Cellular Phone Use While Driving:

Risks and Benefits

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Executive Summary

This report assesses the risks and benefits associated with cellular phone use while driving. The interest of policymakers in this issue has been heightened by the recent decisions of selected foreign countries and several U.S. localities to restrict or prohibit the use of cellular phones while driving.

The weight of the scientific evidence to date suggests that use of a cellular phone while driving does create safety risks for the driver and his/her passengers as well as other road users. The magnitude of these risks is uncertain but appears to be relatively low in probability compared to other risks in daily life. It is not clear whether hands-free cellular phone designs are significantly safer than hand-held designs, since it may be that conversation *per se* rather than dialing/handling is responsible for most of the attributable risk due to cellular phone use while driving.

The benefits of using this communications device while driving appear to be important. They include benefits to the users, households, social networks, businesses, and communities. Many of these benefits, which include public health and safety considerations, have not yet been recognized or quantified. Simple suggestions that drivers can "pull over" on the side of the road to make calls from cellular phones are unrealistic and, in certain situations, potentially dangerous. It is not known which of the benefits of cellular phone use would be foregone under various regulatory scenarios.

Cellular phone use while driving should be a concern of motorists and policymakers. We conclude that although there is evidence that using a cellular phone while driving poses risks to both the driver and others, it may be premature to enact substantial restrictions at this time. Indecision about whether cellular phone use while driving should be regulated is reasonable due to the limited knowledge of the relative magnitude of risks and benefits. In light of this uncertainty, government and industry should endeavor to improve the database for the purpose of informing future decisions of motorists and policymakers. In the interim, industry and government should encourage, through vigorous public education programs, more selective and prudent use of cellular phones while driving in order to enhance transport safety.

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Preface

This study was commissioned by AT&T Wireless Services (Redmond, Washington) through a research grant made to the Harvard Center for Risk Analysis of the Harvard School of Public Health (Boston, Massachusetts). The terms of the grant relationship protected the intellectual freedom of the Harvard researchers to determine the direction of the study as well as to make independent conclusions and recommendations. This Phase 1 report will be supplemented by a Phase 2 report, scheduled for completion in 2001, that provides additional quantitative information on the benefits and risks of the use of cellular phones while driving. The authors thank Candy Castle and her colleagues at AT&T Wireless for their support of this project.

The information in this report does not provide a definitive resolution of the risk-benefit issue concerning use of cellular phones while driving. The objective of the report is to stimulate greater scientific and public policy discussion of this issue. The intended audiences for the report include policymakers in government and industry, scientists interested in cellular phone safety, and any motorist or citizen interested in this matter. Given this broad audience, we have sought to minimize technical jargon throughout the report. A shorter summary of this report has also been issued as the June issue of *Risk in Perspective*, a periodic publication of the Harvard Center for Risk Analysis.

In order to assure the technical quality of this report, a rigorous process of independent peer review was applied. The authors thank the following reviewers who offered constructive comments on an earlier draft of this report: Alasdair Cain (University of South Florida), Nancy A. Dreyer (Epidemiology Research Institute), John Evans (Harvard School of Public Health), Susan A. Ferguson (Insurance Institute for Highway Safety), Michael Finkelstein (Association

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Section 1. Introduction

Cellular phones[1] were first introduced into the U.S. market in the mid-1980s, and have since experienced dramatic growth. Over the past decade in the U.S. alone, cellular phone subscription sales have increased seventeen-fold (CTIA, 2000a), ranking it among the fastest-growing industries in the U.S. Once a luxury available to only the affluent and a small segment of business users, cellular phone use has become increasingly commonplace among American families as well as businesses.

Although cellular phones are functional in a variety of situations, they are a particularly useful technology to people on the move, including people operating motor vehicles. The majority of cellular phone owners report that they use the technology while driving. Indeed, a substantial percentage of the total calls initiated from cellular phones were by drivers of motor vehicles.

Concerns have been raised that use of a cellular phone while driving increases the risk of traffic collisions, property damage, injuries, and fatalities. A variety of groups, including the wireless communications industry and transportation safety groups, have initiated educational campaigns that encourage the prudent use of cellular phones while driving. These safety concerns have also led policymakers to consider whether the use of a cellular phone while driving should be regulated or even prohibited. Such bans, at least with respect to use of hand-held phones by drivers, have already been enacted in some foreign countries, prior to the widespread diffusion of the technology. Many states and localities in the U.S. are now considering restrictions or bans on use of a cellular phone while driving.

[1] The term "cellular phone" is used throughout this document to refer to all types of wireless communication including cellular and digital technology. It includes both hand-held and hands-free models.

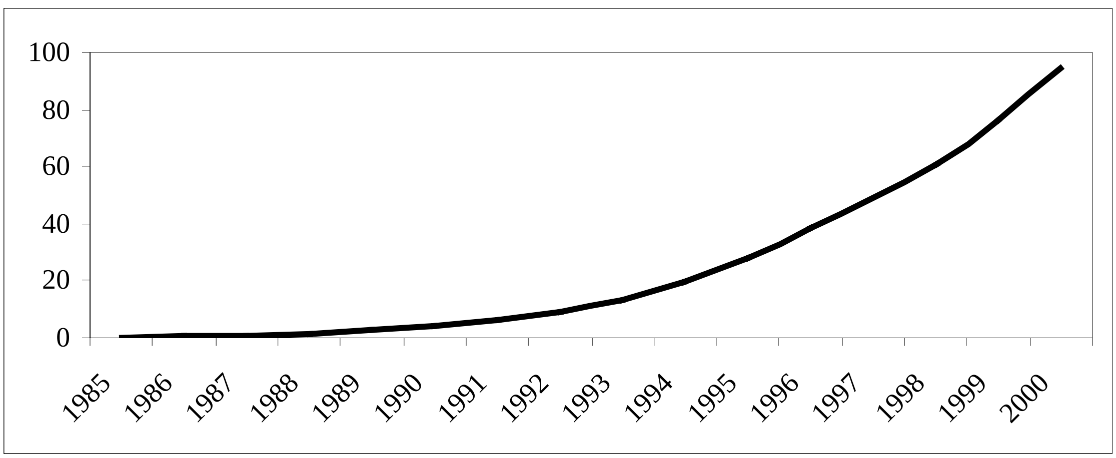
The purpose of this report is to elucidate what is known about the risks and benefits of using a cellular phone while driving, including a discussion of public policy issues relevant to whether use of a cellular phone while driving should be restricted or prohibited. We conclude that it is currently difficult for policymakers to reach an informed conclusion for three primary reasons. First, the risks of using a cellular phone while driving, though real, are not large enough to be detected in overall crash/fatality statistics but are potentially large enough to be a legitimate concern of motorists and policymakers. Second, the benefits of using a cellular phone while driving have been the subject of much less study and attention than the risks. This report begins to address this imbalance in the literature with data from several focus groups with cellular phone users. Finally, the cost-effectiveness of saving lives through restricting cellular phone use does not appear to be very attractive compared to other traffic safety measures. We argue that a targeted and intensive program of scientific inquiry and policy discussion would promote the development of wise regulatory policy in this field.

The report is organized as follows. Section 2 presents data on the rapid penetration of this technology throughout the U.S. Section 3 assembles the available evidence on risk and provides "ballpark" estimates of the magnitude of the risk of death from use of cellular phones while driving. We consider both risks to the cellular phone user as well as risks to other road users whose safety may be endangered when a driver uses a cellular phone while the vehicle is in motion. The magnitude of risk is compared to other voluntary and involuntary risks that people face on a daily basis. Section 4 examines the benefits (non-economic as well as economic) of using a cellular phone while driving. Section 5 discusses the benefits that might be foregone if cellular phone use is restricted while driving. Section 6 compares the cost-effectiveness of restrictions on the use of cellular phones to the cost-effectiveness of other lifesaving measures adopted by state and federal policymakers. Section 7 reviews recent legislative and legal developments, illustrating the extent of uncertainty among policymakers about the wisest course for public policy regarding this issue. Section 8 describes our recommendations concerning future research and risk management.

Section 2. Consumer Use of Cellular Phones

Cellular phone service was introduced in the United States in 1983 (CTIA, 2000a). As of June 2000, the number of subscriptions in the U.S. has exploded to 94.2 million (CTIA, 2000b), with 27% of American households reporting in a recent survey that at least one member owns a cellular phone (PCIA, 1999). Figure 1 reports data on the growth of cellular phone subscriptions in the U.S. from 1985 to 2000. In the United States about 75% of the cellular phones in use are of the hand-held design (National Highway Traffic Safety Administration [NHTSA], 1997a), though hands-free and voice-activated designs are also in use[2].

Figure 1. Growth in Cellular Phone Subscriptions in Millions from 1985 to 2000.



Use of cellular phone technology was initially confined to the affluent and a small segment of business users. However, usage patterns have changed substantially in recent years as the costs of owning and using a cellular phone have declined. The percentage of owners who use these devices primarily for personal/family purposes increased from 40% to 61% between 1990 and 1998 (Cain and Burris, 1999). Cellular phone ownership is correlated with education

[2] A hand-held phone is a portable model, generally small and lightweight, that must be held to the ear and mouth for use. It may be transportable, mobile, or pocket size. In contrast, a hands-free phone is a model that can be used while mounted in a vehicle or placed in a bracket. It may be operated with a remote speaker or microphone to improve performance (NHTSA, 1997a).

level. Only 15% of individuals with less than a high school degree owned cellular phones, compared to 26% of high school graduates, 30% of those with some college education, and 40% of those with a college degree (NHTSA, 1997a). If present trends continue, a majority of American households may be owners of cellular phones by the year 2005.

A hand-held cellular phone can be used in a variety of circumstances: while walking down the street, waiting in line at a store or doctor's office, or operating a motor vehicle. The use of a cellular phone while driving is a common application of this technology. Several surveys have found that 80-90% of cellular phone owners use these devices while driving at least some of the time (NHTSA, 1997a; PCIA, 1999; Cain and Burris, 1999). The extent of use while driving varies substantially among owners. One recent survey found that 15% of cellular phone owners use their cellular phone for more than 1 hour per month while driving, 15% for 30-60 minutes, 20% for 10-30 minutes, and 39% for less than 10 minutes per month while driving; 11% did not respond to the survey (PCIA, 1999).

More precise data are needed on users who frequently initiate and/or receive calls while driving. One survey found that 29% of all cellular phone users regularly use their phone in their car (Hart, 1997)[3], yet publicly available data do not reveal what fraction of owners use this technology primarily or only while driving a motor vehicle.   Individuals who are particularly likely to use cellular phones regularly while driving include owners who use them for business purposes (48%), owners who are commuters (40%), and owners between the ages of 18 and 34 (35%) (Hart, 1997). The elderly and low-income individuals are less likely to use a cellular phone regularly while driving. Men are reported to use their phones regularly while driving more frequently than women (Hart, 1997), though this disparity may decline in the future as the technology becomes further integrated into personal, family, and business life. In certain regions of the country where average commuting distances are long and highways congested, we suspect that cellular phone owners may initiate the vast majority of their total number of calls while operating a motor vehicle. A richer database on characteristics of individuals who use cellular phones while driving and their purpose for use is needed.

Call duration also varies substantially (Table 1). The most frequent type of call while driving lasts between 30 seconds to 2 minutes (37%), followed by calls of less than 30 seconds (23%), calls of 2-5 minutes (18%), and calls of longer than 5 minutes (4%) (PCIA, 1999).

Table 1. Cellular Phone Call Duration While Driving.

Call Duration While Driving	Percentage of Respondents (%)
Less than 30 seconds	23
30 seconds – 2 minutes	37
2 – 5 minutes	18
More than 5 minutes	4
Do not use while driving	10
No response	8

Source: PCIA, 1999

[3] Survey among 409 wireless users/407 non-users nationwide, May 15-17, 1997.

Section 3. Risks of Using a Cellular Phone While Driving

Motor vehicle collisions are harmful in many ways. For motorists these collisions can result in minor, serious, crippling, and even fatal injuries. Collisions result in property damage to vehicles that is often expensive to repair. There are also related health care costs, litigation expenses, insurance administration, lost work time, and other adverse ramifications of collisions. In urban areas, each collision occurring in rush hour can induce a cascade of traffic congestion, emergency response time, and grief for those affected. Thus, if use of cellular phones while driving causes more collisions, motorists and policymakers should be concerned. Businesses and insurers may also become concerned since these firms bear a significant fraction of the monetary costs of motor vehicle collisions.

In response to growing interest in this issue, a number of recent studies have conducted rigorous reviews of the literature. The most comprehensive was NHTSA (1997a); more recent authors have drawn heavily from this initial review (*e.g.*, Hahn and Tetlock, 1999; Cain and Burris, 1999). In this report, we highlight information and studies that may be of strongest interest and/or relevance to the regulatory issue.

