44	9,568,468	0.0451737
M	45–49	9,893,354	0.0467076
F	45–49	9,943,257	0.0469432
M	50–54	10,298,601	0.0486208
F	50–54	10,459,435	0.0493801
M	55–59	9,503,385	0.0448665
F	55–59	9,738,712	0.0459775
M	60–64	8,128,957	0.0383777
F	60–64	8,379,398	0.0395600
M	65–69	6,311,060	0.0297952
F	65–69	6,515,908	0.0307623
M	70–74	4,349,210	0.0205331
F	70–74	4,557,392	0.0215159
M	75–79	3,040,690	0.0143554
F	75–79	3,255,371	0.0153689
M	80–84	2,096,580	0.0098982
F	80–84	2,338,480	0.0110402
M	85+	1,589,660	0.0075050
F	85+	1,889,979	0.0089228

[a] Federal Highway Administration 2014.

TRB OVERSIGHT COMMITTEE FOR THE STRATEGIC HIGHWAY RESEARCH PROGRAM 2*

CHAIR: **Kirk T. Steudle,** *Director, Michigan Department of Transportation*

MEMBERS

H. Norman Abramson, *Executive Vice President (retired), Southwest Research Institute*
Alan C. Clark, *MPO Director, Houston–Galveston Area Council*
Frank L. Danchetz, *Vice President, ARCADIS-US, Inc. (deceased January 2015)*
Malcolm Dougherty, *Director, California Department of Transportation*
Stanley Gee, *Executive Deputy Commissioner, New York State Department of Transportation*
Mary L. Klein, *President and CEO, NatureServe*
Michael P. Lewis, *Director, Rhode Island Department of Transportation*
John R. Njord, *Executive Director (retired), Utah Department of Transportation*
Charles F. Potts, *Chief Executive Officer, Heritage Construction and Materials*
Ananth K. Prasad, *Secretary, Florida Department of Transportation*
Gerald M. Ross, *Chief Engineer (retired), Georgia Department of Transportation*
George E. Schoener, *Executive Director, I-95 Corridor Coalition*
Kumares C. Sinha, *Olson Distinguished Professor of Civil Engineering, Purdue University*
Paul Trombino III, *Director, Iowa Department of Transportation*

EX OFFICIO MEMBERS

Victor M. Mendez, *Administrator, Federal Highway Administration*
David L. Strickland, *Administrator, National Highway Transportation Safety Administration*
Frederick "Bud" Wright, *Executive Director, American Association of State Highway and Transportation Officials*

LIAISONS

Ken Jacoby, *Communications and Outreach Team Director, Office of Corporate Research, Technology, and Innovation Management, Federal Highway Administration*
Tony Kane, *Director, Engineering and Technical Services, American Association of State Highway and Transportation Officials*
Jeffrey F. Paniati, *Executive Director, Federal Highway Administration*
John Pearson, *Program Director, Council of Deputy Ministers Responsible for Transportation and Highway Safety, Canada*
Michael F. Trentacoste, *Associate Administrator, Research, Development, and Technology, Federal Highway Administration*

* Membership as of January 2015.

SAFETY TECHNICAL COORDINATING COMMITTEE*

CHAIR: **Forrest M. Council,** *Senior Research Scientist, Highway Safety Research Center, University of North Carolina*

MEMBERS

Timothy E. Barnett, *State Safety Engineer, Alabama Department of Transportation*
James A. Bonneson, *Senior Principal Engineer, Kittelson and Associates*
Leanna Depue, *Director, Traffic and Highway Safety Division, Missouri Department of Transportation*
Bradley M. Estochen, *State Traffic Safety Engineer, Minnesota Department of Transportation*
Jurek Grabowski, *Research Director, AAA Foundation for Traffic Safety*
Jeffrey Greenberg, *Senior Technical Leader, Ford Motor Company*
Joanne Harbluk, *Human Factors Specialist, Transport Canada*
Brent Jennings, *Highway Safety Manager, Idaho Transportation Department*
Alan F. Karr, *Director, National Institute of Statistical Sciences*
Bani K. Mallick, *Distinguished Professor, Department of Statistics, Texas A&M University*
John C. Milton, *Director, Enterprise Risk & Safety Management, Washington State Department of Transportation*
Harlan J. Onsrud, *Professor, School of Computing & Information Science*
Michael Perel, *Safety Knowledge Engineer*
Charles W. Reider, *Chief Safety Engineer, Nevada Department of Transportation*
David Shinar, *Professor, Department of Industrial Engineering and Management, Ben Gurion University of the Negev*
Alison Smiley, *President, Human Factors North, Inc.*
Thomas M. Welch, *State Transportation Safety Engineer (retired), Office of Traffic and Safety, Iowa Department of Transportation*

AASHTO LIAISONS

Kelly Hardy, *Safety Program Manager, American Association of State Highway and Transportation Officials*
Pam Hutton, *SHRP 2 Implementation Manager, American Association of State Highway and Transportation Officials*
Jim McDonnell, *Program Director for Engineering, American Association of State Highway and Transportation Officials*

FHWA LIAISONS

Monique Evans, *Director, Office of Safety Technologies, Federal Highway Administration*
Michael Griffith, *Director, Office of Safety Integration, Federal Highway Administration*

AUTO INDUSTRY LIAISONS

Michael Cammisa, *Director, Safety, Association of Global Automakers*
Scott Schmidt, *Director, Safety and Regulatory Affairs, Alliance of Automobile Manufacturers*

EUROPEAN SAFETY LIAISON

Fred Wegman, *Managing Director, SWOV Institute for Road Safety Research, Netherlands*

FMCSA LIAISON

Martin Walker, *Chief, Research Division, Federal Motor Carrier Safety Administration*

NHTSA LIAISONS

Richard Compton, *Director, Office of Behavioral Safety Research, National Highway Traffic Safety Administration*
Tim Johnson, *Director, Office of Human-Vehicle Performance Research, National Highway Traffic Safety Administration*
Seymour Stern, *Team Leader, State Based Systems, National Highway Traffic Safety Administration*

* Membership as of July 2014.

Related SHRP 2 Research

- Naturalistic Driving Study: Development of the Roadway Information Database (S04A)
- Design of the In-Vehicle Driving Behavior and Crash Risk Study (S05)
- Naturalistic Driving Study: Technical Coordination and Quality Control (S06)
- Naturalistic Driving Study: Collecting Data on Cell Phone Use (S06)
- Naturalistic Driving Study: Field Data Collection (S07)
- Analysis of Naturalistic Driving Study Data: Safer Glances, Driver Inattention, and Crash Risk (S08A)
- Analysis of Naturalistic Driving Study Data: Offset Left-Turn Lanes (S08B)
- Analysis of Naturalistic Driving Study Data: Roadway Departures on Rural Two-Lane Curves (S08D)
- Naturalistic Driving Study: Alcohol Sensor Performance (S31)
- Naturalistic Driving Study: Linking the Study Data to the Roadway Information Database (S31)