Four types of information address the risks of using a cellular phone while driving: (1) driver performance studies, (2) case reports of crashes where use of a cellular phone appears to have played a role in the crash, (3) statistical comparisons of trends in motor vehicle crashes and cellular phone usage (so-called “ecological” studies of risk), and (4) “epidemiological” studies that use individual-level data on phone use and crash experience to determine the statistical association between use of a cellular phone and collision, injury, and/or fatality. As we shall see, this entire body of evidence is consistent with the common-sense judgment that use of a cellular phone while driving can increase the risk of a motor vehicle collision with attendant injuries and fatalities. However, it is not yet clear what the magnitude and severity of these risks are under real-world conditions.

Driver Performance Studies. The use of a hand-held cellular phone while driving may entail a variety of different maneuvers: searching for a phone in the vehicle, reaching for a phone to initiate or receive a call, dialing, holding a phone near the ear while talking and driving, picking up a phone that has been dropped, and so forth. Even use of a hands-free phone can be distracting to the driver as conversation consumes mental energy while driving. The various tasks entailed in using a cellular phone each require a different amount of time, mental energy, and coordination, leading to potentially different complications of the driving task and resulting risk of collision.

A number of studies, beginning as early as the late 1960s, have examined how cellular phone use affects driver behavior (Brown, Tickner, & Simmonds, 1969; Kames, 1978; Drory, 1985; Stein, Pareghian, & Allen, 1987; Hayes, Kurokawa, & Wierwille, 1989). Some studies observe experimental subjects operating a motor vehicle while other studies make use of a computer-generated driving simulator. The relevant studies published since 1990 are summarized in Table 2. A comprehensive review of the entire literature through 1997 is available in NHTSA (1997a).

Table 2. Summary of Driver Performance Studies, 1991-1999.

Reference	Subject Characteristics	Methods & Measurement	Intervention(s)	Comparison	Key Findings
Brookhuis, de Vries, & de Waard, 1991	12 drivers 10 men, 2 women Equally divided into 3 age categories: 23-35, 35-50, 50-65.	-Modified automobile (*i.e.* redundant controls for use if needed by accompanying driving instructor). -Hand-held and hands-free phone use equally distributed. -Measures included lateral position (swerving) of vehicle, ability to follow car-in-front, steering wheel motions, checking the rearview mirror, and mental workload.	Using hand-held or hands-free cellular phone while driving modified vehicle.	Not using cellular phone while driving modified vehicle.	-Hands-free phone users had better control than hand-held users, as measured only by steering wheel movement. -Phone use *decreased* swerving and delayed reaction time to car following. -Mental workload increased when phoning. -Age effect: none.
McKnight & McKnight, 1993	150 drivers 75 men, 75 women Mean age 39 yrs.	-Computer-based driving simulation using hands-free device. -Measured driver response rate (decelerating, braking, turning away).	-Radio tuning -Call placing (hands-free) -Casual conversation (hands-free) -Intense conversation (hands-free)	Driving with no distraction.	-All interventions and comparison significantly different. Tuning radio and intense conversation most distracting overall. -Age effect: younger drivers more distracted while tuning radio; older drivers more distracted while placing a call or conversing.
Serafin, Wen, Paelke, & Green, 1993	12 drivers 6 men, 6 women Mean age Young group, 24 yrs. Elderly group, 70 yrs.	-Driving simulator. -Manual (hand-held) phones & voice command (hands-free) used. -Measured driving performance and dialing performance.	-Dialing phone while driving. -Performing tasks while driving .(involving recall and conversation).	Driving without using phone.	-Dialing while driving disturbed driving performance most. Voice input led to better driving performance than manual handset. -Age effect: younger drivers performed better than elderly on driving performance.

Table 2. Summary of Driver Performance Studies, 1991-1999. (continued)

Reference	Subject Characteristics	Methods & Measurement	Intervention(s)	Comparison	Key Findings
Alm & Nilsson, 1994	40 drivers 20 men, 20 women Mean age 32.4 yrs	-Driving simulator with moving base, wide-angle view, vibration, sound, and temperature regulation. -Used hands-free cellular phone mounted on steering wheel. -Measured driver reaction time and mental workload, and lateral position (swerving) of vehicle, with easy versus hard driving tasks.	Using a hands-free cellular phone while driving simulator.	Not using a cellular phone while driving simulator.	-Longer reaction time (slower reaction) for phone group in easy driving task; no difference found for hard driving task. -Greater deviation from lateral position (swerving) of vehicle for phone group in hard driving task. -Mental workload increased for phone group. -Contrary to predictions, strongest effects found in phone group exposed to easy driving tasks.
Alm & Nilsson, 1995	40 drivers 30 men, 10 women Mean age Young group, 29.3 yrs. Elderly group, 67.6 yrs.	-Methods and measurement identical to Alm & Nilsson, 1994 (above) with the additional measurement of headway (distance b/t front of subject's car and end of lead vehicle).	Using a hands-free cellular phone while driving simulator involving interaction with other road users.	Not using a cellular phone while driving simulator involving interaction with other road users.	-Longer reaction time and shorter minimum headway for phone group. -Mental workload increased for phone group. -No difference in lateral position (swerving) of vehicle. -Age effect: elderly group had longer reaction time than younger group.
Briem & Hedman, 1995	20 drivers 10 men, 10 women Mean age Young group, 21.0 yrs. Elderly group, 45.5 yrs.	-Simulated driving on slippery or firm road w/ or w/o secondary task (communication or instrument manipulation). -Used hands-free cellular phone mounted on console to the right of steering wheel. -Measured road position, collisions with obstacles, and speed of driving.	-Radio use -Easy conversation -Difficult conversation	Driving condition (compared with multiple distraction).	-Road position improved slightly with introduction of a second task. -Road position most affected by dialing radio, followed by difficult & easy conversation, respectively. -Age effect: none. -Male drivers performed better -Difficult conversation may effect driving adversely.
Lamble, Kauranen, Laakso, & Summala, 1999	19 drivers 10 men, 9 women Mean age 22.7 yrs.	-Modified automobile. -Mounted (hands-free) phone used. -Measured time-to-collision (TTC) and brake reaction time (BRT).	-Phone dialing task -Cognitive tasks (involving memory and addition)	Driving without tasks.	-Driver's detection ability significantly impaired regarding BRT and TTC when either dialing or performing cognitive task. -Cognitive and phone dialing tasks roughly equally distracting.

Virtually all of these studies document some decrement in driver performance that is associated with use of a cellular phone while driving. The studies vary tremendously in the methods employed, the type of phone models (hand-held or hands-free), the type of phone use (initiating vs. receiving a call), and the nature of the conversation (casual vs. intense).

Which task contributes most to poor driving performance: searching for the phone in the vehicle, dialing, conversing, hanging up, picking up a dropped phone, or receiving a call? The answer to this question is not entirely clear because studies to date are of small sample size and usually unreplicated. According to Serafin *et al.*, (1993), the predominant disturbance in driving performance was dialing the phone. Crash data from Japan support this finding. On the other hand, U.S. crash reports suggest that the distraction of conversation may contribute more to risk than the acts of dialing or receiving a call (see below). However, Briem & Hedman (1995) suggested that conversing alone – as long as the conversation was not emotional or involved – did not contribute to driver distraction.

There is insufficient literature on whether or not hands-free models offer any safety advantage over hand-held models. Most studies have investigated only one model type (generally, hands-free). One exception is Serafin *et al.* (1993), who compared hand-held phones to hands-free phones with voice activation. The authors concluded that, when driving and dialing, voice input through a hands-free phone led to better driving performance compared to a hand-held phone (Serafin *et al*., 1993).

Several studies have found that older-aged individuals demonstrated diminished driving performance while using a cellular phone (Serafin *et al.*, 1993; Alm & Nilsson, 1995; McKnight

& McKnight, 1993). In contrast, Briem & Hedman (1995) found no difference in effect on driving proficiency between age groups.[4]

The real-world implications of driver performance studies are uncertain. Drivers may become aware of the risks entailed in using a cellular phone while driving, either through their own intuition and/or through what they learn from family members, friends, or the mass media. Such awareness would be predicted, at least by some behavioral scientists, to induce a change in driving behavior that is aimed at restoring the pre-existing level of driver safety (Peltzman, 1975; Evans, 1991). These theories are rooted in the assumption that the driver cares about his or her own safety. They are not rooted in any altruistic concerns for the safety of other road users, although altruism could also motivate drivers to take some kinds of risk compensation measures. These compensatory behaviors might include maintenance of a constant speed, reduction in passing maneuvers, initiation of calls only when the vehicle is at a stop or is being operated in a remote area, and participation in lengthy and/or intense calls only on certain kinds of trips or in certain kinds of road conditions where there is a perception of relative safety.

Compensatory behaviors are not necessarily exact in their offsetting influences and thus could reduce risk to a lesser or even greater extent than the additional risk induced by use of the cellular phone while driving. Moreover, compensatory behaviors could be greater among some drivers than others. Although driver performance studies may implicitly include some compensatory effects in their research design, it is very difficult for small-scale experimental studies to account for the full range of potential compensatory effects.

In summary, driver performance studies have provided insight into the mechanisms whereby use of a cellular phone while driving could cause or contribute to motor vehicle crashes. They therefore provide a solid basis for believing that use of cellular phone while driving will

[4] See Table 2 for mean sample ages of referenced studies.

cause collisions in the real world. However, the actual risks of real world collisions cannot be accurately inferred from these experimental studies because compensatory behaviors may not be accounted for in the study design.

Case Reports of Crashes Involving Cellular Phones. Information about the influence of cellular phones in particular crashes is difficult to obtain. With the exception of the states of Oklahoma, Minnesota, and Tennessee, police-accident reports typically do not elicit information about whether a cellular phone was present in the vehicle and, if so, whether it was in use immediately before the crash. Even in these states, where such information is supposed to be included on police-accident reports, there are serious questions about the completeness and accuracy of the coded information about cellular phone presence and use (NHTSA, 1997a).[5] Drivers may be reluctant to report their use of a cellular phone to police for fear that they may be admitting culpability for the crash, which might in turn create liability or insurance problems for the driver. Witnesses may be the most reliable source of information about cellular phone use prior to a crash but they are often unavailable or their information is not recorded on a police-accident report. Even if it is known that a cellular phone was in use by the driver immediately prior to a crash, it is not always clear whether use of the cellular phone was the single causative factor in the crash, a contributing factor, or simply an unrelated fact.

In a strictly scientific sense, it may be impossible for a police officer or witness to discern whether a particular crash was caused by a driver's use of a cellular phone. The police officer or witness has no basis for judging how the driver would have behaved behind the wheel if he or she had not been using a cellular phone. Thus, determining whether a particular crash was "phone-related" is a very subjective decision.

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[5] Though NHTSA, 1997a refers only to Oklahoma and Minnesota, Vuong, 2000 reports that Tennessee also requires the documentation of cellular-phone related accidents on police reports.

NHTSA's Fatal Analysis Reporting System (FARS) is a census of all fatal motor vehicle crashes that occur in the United States each year, with information on each crash derived primarily from police-accident reports. FARS does include some information on the role of driver distractions in crash causation, but information on cellular phone use is incomplete. In calendar years 1994 and 1995, a total of 36 and 40 FARS fatal crashes, respectively (of approximately 40,000 fatalities in each year), were identified that included cellular phone use as a "possible distraction inside the vehicle" (NHTSA, 1997a, Section 3.2, p.3). Over half of these cases occurred in Oklahoma each year. When NHTSA's project staff attempted to verify the phone-related crashes in Oklahoma, problems emerged. Only 2 of the 21 Oklahoma cases in 1994 FARS could be verified as phone-related; only 1 of the 26 Oklahoma cases in 1995 FARS could be verified as phone-related.

The national number of FARS cases where fatal crashes were verified as phone-related (17 in 1994 and 15 in 1995) are likely a substantial undercount since FARS depends on a police report. Yet some suggestive patterns emerge even from this incomplete data. In only 3 of the 32 cases was the operator of the cellular phone a driver of the struck vehicle. The drivers using the cellular phone were typically operating the striking vehicle. In one third of the cases, the striking vehicle ran off the road in single-vehicle collisions. The other cases involved pedestrians, bicyclists, or multi-vehicle collisions.

NHTSA's National Accident Sampling System (NASS) is a different database that includes a stratified, random sample of 5,000 police-reported crashes per year in the U.S. Information on cellular phone use in NASS is present only if drivers and/or occupants of crash-involved vehicles were willing to state such involvement in an interview with NASS researchers. Thus, the reported data on cellular phone use in NASS accidents are also likely to be incomplete.

In 1995, for example, there were 8 relevant cases out of 4,555 (one involving a driver dialing a phone; the other seven involving a driver conversing on the cellular phone).

In a special one-time investigation, a team of crash analysts at NHTSA reviewed 60,233 police-crash report narratives---only ten were cellular-phone related. Again, these reports were likely subject to a vast undercount of the true number of phone-related crashes. The following are short descriptions of these 10 crashes, as reported by NHTSA (1997a, Table 3-10):

- **Case 1:** The driver of the vehicle was talking on his cellular phone to get directions when his vehicle hit a concrete island on the left, and veered through the right lane down an embankment into a tree.

- **Case 2:** The driver of the vehicle took his eyes off the road while attempting to “use” a cellular phone and the vehicle veered to the right, striking a curb.

- **Case 3:** The driver was talking on a cellular phone and proceeded to turn left at an intersection as the light was turning yellow/red, and turned into the path of an on-coming vehicle.

- **Case 4:** The driver attempted to answer the cellular phone and ran off the road into a tree.

- **Case 5:** The driver, reaching for a cellular phone, ran a red light and struck another vehicle.

- **Case 6:** The driver was answering his cellular phone, when he looked up and saw a vehicle stopped in front of him and was not able to stop in time.

- **Case 7:** The driver “was distracted by a cellular phone” and skidded into an intersection against a red signal and struck another vehicle.

- **Case 8:** The driver was talking on a cellular phone and “not paying attention” when she rear-ended another vehicle stopped for a crossing pedestrian.

- **Case 9:** The driver was talking on a cellular phone and did not see a red light until it was too late to stop for an on-coming vehicle.

- **Case 10:** The driver was talking on a cellular phone and made a left turn into another turning vehicle in an adjacent turning lane.

These case reports, while they do not provide definitive cause-effect evidence, suggest that cellular phone use while driving has proven to be hazardous in certain real-world circumstances.

In a pilot program in the Baltimore-Washington area, Dynamic Science Inc. (DSI) was contacted by police agencies whenever a cellular phone-related crash came to the attention of the police (NHTSA, 1997a). A special DSI crash investigation team was then commissioned to perform an in-depth investigation of the crash. During the 6-month period of the pilot, seven crashes were reported to DSI. Each of these crashes had notable circumstances or consequences: one involved a driver denying reports of witnesses that he was using a cellular phone prior to the collision; another involved a state trooper who refused to release information about the crash to DSI; another involved a driver talking and writing down notes (directions) prior to the collision; two cases involved drivers receiving calls prior to their respective collisions; one involving the death of the cellular phone user's child; one involved a cellular phone user involved in a head-on collision where a police officer was killed; and one involved a driver who struck a school bus from behind while picking up her cellular phone (NHTSA, 1997a, Section 3.7).

The National Police Agency of Japan also studied the frequency of cellular phone use antecedent to motor vehicle crashes (NHTSA, 1997a). In the month of June 1996, 129 crashes involving cellular phones were identified: 76% involved rear-end impacts, 2.3% were single-vehicle crashes, and 19% were categorized as "others" (presumably frontal or side impacts with other vehicles at intersections or during lane changes). At the time of the crash, 42% of drivers were responding to a call, 32% were dialing, 16% were conversing on the phone, and 5% were hanging up the phone (remaining cases unknown). There are also news reports that the Japanese ban on the use of hand-held cellular phones while driving has been followed by a reduction in phone-related crashes, though a scholarly evaluation has not yet been published (Yomiuri, 1999). It is not known whether the determinations in the Japanese data have greater or lesser validity than the determinations found in U.S. investigations of crashes.

NHTSA (1997a) has noted that the percentage of Japanese crashes involving dialing appears to be larger than observed in the U.S., where distraction from conversation appears to be a more common mechanism of crash causation. Crash circumstances in the U.S. may also be somewhat different. In order of frequency, the crash circumstances involving cellular phones in the U.S. include drivers moving out of designated lanes, drivers striking a stopped vehicle in the same lane, and drivers failing to stop for a red traffic signal.

In summary, despite the uneven quality of case reports and the inability to draw rigorous cause-effect inferences from post-crash investigations, these case reports suggest that use of a cellular phone while driving has caused or contributed to motor vehicle crashes, injuries and fatalities in the U.S. and abroad. The types of driver distractions noted in police reports of phone-related crashes are consistent with those predicted by driver performance studies. What cannot be determined from any individual crash report is the magnitude of risk (elevation in crash probability) that is associated with use of a cellular phone while driving.

Overall Trends in Crashes and Fatalities. If use of a cellular phone while driving is an important causal factor in motor vehicle collisions, injuries, and fatalities, one might expect that the recent growth in cellular phone use would produce an increase in the overall number of motor vehicle collisions, injuries, and fatalities. The growth in cellular phone use has been explosive and concentrated in a relatively short time period in the U.S.; therefore, any substantial adverse effect should be immediately observable, since there would not be any expected latency period to detectable effect that is typical of technologies or behaviors that cause chronic diseases.

Analysts have searched for such a correlation in national, state, and local data. We have chosen to report selected data of this type because they are often cited in the cellular-phone policy debate. Yet, as we shall see, these data are unlikely to provide any persuasive evidence, of either an incriminating or reassuring nature.

When national traffic fatality counts are used as the dependent variable, there does not appear to be any simple association between fatalities and national cellular phone subscriptions (a surrogate for the extent of cellular phone use while driving). Figure 2, for example, plots data for the U.S. mileage fatality rate and U.S. cellular phone subscriptions (in millions) for the 1970-1999 period. Similarly, figure 3 presents traffic fatalities and cellular phone subscriptions in the U.S. There is no indication in Figures 2 or 3 of an explosive growth in the number of traffic fatalities or in the mileage fatality rate that is attributable to cellular phone use.

Traffic safety researchers do not find much reassurance in the data presented in Figures 2 and 3 because there are many powerful variables (beneficial and adverse) that influence overall fatal crash statistics. As an example, if cellular phones were in fact causing 500 additional fatalities each year in the U.S., the problem – even though large in absolute magnitude – might be masked in the aggregate data by recent reductions in accident fatalities from campaigns against drunk driving and for safety belt use.

Alternatively, if cellular phone use were to increase the risk of motor vehicle collisions but primarily in less severe crashes (i.e., those collisions least likely to cause a fatality, such as rear-end impacts), then one would not expect to see a simple correlation between traffic fatalities and cellular phone use. For example, in rush-hour traffic where cellular phone use is common, fatal crashes account for a disproportionately small share of crashes because congestion produces low-speed collisions in which vehicles may be damaged but occupants receive little or no injury. The times of the day, week, and year when drivers are particularly susceptible to severe, fatal crashes (*e.g.*, weekend nights) are not necessarily periods when use of a cellular phone while driving is particularly likely. Although fatal crashes are of obvious human significance, they may not be the most important outcome when scientists study the risks of using a cellular phone while driving.

Figure 2. Traffic Fatalities per Billion Vehicle Miles Traveled and U.S. Cellular Phone Subscribers in Millions, 1970-1999.

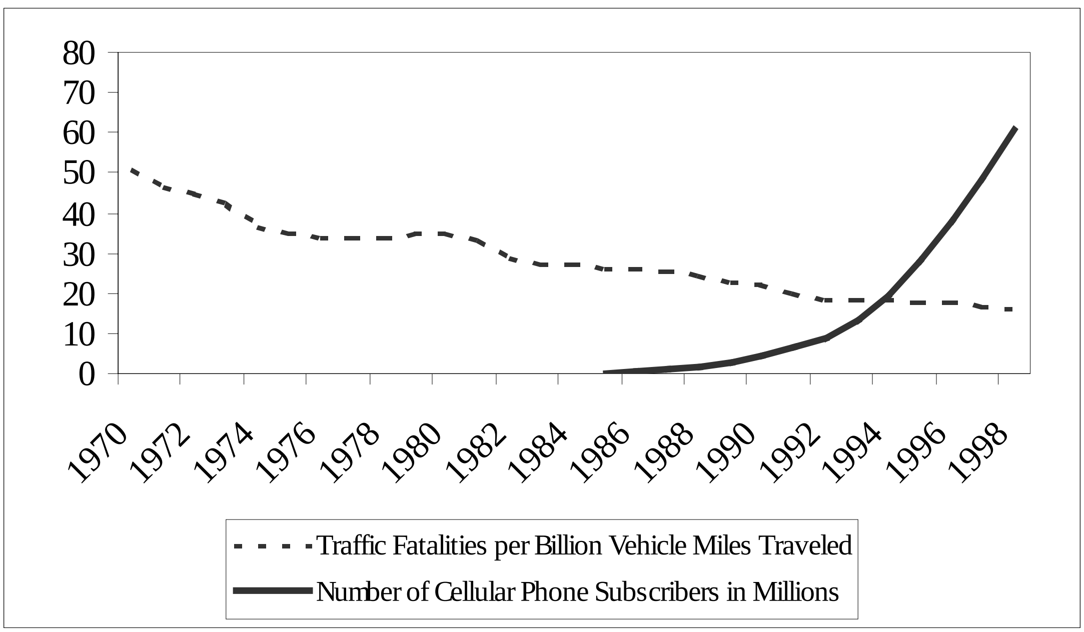
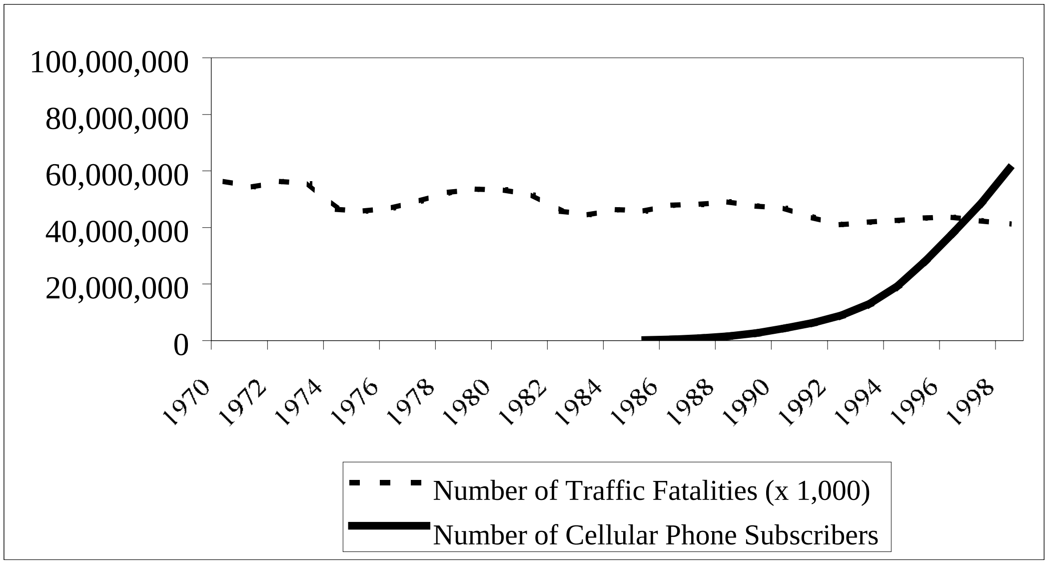


Figure 3. Traffic Fatalities and U.S. Cellular Phone Subscribers, 1970-1999.



Researchers in the state of North Carolina made an effort to determine whether increases in cellular phone use from 1989 to 1995 were associated with an increase in the frequency of police-reported motor vehicle crashes. The circumstances of each accident were detailed in the reporting police officer's "narrative", a description of how the crash occurred and what the contributing factors were. Researchers then used a key-word search of narratives to identify crashes involving cellular phone use. This exploratory study, cited in NHTSA (1997a), did report a positive correlation between cellular phone subscriptions and collisions. The absolute number of phone-related crashes did not increase as sharply as the number of cellular phone subscriptions. Nonetheless, useful information was extracted from these narratives regarding the nature of cellular phone use that may have contributed to crashes. Reaching for cellular phones and picking up dropped cellular phones were considered major contributors to crashes. The major limitations of this study are that errors in police reporting of crashes are likely to be significant, with both false-negative errors (missing cases) and false-positive errors (crashes unrelated to cellular phone use).

A more recent study in metropolitan Toronto, Canada also used police-reported crashes as the dependent variable in a time-trend analysis (Min and Redelmeier, 1998). The objective was to determine whether the change in collision rates from 1984 to 1993, at a street-by-street level, was correlated with the growth of cellular phone usage. Cellular phone usage at each of the study's locations was estimated by the density of cellular towers (or antennae) in the surrounding area. The police officer's judgment as to whether cellular phone use played a role in the crash was not used in this study. The authors controlled statistically for two potentially confounding variables: pedestrian flow and traffic flow. The average street location in Toronto had 9 more collisions in 1993 than 1984. However, locations in Toronto with 6 or more towers had a smaller average increase in collision rates than locations with 5 or fewer towers. The authors caution that there may have been biases in their research design that could have concealed a real, positive association between cellular phone use and collision frequency. Their conclusion was that ". . . the effects of cellular phones on collision risk are smaller than the biases of ecological analysis" (Min and Redelmeier, 1998, p.160).

In summary, aggregate statistical analyses of crash data (so-called "ecological" studies) do not provide convincing evidence that the growth of cellular phone usage while driving is associated with an increase in the number of traffic fatalities or collisions. While this lack of evidence suggests that use of cellular phones while driving has not caused an explosive growth of traffic collisions, injuries, and fatalities, these kinds of "ecological" studies are too crude (imprecise) to detect substantial risks that would be of interest to motorists and policymakers (Min and Redelmeier, 1998).

Epidemiological Studies. Four epidemiological studies in the peer-reviewed scientific literature have assessed the association between use of a cellular phone and involvement in motor vehicle collisions. By "epidemiological", we refer to studies that employ individual-level data on cellular phone use and traffic crashes in conjunction with modern statistical tools.

Violanti and Marshall (1996) were the first to study the association between use of a cellular phone and motor vehicle collisions. Their "case-control" study of New York State residents compared the experience of 100 randomly selected drivers (the "cases") who had been in an accident within the past two years to the experience of 100 different, randomly selected drivers (the "controls") who had not been in an accident for the previous 10 years. The cases were drivers in crashes severe enough to cause at least $1,000 in property damage or personal injury (so-called "reportable" accidents). A mail survey was conducted to obtain demographic and risk factor information on each case and control (response rates were 60% for the cases and 77% for controls), including information on cellular phone use while driving. Of those subjects reporting use of a cellular phone while driving (11%), the majority reported use of a hand-held design.

Both cases (13%) and controls (9%) reported at least some use of a cellular phone while driving. The authors, using logistic regression analysis, reported that the amount of cellular phone use, categorized as median time per month on the phone while in the vehicle, was strongly associated with the risk of a traffic collision (adjusted odds ratio (OR) = 5.59; 95% confidence interval (CI) [1.19-37.33]). An important feature of this study was control for other risk factors for accidents including average miles driven per year, years of driving experience, driver age, and 18 self-reported behavioral variables ranging from smoking while driving to dozing off while driving.

This study has several important limitations. No information is provided about crashes involving serious injuries or fatalities. The sample sizes in both groups are small and the data are too sparse to compare hand-held and hands-free designs. The reliability and validity of the self-reported information in this study – the information on cellular phone use and other risk-taking behaviors (*e.g.*, miles driven) – is not assessed by the authors. No information was collected about whether a cellular phone was actually in use by cases when the accident of interest occurred.

A larger and better designed study was performed by Redelmeier and Tibshirani (1997) in metropolitan Toronto, Canada. Among the subject pool of 5,890 drivers, of whom 1064 acknowledged having a cellular phone, 699 met study inclusion criteria of having been in a car collision resulting in substantial property damage but no personal injury. In addition, each driver's cellular phone calls on the day of the collision and during the previous week were analyzed through detailed billing records. A total of 26,798 cellular phone calls were made during the 14-month study period.

This study employs a "case-crossover design", wherein each driver serves as his or her own control. Cellular phone usage 10 minutes prior to the collision is compared to usage during a control period on the day before the collision. Case-crossover analysis would identify an increase in risk from cellular phone use if there were more phone calls immediately before the collision than during the time period on the previous day, allowing for chance fluctuations in the frequency of cellular phone calls.

Overall, 170 subjects (24%) had used a cellular phone during the 10 minutes immediately before the collision, 37 (5%) had used the cellular phone during the same period on the day before the collision, and 13 (2%) had used the cellular phone during both periods. An adjusted statistical analysis revealed that cellular phone activity was associated with a relative risk of motor vehicle collision of 4.3 (95% CI, 3.0 - 6.5). The relative risk was 4.8 for calls within 5 minutes before the collision as compared to 1.3 for calls more than 15 minutes before the collision. A similar result was found when the sample was restricted to those crashes whose time of occurrence was known exactly. The authors detected no statistical safety advantage of hand-held over hands-free cellular phones, and therefore postulated that the distraction of conversation or attention, rather than manual dexterity involved in activities such as dialing, is responsible for cellular-phone related collisions.

Despite its many strengths, this study also has important limitations. As the authors note, the reported association may not be causal since underlying road conditions (*e.g.*, congestion or poor weather) might cause both cellular phone use and crashes. No information is provided about crashes involving serious injuries or fatalities. The refusal of many drivers (30% of 1064 drivers) to participate in the study may have induced a downward bias in the relative-risk estimates. The validity of the reported information regarding time of collision – even for the so-called "exact times" – is unknown. Although most of the calls were less than 2 minutes in length, the authors focused their analyses on 5-minute and 10-minute time intervals prior to the collision (though shorter intervals were also analyzed). On the other hand, it is possible that driver distraction (due to the cellular phone) can cause a crash before or after a call takes place. In order for the relative-risk estimates to be interpreted as causal, the collision day and the day preceding the collision must be assumed to be comparable with regard to multiple risk factors.

Violanti (1998) used a case-control design in the state of Oklahoma to determine whether or not use of a cellular phone was associated with fatal crash involvement. Since 1992, police in Oklahoma have been provided, on standardized accident report forms, a "check box" for officers to indicate the presence and/or use of a cellular phone. Over a four-year period (1992-1995), 223,137 cellular phone-related accident reports were obtained from the Oklahoma State

Department of Public Safety. Of 1,548 driver fatalities, 65 (4.2%) had a phone present in the vehicle, and 5 (7.7%) were reported to have been using their phones at the time of the collision.

In order to determine whether or not cellular phone use increased the risk of fatal crash involvement, the author compared "cases" (fatally injured drivers) to "controls" (drivers who survived). The author hypothesized that if cellular phones were to increase fatality risk, the presence of phones and/or the reported use of phones should be more frequent among cases than the controls. To justify this analysis, it was presumed that phone presence indicated an elevated probability of dialing and/or use, since use may be underreported to or by police. A limited number of potential confounding variables were controlled in statistical analyses (age, gender, type of collision, driver actions, reported cause of collision). The author calculated an adjusted odds ratio of 9.29 (95% CI, 3.70-23.14) for cellular phones <u>in use</u> by the driver and a corresponding 2.11 (95% CI, 1.64-2.71) for cellular phone <u>presence</u> in the vehicle.

This study suffers from several serious limitations. First, the author acknowledged that cases may differ from controls by a variety of unmeasured dimensions associated with fatal crash involvement (*e.g.*, total miles driven, number of miles driven on high-speed roads, number of miles driven while fatigued, and other sources of driver distraction such as eating or smoking while driving). Second, the author expressed confidence that police reporting of cellular phone presence and use is accurate and complete. This confidence is not buttressed by any reported validity data. In particular, the study's key findings are biased against the safety of cellular phones if police are more successful in capturing cellular phone presence/use for cases (fatally-injured drivers) than for controls (drivers who survive). It is certainly plausible that police are more diligent in investigating and reporting information about fatal than nonfatal crashes. It is also plausible that surviving drivers are more successful in concealing the presence and/or use of cellular phones. No phone records are typically used by police to establish phone use and thus the author reports “phone use was likely the result of expert judgment on the part of police or reported by witnesses” (p.523).

In a separate report, NHTSA (1997a) analyzed the process by which police in Oklahoma code information on cellular phone presence and use. The data are collected by the investigating officer, generally at the scene of the crash. Officers are trained to look into the crash-involved vehicle to see if a cellular phone is present. Installed phones and large portable units are likely to be visible but more popular hand-held models may not be readily visible. If a phone is observed, the driver (or any other witness) is asked if (s)he was using the phone at the time of the crash. If a positive response is received, then the “in use” box is checked. NHTSA (1997a) believes that underreporting of presence is likely for hand-held phones and for phones that are not visible. Moreover, potentially culpable or simply nervous drivers may be less inclined to acknowledge that they were using their cellular phones at the time of the crash. Witness testimony may be more reliable in some cases but it is often unavailable since many crashes that kill drivers involve no other passengers. NHTSA (1997a) authors also concluded, based on discussions with instructors at the Oklahoma State Police Training Academy, that “there are no strict guidelines for collecting this (cellular phone) information, and it cannot be determined from the data whether a cellular phone was being used at the time of the crash or was being used to report the crash” (Ch.6, p.5).

In addition to these problems, Cher *et al*. (1999) have expressed concern about the sensitivity of Violanti’s findings to the small number of driver fatalities where cellular phones were reported in use (N = 5). They also note several anomalies in how the data are reported and raise serious questions about whether the data were analyzed properly.

Dreyer *et al*. (1999), extending previous work by Rothman *et al*. (1996), have reported the mortality experiences of a large cohort of users of cellular phones. The cohort was compiled from two large U.S. cellular phone carriers serving several metropolitan areas. Detailed billing information and demographic data were obtained on each noncorporate customer, with these records linked to the National Death Index to ascertain mortality experience. The authors found that only one cause of mortality (of several dozen examined) was positively associated with cellular phone use (average minutes of daily use): death from a motor vehicle collision. To evaluate the association between phone use and fatal motor vehicle collisions, data for hand-held cellular phone users and car phone users were pooled and examined for trends of fatality risk with increasing phone use. The reference group for this comparison was phone users with the least amount of use; thus, the association relates to more use compared with less use. For categories of use of less than 1 minute per day, 1 to 3 minutes per day, and more than 3 minutes per day, the authors found motor vehicle mortality rates of 5, 10, and 12 per 100,000, respectively. A similar association was reported with number of calls per day, though an inverse trend was found with history of cellular phone use (in years). The authors acknowledge that they do not know which calls were placed from a motor vehicle or whether a cellular phone was in use immediately prior to a crash.

This promising study reveals an important statistical association that needs to be analyzed in more detail. The association may reflect a cause-effect relationship, or it may be that drivers who use cellular phones more frequently, compared to less frequent users, happen to have more exposure to fatal crashes (*e.g.*, because they drive more frequently or in a more risk-prone manner).

In summary, there are four epidemiological studies published in the peer-reviewed literature which examine whether use of a cellular phone while driving is associated with risk of traffic accident involvement. The two studies of police-reported collisions suggest that use of a cellular phone is associated with collisions that involve property damage, but these data do not address serious or fatal injuries. The two studies that address risk of fatal collisions are positive but problems with data quality and potential confounding variables preclude a confident cause-effect inference. Nonetheless, the epidemiological evidence is qualitatively consistent with the suggestions of risk found in the driver performance studies and the case reports of crashes. The strongest epidemiological evidence to date (Redelmeier and Tibshirani, 1997) is used below in a quantitative risk comparison.

Risk Comparisons. The purpose of risk comparisons is to provide readers an intuitive grasp of risk magnitude (Crouch and Wilson, 1982). Risk comparisons are a helpful risk communication device but they do not, by themselves, establish whether or not a risk is acceptable (Roth, 1990). Judgments about risk acceptability require risk-benefit comparisons as well as ethical considerations.

Although the precise risks of using a cellular phone while driving are unknown, it is feasible to perform a risk assessment using the best available data and plausible (yet unverifiable) assumptions. We estimated two types of risks: (1) the risk of fatality to the user of the cellular phone, which we compared to other voluntary risks that drivers accept; and (2) the risk of cellular phone use to other road users (occupants of other vehicles, pedestrians, bicyclists), which we compare to other involuntary risks in daily life. We recognize that there is subjectivity in deciding which risks are voluntary and which are involuntary.

We omitted from our calculations risks incurred by passengers traveling with a driver who uses a cellular phone because it is not clear whether these individuals incur the associated risks voluntarily or involuntarily. It is likely that many passengers choose to ride with a driver even though they know the driver may use a cellular phone. On the other hand, some passengers may not be aware beforehand that the driver will use a cellular phone, or may have no choice about riding with the driver (*e.g.*, children).

The "voluntary" incremental fatality risks as a driver were calculated by multiplying the annual risk of being in a collision while driving and using a cellular phone (using estimates reported by Redelmeier and Tibshirani, 1997) and the conditional probability of being fatally injured in a collision. The "involuntary" incremental fatality risk to third parties is the product of three quantities: the number of individuals using a cellular phone while driving, the annual probability of being in a collision while driving and using a cellular phone, and the average number of fatalities per collision to individuals not riding with the cellular phone user. More detail on these calculations, including input data and assumptions, is reported in Appendix A.

Table 3 reports the magnitude of voluntary risks assumed by drivers. The annual probability of driver fatality due to cellular phone use is smaller than the risk of not wearing a safety belt, yet larger than the risk of taking a short trip on a rural road instead of a safer interstate highway. In absolute terms, the average annual probability of death to a driver using a cellular phone is about 6 chances in 1,000,000 (assuming 318 minutes of use per year, or about 26 minutes per month – the estimated average usage rate among cellular phone owners while driving during 1999 [PCIA, 1999]).

Table 3. Voluntary Risk Factors Affecting Driver Fatality Rates.

Risk Factor	Relative Risk While Risk Factor is Applicable	Annual Time or Miles During Which Risk Factor is Applicable	Annual Fatalities per Million Drivers
Driving while using a cellular phone	4.3	318 minutes	6.4
Driving with a blood alcohol concentration at the legal limit of 0.10% for one-half hour, 12 times per year (hypothetical)	15	360 minutes	30.9
Driving without wearing a lap and shoulder belt (assumes vehicle has airbags)	1.41	Always	49.3
Driving in a small car instead of a large car (1,000 pound difference in weight)	1.11	Always	14.5
Driving 60 miles once per year on a non-interstate rural roadway rather than on a rural interstate highway	2.78	60 miles	1.5

Note that the estimated risk associated with using a cellular phone is uncertain. Redelmeier and Weinstein (1999) point out that the confidence interval for the relative risk, which reflects uncertainty introduced by the limited sample size in Redelmeier and Tibshirani (1997), ranges from 3.0 to 6.5. That source of uncertainty alone indicates that the true incremental risk to a driver associated with the use of cellular phone for 318 minutes per year while operating a motor vehicle ranges from 61% to 167% of the central value reported in Table 3. There are other potentially important sources of uncertainty that are discussed in Section 1.1 of Appendix A, including:

- The possibility that fatalities are underrepresented in accidents at times when cellular phones are typically used (*e.g.*, rush hour), a factor not reflected in the Redelmeier and Tibshirani relative risk estimate;
- The possibility that collision rates are higher at times when cellular phones are typically used (*e.g.*, because traffic density is greater during rush hour) or lower at these times (*e.g.*, because typical road speeds are lower);
- The possibility that the collision and fatality risks remain elevated after a cellular phone call ends.

The magnitude of the uncertainty induced by these factors is difficult to quantify. The overall uncertainty associated with the cellular-phone risk estimate is likely to be larger than the uncertainties associated with the other risk factors reported in Table 3.

Involuntary risk estimates are reported in Table 4. Given the current rate of cellular phone use in the U.S., the average annual probability of being killed in a crash by a cellular phone user is about 1 in 1,000,000. This probability will increase as cellular phone use increases, unless new users are more cautious than current users, or unless motorists take new precautionary measures to protect themselves. A person is less likely to be killed in a crash caused by a cellular phone user than to be killed as a pedestrian, to be killed by a drunk driver, or to be killed in a crash involving a heavy truck. The average risks imposed on others by cellular phone users are larger than the risks of being struck and killed on the ground by a crashing airplane.

Table 4. Involuntary Risk Factors Affecting Fatality Risks.

Risk Factor	Annual Fatalities per Million Individuals in the U.S. Population
Motorist struck and killed by driver using cellular phone	1.5
Sober driver struck and killed by driver with a non-zero blood alcohol concentration	17.6
Motorist struck and killed in crash with large truck	16.8
Person struck and killed on ground by crashing airplane	0.013
Pedestrian struck and killed in motor vehicle crash	22.2

Note that the same sources of uncertainty discussed in the case of voluntary risks associated with cellular phone use also apply to the first risk estimate listed in Table 4.

Section 4. Benefits of Using a Cellular Phone While Driving

In this section, we define "benefits" as any positive consequences – whether tangible or intangible – of using a cellular phone while driving that may accrue to the user of the phone, the user's family or household, the user's social network of friends and acquaintances, the user's business, or the community as a whole.[6] We define "disbenefits" as adverse consequences of cellular phone use while driving other than those related to the risk of motor vehicle collisions. In any discussion of the benefits of cellular phone use, we recognize that it is difficult to determine which of these benefits relate to use of the phone <u>while driving</u> and which could be maintained if calls were made at other times. We address this complicated issue in Section 5, reserving Section 4 for a qualitative identification of benefits and disbenefits that should be considered.

Focus Groups

Our review of the scientific literature uncovered few studies that identified the benefits of using a cellular phone while driving. Given the lack of previous research to identify benefits, we conducted a series of exploratory focus groups to identify the types of perceived benefits of using cellular phones while driving.

The authors commissioned Axiom Research Company, LLC of Cambridge, MA to conduct a total of three focus groups in each of two markets of varying size. Springfield, MA and Los Angeles, CA were selected to represent mid-size and large-size markets, respectively. In each market, two focus groups were conducted among consumers and one was conducted among a specialized group of emergency medical personnel and dispatchers (*e.g.*, police dispatchers, AAA, and tow-truck personnel). A total of 52 participants attended the groups, with an average of 7 in each of the emergency personnel groups and 9.5 in each of the consumer groups. The two consumer groups were divided so that one consisted primarily of "commuters" (defined as those with at least a 20-minute drive to work in Springfield or at least a 30-minute drive to work in Los Angeles) and the other "non-commuters" (including those who commute, but less than the durations required for commuters). All participants in the consumer groups were required to own cellular phones and report that they use them while driving a motor vehicle. Each focus group lasted approximately 90 minutes; all were conducted in early March, 2000. Protocols for the focus groups were reviewed and approved by the Human Subjects review committee at Harvard University. More information on the recruitment and analysis methods, in addition to participant characteristics, is included as Appendix B. A full report of the results of the focus groups (Axiom Research Company, 2000) is available from the authors upon request.

Our focus groups did not include people who own cellular phones but do not use them in the car. We also did not include people who do not own cellular phones. Thus, drivers in general are likely to have different perceptions of risks and benefits and thus are worthy of study in the future.

Several limitations inherent in focus group research are important to keep in mind while reviewing this section. The purpose of focus groups is to provide context and depth to a research topic (Barbour and Kitzinger, 1999). The results of focus group research are neither representative of nor generalizable to the population of cellular phone users in a particular geographic area or across the United States. Focus groups can be subject to a "social desirability" bias whereby participants may provide responses that are perceived as being pleasing to the moderator or to other participants. In addition, results can be biased if they reflect the opinions of participants who are naturally more vocal than other participants. While

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[6] The economics of regulating the use of cellular phones while driving is addressed in Section 5.

skilled focus group moderators can mitigate these biases, they cannot be completely controlled for during the group discussion or in the analysis.

Below we discuss the major types of benefits that were identified either in the focus groups or the existing literature. It should be noted that while this section describes the range of benefits perceived by consumers and emergency personnel, it does not provide context as to the frequency with which they occur, nor their magnitude or value. We also do not address which types of benefits are most likely to be lost by a prohibition on cellular phone use <u>while driving</u>.

Personal Benefits

The following are categories of benefits to the user of a cellular phone that are salient to cellular phone owners and users:

- <u>Preventing Unnecessary Trips</u>. Use of a cellular phone while driving can reduce unnecessary trips, minimize the length of trips, and diminish overall time on the road by allowing more effective communication with household members, friends/acquaintances, and other parties whose schedules and transit plans need to be coordinated with the schedule of the cellular phone owner/user. Curtailing unnecessary trips and travel time is not just a time-saving matter; it also curtails exposure to traffic crashes, injuries, and fatalities, cuts fuel expenses, reduces pollution, and reduces wear and tear on a motor vehicle. The ability to make calls while driving may also stimulate some additional travel such as making a stop at the grocery store. Typically this travel has additional value to the owner; otherwise, (s)he would not undertake the additional travel.

- <u>Diminishing the Tendency to Speed</u>. When a driver is running late, (s)he may have a tendency to speed in order to reach the destination quickly, thereby reducing the imposition on others at his/her destination. Yet, a call from a cellular phone by the driver can notify colleagues of late arrival and diminish the driver's urge to speed. A possible disbenefit would be excessive speed by a driver who is distracted by use of the cellular phone and does not pay attention as his/her speed exceeds the posted limit.

- Contributing to Security and Peace of Mind. Knowing that it is permissible to use a cellular phone while driving reduces worry and stress while contributing to peace of mind. The ability to achieve virtually instant communication, whether from or to a driver, provides the driver a psychological reassurance that unexpected events of the day can be managed effectively and that worries related to uncertainties can be resolved by instant news conveyed through a phone call. The added sense of security may arise when traveling alone, at night, in poor weather, in a crime-ridden part of town, in an unfamiliar location, or at any moment when the driver is feeling vulnerable.

Cellular phone use may also contribute to actual (as well as perceived) security by decreasing stress and time on the road when a driver is lost. Women in particular mention using cellular phones while driving to obtain directions when trying to find an unfamiliar location or when disoriented by environmental conditions (*e.g.*, inclement weather or nightfall).

A disbenefit of cellular phones is the potential to increase stress while driving in the case of “road rage.” For example, a motorist may call emergency services to report another motorist who cut him off (a minor traffic offense) rather than forgetting the incident. This rage can now be acted on, with the driver weaving through traffic to follow the offending car and reporting its position to police.

Being able to be contacted while on the road may not always be beneficial. Another disbenefit of cellular phones is that the increased accessibility, including repeated incoming calls from others, may lead to increased stress and ultimately decreased personal peace of mind.

- Improving Mental Alertness. Cellular phones may also increase alertness on what might otherwise become a long, monotonous drive. There is some evidence of increased awareness in the literature: Drory (1985) found that voice communication while driving long distances significantly decreased driver fatigue.
- Facilitating Privacy in Communication. Making a phone call while driving alone in one's vehicle can provide a measure of privacy in communications that is not always available when phone calls are initiated from one's home, business, or a public place. Moreover, emergency services personnel report that they use cellular phones if they want to talk freely about sensitive information that they do not want broadcast across police radio.
- Expanding Productivity for Commuters. Among consumers with long commutes to and from work, conducting personal and business matters by phone while driving is sometimes considered a necessity since these people spend a substantial percentage of their workday in their motor vehicles. Yet, consumers also report using their cellular phones to call radio stations for promotions, giveaways, or to join talk shows.

For the cellular phone user, being accessible while driving (and being able to reach others while driving) is not always perceived as being beneficial. There are some occasions where the driver might prefer not to be reached, at least by particular people or on particular matters, but even in these situations new technology (such as caller ID) is allowing drivers to be more selective about who can reach the driver and when they can be reached. The consumers in the focus groups were of the general view that the personal benefits of using a cellular phone while driving far outweighed any disbenefits and risks, even though they recognized a measure of risk from this particular use.

Family/Household Benefits

As the hand-held cellular phone has transitioned from primarily business use to a wide range of uses within households, there are clear day-to-day benefits that have accrued to households. Here are some categories of household benefits and examples that are salient to cellular phone owners/users:

- <u>More Efficient Execution of Household Responsibilities</u>. Communication among household members, while at least one member is in transit, facilitates the accomplishment of household chores, whether it is picking up a gallon of milk on the way home from work, providing notice of an early or late arrival to the dinner table, or making a last-minute adjustment as to who can more readily pick up younger members of the household from day care, soccer practice, or other activities.
- <u>Parental and Familial Peace of Mind</u>. When teenagers drive, parents worry. Similar concern is expressed for other members of the household (spouses or parents), particularly if they are driving long distances or driving late at night. Knowing that these individuals can, if necessary, call home while driving or can be contacted while in transit – even if this capability is rarely exercised – contributes to peace of mind for all concerned family members. Yet the risks of teens using a cellular phone while driving are also a source of worry. There may also be a tangible aspect of this benefit. A teacher or caregiver can reach the parent at any time (even in the car), and parents can check on their child at any time. Use of these capabilities may result in safer and healthier children.
- <u>More Time at Home</u>. Use of a cellular phone while driving permits a parent to leave the office earlier, making calls on the commute home, and thereby spend more time with his/her children.

Social Network Benefits

Some researchers have suggested that America is losing its "social connectedness," sometimes referred to as social capital, as networks of friends and acquaintances weaken in the face of growing time pressures and the commercialization of life (Putnam, 1995). Declines in social capital have also been suggested to have detrimental effects on health-related outcomes (Kawachi, 1999). The use of a cellular phone while driving may help counteract the deterioration of social networks by allowing motorists to capitalize on otherwise idle time to stay in touch.

- <u>Increased Social Connectedness.</u> Caught unexpectedly in a 90-minute traffic jam, the driver places a call to a friend he or she has been remiss about contacting, using this time window as a way to reconnect with friends and associates.

- <u>Coordinating Social Engagements</u>. A social engagement that is jeopardized by scheduling conflicts is rescued rather than cancelled as a driver in transit makes one or more calls at a critical time to hold the engagement together or to reschedule it. Coordinating such events reduces stress on both parties, which might otherwise strain interpersonal relationships. Focus group participants also noted the social disbenefits of widespread cellular phone use. Cellular phones ring during meetings or at the theatre. People talk on cellular phones while they are at a party or business function. Inappropriate or rude use of cellular phones has a negative effect on social connectedness.

Business Benefits

Increased use of automated answering or voice messaging systems – often a result of workers on the move – has contributed to frustration among workers and clients trying to get in touch with employees. Possession of mobile technology, such as cellular phones, by workers enhances relationships with clients by improving response time to their calls. This technology also increases business productivity by making employees more efficient and accessible while traveling.

- Increased Productivity and Efficiency. Mentioned earlier as a benefit to the user, cellular phone use can also help businesses by creating productive time out of idle time otherwise spent commuting to the office or traveling between job sites. In business, time is money; conducting business over the phone while driving can generate revenue and allow employees to seize opportunities in a fast-paced, competitive environment.

- Increased Responsiveness to Clients and Co-workers. Making it possible to contact workers while driving improves an individual's responsiveness to issues that arise with his/her clients or co-workers. For example, an anxious co-worker is trying to find an answer to a question before a client meeting and is able to do so on his cellular phone while he drives between other client sites. This increased responsiveness likely improves relationships with clients. Clients know that they can reach the consultant in charge of their account almost immediately in a time-sensitive situation. This ability is especially valuable in industries such as financial services that require quick action. Immediate contact or quick response contributes to clients' feeling more secure about the organization, and about the value of their business to the company.

Community Benefits

Communities as a whole benefit from the use of cellular phones while driving. These benefits range from providing emergency services personnel with more accurate and complete information as they approach an accident or crime scene, increased ability to apprehend criminals or thwart a crime in progress, and decreased response time to arrive at roadside emergencies.

- Improved Knowledge of Emergencies. Emergency personnel report that, because motorists use cellular phones from their cars to report emergencies, emergency personnel are better able to anticipate the emergency situation and what types of equipment might be needed. Several emergency workers reported that they receive information from multiple callers with different views of the same scene. This information may help emergency services to better distribute resources (vehicles, manpower), and it has the potential to save the lives of emergency workers (especially police). For example, a motorist reporting a roadside emergency who notes that a gun is being waved warns police to approach the scene with greater caution.

- Apprehending Criminals. Emergency services personnel are receiving more help in identifying and apprehending criminals from citizen drivers. Drivers report more suspicious activity (speeding, road rage, reckless driving) or offenses (*e.g.*, carpool lane violators) on the road than ever before and can provide detailed information about the route the car is taking, car make and model, license plate, and driver characteristics – largely because they have the ability to call while driving. Emergency services personnel overwhelmingly noted that motorists report drunk drivers, which previously occurred only rarely. Getting drunk drivers off the road improves road safety for the drunk driver himself, for any passengers in his/her vehicle, and for all other road users (pedestrians, bicyclists, drivers, passengers). More generally, the growing proportion cellular phone users in motor vehicles may have an unmeasured deterrent effect on reckless driving and other criminal behavior. Would-be offenders are now aware of the ease with which citizens can report a crime through prompt use of a cellular phone while driving.

- Decreased Accident Response Time. The hour immediately following a traumatic injury is referred to as the "golden hour" in medicine: the time during which an individual who has suffered severe injury has an increased likelihood of survival if medical attention is received. Motorists with cellular phones report roadside accidents immediately after they occur, which improves the overall response time of emergency personnel. Reporting roadside emergencies may benefit the user if he or she were involved in the accident. However, this benefit also extends beyond the user to the community at-large, in a "Good Samaritan" effect. A survey of over 700 Australian cellular phone users confirmed the widespread use of cellular phones for this purpose: 12% of respondents reported using their cellular phones to contact authorities to report roadside accidents involving others (Chapman and Schofield, 1998).

The ability to use cellular phones while driving to report accidents has a downside. Increased numbers of calls to 911 have led to emergency response systems being inundated with calls reporting the same event. It has been suggested that this increased volume can delay other emergencies from being reported and responded to quickly. In addition, emergency personnel have reported an increased number of calls for non-emergency situations. For example, motorists will call to report that their vehicle has broken down along the highway, an event that does not require an immediate emergency response.

Summary

There are numerous benefits to being able to use cellular phones while driving. However, the frequency of these benefits is unknown, as researchers have yet to quantify them. Moreover, the value of each benefit has not been assessed: some benefits may be worth more than others as contributions to the common good. Many of these benefits also have tradeoffs. For instance, the increased accessibility of individuals by cellular phone may contribute to a feeling of lost privacy, and the increased reporting of accidents can overwhelm emergency response systems. Perhaps most importantly, it is not clear which of these benefits would be lost if cellular phone use while driving were banned, since use of the technology at other times would still be permitted (see Section 5).

Section 5. Benefits Foregone if Cellular Phone Use While Driving is Restricted

A critical question is whether a ban or restriction on the use of cellular phones while driving would cause any loss of the benefits of cellular phone use. It is often argued that users can make whatever calls they need to make at times other than when they are operating a motor vehicle. For example, a driver may pull over to the side of the road, stop the vehicle, make a call, and re-enter traffic after the call is completed.

There are several ways that a regulation of cellular phone use while driving might result in a loss of benefits from the use of cellular phones. None of these possibilities has yet been investigated rigorously in the scientific or policy literature.

First, a prohibition on the use of cellular phones while driving might curtail cellular-phone ownership rates among users who find the device useful only or predominantly during motor vehicle travel. We know of no information as to whether such a user group exists (*e.g.*, long-distance commuters) or the size of the group and the benefits of the calls they make. In light of the many users who also find this technology useful in non-transportation settings, a decline in overall ownership after a prohibition on use while driving does not seem plausible.

Second, a prohibition on the use of cellular phones while driving might reduce the rate at which cellular phones are carried (transported) during motor vehicle trips. Although a decline in carrying might occur, it seems that many of the security ("peace of mind") advantages of carrying a cellular phone would remain, even if use while driving were prohibited, thus causing continued possession of phones by drivers.

Third, the location/accessibility of the phone in the vehicle might be diminished by a prohibition. Since the benefits and safety of phone use would certainly be diminished if the phone is not readily accessible to the driver, the effects of regulation on phone accessibility need to be investigated.

Finally, a prohibition on the use of a cellular phone while driving could jeopardize the convenience and time-saving feature of communications while driving, perhaps resulting in an overall decline (and/or delay) in the amount of communications that occur between people compared to what would occur if cellular phone use while driving were permitted. Permitting the use of cellular phones while driving does facilitate the productive use of relatively idle time, with potentially important benefits to users, families, social networks, businesses, and communities.

It has been suggested that the benefits of cellular phone use while driving could be preserved under a restrictive regulation since a driver could simply pull over on the side of the road and place (or return) a call, re-entering traffic when the call is completed. We believe that this argument is naïve and potentially encouraging of hazardous behavior. If drivers retain a cellular phone in their car and pull over to the side of the road to make their calls, there is an incremental risk of collision associated with stopping on the shoulder of a road/highway and re-entering traffic after the call has been made. These risks are of unknown magnitude and are not included in the epidemiological comparisons reviewed above. Moreover, many roads and highways are not designed with an adequate shoulder for drivers to pull over safely and make phone calls. In these settings especially, which are common on congested urban freeways, it is not realistic to expect drivers to simply stop for a brief moment at the roadside to make a phone call.

If it is suggested that drivers should not make calls until they reach an appropriate stopping point (*e.g.*, a rest area, an exit ramp, or refueling station), then there may be incremental risks from exiting and re-entering traffic streams, as well as additional time on the road. Moreover, the longer the delay between the point at which a call could be made or received (while driving) and the point when it can legally be made or received (under a regulatory policy), the less likely it is that call will occur. Delays in communication may also reduce the supply of accurate and up-to-date information. Delays in making and returning calls can clearly cause diminished benefits due to the time sensitivity of many calls. There may also be extreme situations where continuous contact between the driver and another party is critical to beneficial communication (*e.g.*, following another vehicle with a suspected criminal).

If prohibitions apply only to a subset of wireless technologies (*e.g.*, hand-held designs), then policymakers need to consider the risks and benefits of drivers switching to other communications devices (hands-free phones, pagers, fax machines, and so forth). Drivers can already convert a hand-held phone into a hands-free phone with use of an earpiece or head set. If a prohibition is more comprehensive with respect to wireless devices or technological distractions, then driver compliance with the prohibition is likely to be lower, especially since these kinds of prohibitions are difficult and tedious for police to enforce.

A risk-benefit analysis of a prohibition with partial compliance is even more complicated than an analysis of complete prohibition, as the risks and benefits of discouraged calls may be different from the risks and benefits of calls permitted by law. If a weakly enforced prohibition curtails only the high-risk and low-benefit calls, the prohibition might be attractive. Yet partial compliance also raises the cost of police enforcement and suggests possible diversion of police time from more cost-effective safety activities (*e.g.*, primary enforcement of child seat and safety belt laws or drunk driving laws). If such laws are adopted, it is important to consider whether primary police enforcement should be permitted or whether only secondary police enforcement (where cellular phone violations are enforced only in the context of other offenses) should be permitted.

In jurisdictions where restrictions or prohibitions have been adopted, there are often exceptions for calls made while driving that concern emergencies or other public purposes. Although such exemptions are sensible, guidance to motorists and police is required as to what constitutes a compelling emergency or public purpose.

If laws were passed restricting cellular phone use while driving, a variety of crucial questions may be treated differently in various jurisdictions: the specific devices covered (*e.g.*, hand-held versus any wireless phone), the nature of calls exempted (if any) from a ban, the type of police enforcement permitted, and the magnitude of fines for noncompliance. It will be difficult for drivers who travel across jurisdictions to know how the traffic laws concerning use of cellular phones vary from locality to locality, from state to state, and from country to country. Given the potential confusion created by non-uniform traffic laws, policymakers should have a clear rationale before introducing new traffic laws in the U.S.

Section 6. Cost-Effectiveness of Alternative Safety Measures

When considering restrictions on the use of cellular phones while driving, it may be instructive to compare the cost-effectiveness of such restrictions to the cost-effectiveness of other measures to improve traffic safety. The key summary statistic in a cost-effectiveness analysis is the cost-effectiveness ratio: the net monetary costs of the measure divided by the number of years of life saved, compared to a well-defined policy alternative. A recent review article by Graham *et al*. (1998) summarizes cost-effectiveness ratios for a wide range of public health and medical interventions, including selected highway safety programs.

The cost effectiveness of a ban on the use of cellular phones while driving is estimated using cost information in Hahn and Tetlock (1999), who quantify the monetary cost of such a ban, and effectiveness information in Redelmeier and Weinstein (1999), who estimate the health benefits, expressed in Quality Adjusted Life Years (QALYs) saved. The QALY is a measure that reflects the value of both reduced morbidity and extended life.

Hahn and Tetlock (1999) offer the most comprehensive estimate of the monetary costs associated with such a proposal. They define costs of a ban as the lost welfare estimated from the willingness of consumers to pay money for cellular phone calls. Aggregated over the U.S. population in 1999, Hahn and Tetlock estimate those costs to amount to $25 billion (p. 11). From this figure, the direct costs associated with accidents caused by cellular phones (medical expenses, lost productivity, property damage) must be subtracted. Redelmeier and Weinstein (1999) offer the most comprehensive calculation of this quantity, concluding that it amounts to around $3,000 per collision (p.3), or approximately $2 billion per year. Hence, the net cost of banning cellular phone use while driving is $25 billion - $2 billion, or $23 billion per year. Weinstein and Redelmeier (1999) also offer the most comprehensive calculation of a ban's effectiveness, defined as the number of QALYs saved by preventing collisions caused by the use of cellular phones while operating a motor vehicle. They estimate that each year in the United States the collisions caused by use of cellular phones while driving result in a loss of approximately 33,000 QALYs. Hence, the cost-effectiveness ratio for a ban on the use of cellular phones while driving is \$23 billion ÷ 33,000 QALYs, or approximately \$700,000 per QALY saved.

Both the monetary cost and the effectiveness (QALYs saved) estimates just described are uncertain. In order to estimate the value consumers place on being able to use their cellular phones while driving, Hahn and Tetlock (1999) first estimate the total value of all cellular phone calls and then estimate the fraction of that value associated with calls made while driving. Estimating the value of all cellular phone calls involves determining how much consumers would insist on being compensated if they were no longer allowed to make those calls, or if they had to substitute for those calls other means of communication (pagers, land-based phone links, *etc.*). The authors conclude that cellular phone calls made while driving have a particularly high value, as these calls are typically made by people who place a high value on their time. For many such people, the next best communication alternatives are inferior to the use of a cellular phone, especially when an individual (such as business person or long-distance commuter) is in his or her own car. Nonetheless, the authors acknowledge that the price elasticity of demand for cellular phone use does have a range of plausible values. They also state that the fraction of all cellular phone calls made while driving may range from 40% to 70%. Based on these two sources of uncertainty, Hahn and Tetlock (1999) calculate that the net benefits associated with cellular phone use while driving range from \$14 to \$73 billion. Replacing the direct costs associated with accidents caused by cellular phones estimated by Hahn and Tetlock (\$1.2 billion) with the corresponding figure estimated by Redelmeier and Weinstein (\$1.9 billion) indicates that a ban on cellular phones would result in a net cost to society of \$13 billion to \$72 billion, with a central estimate of \$23 billion. This source of uncertainty alone indicates that the cost effectiveness ratio may range from approximately one-half (\$13 billion ÷ \$23 billion) to more than three times (\$72 billion ÷ \$23 billion) its central estimate.

The estimates of effectiveness (QALYs saved) are uncertain for two reasons. First, as discussed in Section 3, the incremental collision and fatality risks associated with the use of a cellular phone while driving are uncertain. Taking into account only the stochastic (statistical) uncertainty about the relative risks estimated by Redelmeier and Tibshirani (confidence interval of 3.0 to 6.5) produces cost-effectiveness ratios ranging from 60% to 165% of the central value[7]. Second, the average number of QALYs saved per averted collision is uncertain because the value of each averted injury or fatality is uncertain. In the case of the cost-effectiveness ratio calculated by Redelmeier and Weinstein (1999), uncertainty associated with the QALY value of each averted injury is nearly as important as the stochastic uncertainty in the relative-risk estimate.

Table 5 reports cost-effectiveness ratios for eight highway safety measures that have been analyzed using comparable analytic methods and assumptions. From this comparative information, it appears that a prohibition on the use of cellular phones while driving is a relatively inefficient way for policymakers to save lives and reduce injuries from traffic crashes. Efforts to promote safety belt use, for example, are far more cost-effective.

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[7] Effectiveness (QALYs saved) appears in the denominator of the cost effectiveness ratio. Hence, use of the upper bound on the confidence interval (CI) for the relative risk (6.5) reduces the cost effectiveness ratio to 60% of its value $(6.5\text{-}1.0 \div 4.3\text{-}1.0)^{-1}$. Similarly, use of the lower bound on the CI for the relative risk (3.0) increases the cost effectiveness ratio $(3.0\text{-}1.0 \div 4.3\text{-}1.0)^{-1}$.

Table 5. Cost-Effectiveness Ratios for Selected Highway Safety Investments. [8]

Intervention	Target Population	Net Cost Per Life-Year* Saved
Lap/shoulder belts (assuming 50% use)	Front-seat occupants	< $0
Daytime running lights	All motor vehicles	< $0
Front-crash airbags	Drivers only	$24,000
Side door beams	Light trucks	$53,000
Frontal-crash airbags	Front-right passengers	$61,000
55 MPH speed limit	Rural interstate travelers	$82,000
Add shoulder belts to lap belts (assuming 9% use) for rear outboard seats	Passengers using rear outboard seats	$160,000
Cellular phone restrictions	All drivers	$700,000
Add shoulder belts to lap belts (assuming 9% use) for rear center seats	Passengers using rear center seats	> $2,400,000

* Life-years saved have been adjusted to account for both enhanced life expectancy and improvements in quality of life due to reductions in morbidity and functional impairment due to trauma. The adjustments are based on the quality-adjusted life year (QALY), a preference-based system that accounts for trauma severity and the health preferences of consumers for quality of life.

The information presented on speed limits is particularly instructive. Many states have recently raised speed limits on rural interstate highways from 55 to 65 miles per hour (MPH) (or even higher), despite the fact that the cost-effectiveness ratio for the 55 MPH limit ($82,000) is close to ratios published for passenger airbags, a mandated safety feature in all new motor vehicles. The "costs" of a lower speed limit are primarily the time/productivity costs to motorists and truckers, the sort of "inconvenience" cost that is central to the policy debate about using cellular phones while driving. Yet a speed limit of 55 MPH on rural interstates would appear to be far more cost-effective than a prohibition on the use of cellular phones while driving. This conclusion should be tempered with the

[8] Note: For technical details on assumptions, input data, and primary references regarding specific interventions, see Graham *et al*. (1998) and Redelmeier and Weinstein (1999).

qualification that the cost-effectiveness ratio for the cellular-phone prohibition is highly uncertain. The estimates from the sensitivity analysis reported in Redelmeier and Weinstein (1999) range from $50,000 to $700,000 per QALY saved.

There is, moreover, no public consensus about when a cost-effectiveness ratio is small enough to be acceptable. Some public health programs that cost more than $1 million per life-year saved have been adopted while others that cost less than $100,000 per life-year saved have been rejected (Tengs *et al.*, 1995; Tengs and Graham, 1996). Recent research suggests that public preferences for lifesaving investments may be influenced by a variety of qualitative and ethical considerations (Cookson, 2000).

One of the limitations of cost-effectiveness analysis is that effectiveness is not expressed in the same units as costs, and thus it is impossible to determine whether the effectiveness of a policy is worth the costs. A cost-benefit analysis can provide such a result, at least from the perspective of economic efficiency.

We are aware of only one benefit-cost study that has attempted to quantify, in monetary units, the benefits and costs of a prohibition on the use of cellular phones while driving. In this study Hahn and Tetlock (1999) estimate that the costs of a nationwide ban on cellular phone use would exceed the benefits of the ban by more than $20 billion per year. The same study concluded that permitting only use of "hands-free" phones while driving would also have costs in excess of benefits. An important limitation of this type of study is that there is no public consensus on what dollar value should be applied to the prevention of a traumatic death or injury, although there are estimates of such values in the economics literature that are employed by Hahn and Tetlock (1999).

In summary, a prohibition on the use of cellular phones while driving appears to be a relatively inefficient investment in traffic safety. Economic efficiency is not necessarily a decisive factor in public policy but it is certainly a perspective worthy of consideration by policymakers.

Section 7. Legislative, Legal, and Policy Perspectives

It is unlawful to drive recklessly in every U.S. state. Moreover, the tort liability system constrains drivers who operate a vehicle negligently (while using a cellular phone or otherwise) by holding such drivers financially accountable to any injured party. Companies may likewise incur the same liability; in 1999, the brokerage firm Smith Barney settled for $500,000 in a wrongful death suit filed against them. An employee was engaged in a business call on his cellular phone when his car struck and killed a 24-year-old man on his motorbike (Carter, 1999). Between 1990 and 1999, there were 34 tort cases entailing cellular-phone related accidents. Juries awarded 14 verdicts for the plaintiffs and 11 for the defense; six cases were settled out of court and three were resolved in mediation or arbitration (Carter, 1999). These cases notwithstanding, some advocates assert that our current tort system is not sufficient to deter phone-related crashes and that new legislation is imperative to clarify the traffic rules drivers must follow. Thus, numerous bills are under consideration in many jurisdictions.

Though no state has yet passed a law to specifically curtail cellular phone use while driving, since 1995 more than one hundred bills from 30 states have been proposed. Twenty-two bills from various states are under consideration this year alone[9]. At least 300 towns and cities, including Chicago, are considering similar measures. Currently, police in only three states, Oklahoma, Minnesota, and Tennessee, are required to record whether or not a cellular phone was present at the time of the accident (Vuong, 2000). Three other states, California, Florida, and Massachusetts, have legislated minor cellular phone related restrictions (Table 6).

[9] See Appendix C for a state-by-state list of legislative activity regarding cellular phone use while driving.

Table 6. Cellular Phone Related Restrictions in U.S.[10]

State	Statute	Description	Penalties
CA	Vehicle Code 28090	Requires car rental agency to provide renters with written instructions for the safe operation of a cellular phone while driving.	$100 maximum for first violation. $200 maximum for second violation. $250 for third and subsequent violations committed within one year.
FL	FLS 316.304	Regarding hands-free models: Models with headsets hooked up to a cellular phone that provide sound through only one ear are permissible, so long as surrounding sound can be heard with the other ear.	$30 for each violation. Non-moving violation.
MA	GLA 90-13	Cellular phone use is permitted, provided it does not interfere with the operation of the vehicle and one hand remains on the steering wheel at all times.	$35 maximum for first violation $35-75 for second violation $75-150 for third and subsequent violations committed within one year.

Already, a variety of countries have implemented legislative bans of hand-held cellular phones during vehicular operation (Vuong, 2000). Among 29 developed nations currently belonging to the Organization for Economic Cooperation and Development (OECD), eight countries (27.6%) -- Australia, Japan, France, Italy, Portugal, Spain, Sweden, and Switzerland--have legislation that prohibits hand-held phone usage while driving.[11] France and Sweden have not created legislation that specifically delineates a driver's use of a cellular phone but instead uses general legislation to encompass the restriction. The United Kingdom is often reported as another OCED country that has decreed a lawful ban; however, The Highway Code, wherein the relevant restriction exists, is a form of quasi legislation that falls between legislation proper and mere administrative rule making. Breach of The Highway Code does not give rise to direct liability but violations are admissible as evidence of negligence (Holborn, 1993). In addition, at least six other non-OECD countries including Brazil,

[10] Sundeen, 1999.
[11] See Appendix D for sampling of international legislative activity regarding cellular phone use while driving.

Taiwan, Israel, Singapore, Chile, and Malaysia have adopted similar legislation. Many developed and developing countries have yet to legislate in this area.

To date, five municipalities in the U.S. have enacted ordinances to regulate cellular phone use while driving. In March 1999, the town of Brooklyn, Ohio became the first to ban drivers from speaking on a hand-held cellular phone while operating a motor vehicle (Brooklyn, 1999). Violators face misdemeanor fines ranging from $3 up to $100 for repeat offenders or for causing accidents; however, drivers contacting public safety services are exempted from the prohibition (Bowles, 1999).

Three Pennsylvania towns have passed similar restrictions on hand-held cellular phones. The three towns, Hilltown (Hilltown Township, 1999), Conshohocken (Conshohocken, 2000), and Lebanon (Lebanon, 2000), enacted their ordinances after 2-year-old Morgan Pena was fatally injured in November 1999 when a driver who reportedly ran a stop sign while using a cellular phone struck her mother’s car. Unlike drivers in Brooklyn, OH and Lebanon, PA, drivers in Hilltown and Conshohocken, PA cannot be stopped solely for using a cellular phone while driving but can be fined up to $75 or $1000, respectively, if pulled over for another traffic violation. In all four towns contact to public safety forces or 911 as well as use of hands-free phones are permissible. Additionally, exemptions are provided for law enforcement officers and operators of emergency vehicles when on duty and acting in their official capacities.

The fifth municipality, New York City, restricts only car service drivers, such as taxicab and limousine drivers. Since July 1, 1999, violators have faced a $200 fine and two penalty points on their licenses if found using either a hand-held or hands-free phones (Haberman, 1999). The only other city that has come close to enacting a law is Aspen, Colorado. Its ordinance passed in November 1999, but was held in abeyance after the council voted to revisit the issue in May 2000 (Vuong, 2000).

Our review of international, state, and local legislative activity reveals uncertainty among policymakers about whether legislation should be passed to restrict or prohibit the use of cellular phones while driving. This uncertainty is reasonable in light of the weak scientific database on risks and benefits. First, the risks of using a cellular phone while driving, while real, are too small to be detected in overall crash/fatality statistics; however, they are potentially large enough to be a serious concern to motorists and policymakers. Second, the benefits of using a cellular phone while driving, including benefits to public health and safety, may be substantial but have been the subject of much less study and attention than the risks. Finally, compared to other highway safety policies, a prohibition on the use of cellular phones while driving does not appear to be a relatively efficient way to save lives and prevent injuries. This finding is preliminary because the underlying database on costs, risks and benefits is weak and uncertain.

In the face of these sources of uncertainties, policymakers can either await better scientific information prior to passing restrictive legislation, or they can pass restrictive legislation now, with an understanding that such legislation can be modified or repealed if new scientific information suggests changes are warranted. The advantage of immediate restrictions is that they respond to citizen concerns that cellular phone users may be imposing significant risks on other road users, though our analysis suggests these risks are small. There are also at least two drawbacks to passing restrictive legislation now. First, legal restrictions on the use of cellular phones while driving could complicate or undercut the ability of scientists to gather information on the magnitude of risks associated with use of cellular phones while driving, particularly as the technology changes (*e.g.*, toward voice activation). It is difficult to imagine citizens cooperating with scientists in an effort to study the risks of a prohibited technology/behavior, though some kinds of studies may still be feasible (*e.g*. those that involve use of billing records). For example, the validity of the police-report information on safety belt use by drivers has become more suspect now that virtually all states require drivers to wear safety belts. Second, historical experience with other technologies suggests that legal restrictions are very difficult to reverse, even if future scientific research provides strong, reassuring evidence that benefits outweigh risks. In particular, social scientists have found that legal restrictions create a "social stigma" about a technology or behavior, a stigma that is easier to create than to dispel (Gregory, Flynn, & Slovic, 1995; Kunreuther & Slovic, 1999). Given that the existing literature has focused more on risks than benefits and that qualitative data suggest that the unquantified benefits of using cellular phones while driving may be significant, it may be unwise to pass restrictive legislation until better scientific information on both benefits and risks have been collected and analyzed.

Section 8. Recommendations

In order to make more informed decisions about the use of cellular phones while driving, motorists and policymakers need better knowledge of the risks and benefits, knowledge that will require a concerted scientific research program. While this research program is conducted, a variety of common-sense measures should be taken to reduce the risks of using a cellular phone while driving. Thus, our recommendations fall into two categories: scientific research and risk management.

Scientific Research Program

Government and industry should develop a jointly funded research program on the risks and benefits of the use of wireless communication in the transportation sector. Joint funding will enlarge the resource base and enhance the credibility of the effort. We recommend that a well-established, neutral research organization[12] be charged with the task of managing this national research program. In our judgment, the following research issues should be priorities for funding through such a program. Although we are recommending additional studies, we recognize that there is no guarantee that such studies will produce definitive results, particularly on these difficult issues, and that funders need to make difficult decisions about whether investments in science (as opposed to risk management) are the best use of resources.

Replicate the Case-Crossover Study Design in Several Geographical Locations. The strongest epidemiological evidence of a substantial risk from use of cellular phones while driving comes from a single, unreplicated study by Redelmeier and Tibshirani (1997). A key feature of this study was billing information that documented the precise times that a cellular phone was in use, information that can be linked to crash records. This study needs to be replicated in several geographical locations. The times

[12] One example of a research organization that is a collaboration of industry and government is the Health Effects Institute (Boston, Massachusetts).

of collisions need to be pinpointed as accurately as possible. The outcomes to be studied need to be extended beyond minor crashes, including crashes that produce serious injuries and fatalities. Studies need to be designed with sufficient statistical power to detect any substantial risk differences between design features of phones (such as hand-held and hands-free phones). The federal government and/or large states need to work with the cellular phone industry to address concerns that release of billing information to researchers will create liability problems for firms/motorists or compromise customer privacy. There are precedents in related fields where these kinds of concerns have been addressed, allowing critical research to move forward. The National Highway Traffic Safety Administration or Centers for Disease Control and Prevention should take a lead role in this research agenda in collaboration with industry.

International Comparisons. Developed countries throughout the world are adopting different policies toward the use of the hand-held cellular phone while driving. There is little hard evidence about what is happening in different countries. Rigorous research should be undertaken to determine the impact of these different policies on the risks and benefits of using cellular phones while driving, while taking into account differences in cultural norms related to driver distraction. In countries where use of hand-held phones while driving has been restricted, data must be collected on the degree of motorist compliance with these restrictions, the resources invested in police enforcement, the extent of any shift toward use of hands-free technologies or other communications devices, and the relative risks and benefits of any behavioral changes and technological shifts. Without rigorous research into international experience, anecdotes about international experience will continue to dominate policy debate. In the related field of mandatory safety belt use legislation, careful evaluation of early laws in Australia and Sweden played an important role in the ultimate trend toward international harmonization of traffic laws (Graham, 1989). Both NHTSA and the industry should play leadership roles in this area.

Undertake Modified Cohort Studies of Collisions and Mortality Among Cellular Phone Users. The industry supported a large-scale, prospective cohort mortality study of cellular phone users (Dreyer *et al*., 1999). Industry and government should work together with these researchers and others to extend the study to include collisions as well as mortality. Moreover, study plans should include a refocus on the motor vehicle crash issue, including collection of critical data on confounding variables such as miles driven per year, travel patterns by road type and time of week/day, risk-taking behaviors, and type of motor vehicle used. Well-done cohort studies will provide information to complement findings from case cross-over studies. NHTSA or CDC should also take a lead role in this arena in collaboration with industry.

Surveillance of the Use of Cellular Phones Prior to Police-Reported Crashes. The current approaches to using police reports to determine the role of cellular phones in motor vehicle crashes do not appear to be generating valid and complete information. Underreporting and false-positive reports both appear to be serious problems. Neither searches of police-report narratives nor implementation of box-checking reporting methods have been shown to resolve data-quality issues. A concerted effort needs to be made in several geographical locations to produce higher-quality data on the role of cellular phones in crashes. The methods employed to determine whether a particular crash is "cellular phone-related" need to be transparent and tested for inter-observer reliability and, where feasible, validity. If these pilot efforts are successful, a comprehensive, national approach to collecting information on the role of cellular phones in police-reported crashes should be implemented. NHTSA and state transportation departments should play a leadership role in this area.

Broad-Based Driver Distraction Research Program. Research on the risks of using cellular phones while driving needs to be expanded to include a broad-based inquiry into the role of driver distraction in traffic crashes. The concern should extend beyond hand-held phones and include the potential risks of a wide range of technologies such as hands-free phones, voice-activated devices, CBs and dispatch 2-way radio, 2-way messaging devices, palm pilots, auto PCs, and fax machines. Some vehicle manufacturers may install a variety of office equipment in the front seats of new motor vehicles, which raises serious concern about driver distraction. "Low-tech" behaviors of drivers that contribute to crash risk also need to be examined: smoking, eating, drinking, shaving, disciplining children and pets, searching for lost articles, and so forth. Some not-for-profits (*e.g.*, the AAA Foundation for Traffic Safety) have already launched a modest initiative to study driver distraction. The U.S. Congress should provide NHTSA with adequate resources to undertake a serious, long-term scientific inquiry into the role of driver distraction in motor vehicle crashes.

Quantify the Benefits of Using Cellular Phones While Driving. The current body of published scientific information is heavily dominated by risk-related studies, with relatively few studies of benefits. Yet our focus group research suggests that there are important benefits to using cellular phones while driving. Studies in this area need to address community and business benefits as well as direct benefits to users and families. The public health and safety benefits of using cellular phones while driving need to be examined carefully to determine their magnitude compared to the health and safety risks. The industry should take a leadership role in supporting peer-reviewed scientific work on benefits.

Encourage Development of Safer Technology. Industry and NHTSA should fund driver performance studies with adequately large samples to tease out the most risky aspects of using a cellular phone while driving. Experiments with alternative cellular-phone designs should be encouraged.

Risk Management

Scientific research should not be used as an excuse to refrain from investment in promising educational efforts to reduce the risks of using cellular phones while driving. NHTSA and the industry, with support from the U.S. Congress and state legislatures, should develop a comprehensive educational effort aimed at drivers to promote the responsible use of cellular phones while driving.

Based on common sense and the limited available scientific evidence, the following components should be considered for inclusion in a “responsible-use” program: initiation of calls (dialing) only when a vehicle is stopped, discretion in choosing whether and when to receive an incoming call, non-use of hand-held cellular phones in vehicles with manual transmissions, keeping calls short in duration (under 2 minutes), refraining from stressful or anxiety-ridden calls, refraining from multi-tasking (*e.g.*, drinking coffee and reading while driving), and encouraging a passenger to use the cellular phone instead of the driver (when feasible).

Industry, on a broad scale, has developed a message targeted to consumers to encourage responsible use of cellular phone technology. The recent recommendations by NHTSA (1997a) in this area also represent a useful framework for progress. What is urgently needed is a more aggressive collaborative effort, perhaps modeled after the recent government-industry partnership that is promoting airbag safety through increased use of safety belts and child restraints and greater use of the rear seat for child passengers. The collaborative effort at cellular phone safety needs to establish objective indicators of success and a rigorous program evaluation.

References

Alm, H., & Nilsson, L. (1994). Changes in driver behaviour as a function of handsfree mobile telephones – A simulator study. *Accident Analysis and Prevention*, 26 (4), 441-451.

Alm, H., & Nilsson, L. (1995). The effects of a mobile telephone task on driver behaviour in a car following situation. *Accident Analysis and Prevention*, 27 (5), 707-715.

Axiom Research Company, LLC. (2000). *Attitudes about Cell Phone Use by Drivers*. Cambridge, MA.

Baker, S. P., O'Neill, B., Ginsberg, M., & Li, G. (1992). *The Injury Fact Book*. New York, NY: Oxford University Press.

Barbour, R. S., Kitzinger, J. (eds) (1999). *Developing Focus Group Research*. London, UK: Sage Publications.

Bowles, S. (December 20, 1999). States warn drivers to mute phone chats. *USA Today* [online]. Available: www.usatoday.elibrary.com/s/usatoday/ (December 21, 1999)

Briem, V., & Hedman, L. R. (1995). Behavioral effects of mobile telephone use during simulated driving. *Ergonomics, 38 (12)*, 2536-2562.

Brookhuis, K. A., de Vries, G., & de Waard, D. (1991). The effects of mobile telephoning on driving performance. *Accident Analysis and Prevention, 23 (4)*, 309-316.

Brooklyn. (1999). City of Brooklyn, Ohio. Ordinance No. 1999-27.

Brown, I. D., Tickner, A. H., & Simmonds, D. C. V. (1969). Interference between concurrent tasks of driving and telephoning. *Journal of Applied Psychology, 53 (5)*, 419-424.

Cain, A., & Burris, M. (1999). *Investigation of the use of mobile phones while driving.* Tampa, FL: Center for Urban Transportation Research, University of South Florida.

Carter, T. (1999). Crash course for business; companies can be liable for accidents resulting from job-related cell phone use. *ABA Journal, 85,* 40.

Cellular Telecommunications Industry Association (CTIA). (2000a). *The History of Wireless*. [online]. Available: http://www.wow-com.com/consumer/faqs/faq_history.cfm (February 25, 2000)

Cellular Telecommunications Industry Association (CTIA). (2000b). *WOW-COM's World of Wireless Communications*. [online]. Available: http://www.wow-com.com/ (June 26, 2000)

Cher, D. J., Mrad, R. J., & Kelsh, M. (1999). Cellular telephone use and fatal traffic collisions: a commentary. *Accident Analysis and Prevention*, *31*, 599.

Chapman, S., & Schofield, W. N. (1998). Lifesavers and Samaritans: emergency use of cellular (mobile) phones in Australia. *Accident Analysis and Prevention, 30 (6)*, 815-819.

Conshohocken. (2000). Borough of Conshohocken, Montgomery County, PA. Ordinance No.2 of 2000.

Cookson, R. (2000). Incorporating psycho-social considerations into health valuation: an experimental study. *Journal of Health Economics, 19(3)*, 369-402.

Crouch, E., & Wilson, R. (1982). *Risk-Benefit Analysis*. New York, NY: Bellinger Press.

Dreyer, N. A., Loughlin, J. E., & Rothman, K. J. (1999). Cause-specific mortality in cellular telephone users (letter). *Journal of the American Medical Association*, *282 (19)*, 1814-15.

Drory, A. (1985). Effects of rest and secondary task on simulated truck-driving task performance. *Human Factors, 27 (2)*, 201-207.

Evans, L. (1991). *Traffic Safety and the Driver*. New York, NY: Van Nostrand Reinhold.

Federal Highway Administration (FHWA). (1998). [online]. Available: http://www.fhwa.dot.gov/ (February 30, 2000)

Goldstein, B. D., Demak, M., Northridge, M., & Wartenberg, D. (1992). Risk to groundlings of death due to airplane accidents: a risk communication tool. *Risk Analysis*, *12*, 339-341.

Graham, J. D. (1989). *Auto Safety: Assessing America's Performance*. Dover, MA: Auburn House Publishing Company.

Graham, J. D., Corso, P. S., Morris, J. M., Segui-Gomez, M., & Weinstein, M. C. (1998). Evaluating the cost-effectiveness of clinical and public health measures. *Annual Review of Public Health, 19*, 125-152.

Gregory, R., Flynn, J., & Slovic, P. (1995). Technological stigma. *America Scientist, 83*, 220-223.

Haberman, C. (June 15, 1999). NYC; phoning and driving don't mix. *The New York Times*. [online]. Section B; p.1; Column 1 (735 words) Available: http://archives.nytimes.com/archives/ (February 29, 2000)

Hahn, R. W., & Tetlock, P. C. (1999). *The economics of regulating cellular phones in vehicles*. Washington, DC: American Enterprise Institute-Brookings Joint Center for Regulatory Studies.

Hart, P. D. (1997). *Wireless Telephone Safety*. Survey among 409 wireless users/407 non-users nationwide, May 15-17, 1997.

Hayes, B. C., Kurokawa, K., & Wierwille, W. W. (1989). Age-related decrements in automobile instrument panel task performance. Proceedings of the Human Factors Society 33rd Annual Meeting, 159-163.

Hilltown Township. (1999). Hilltown, PA. Ordinance No. 99-14.

Holborn, G. (1993). *Butterworths Legal Research Guide*. London; Boston: Butterworth & Co. Ltd.

Kames, A. J. (1978). A study of the effects of mobile telephone use and control unit design on driving performance. *IEEE Transactions on Vehicular Technology, VT-27 (4)*, 282-287.

Kawachi, I. (1999). Social capital and community effects on population and individual health. *Annals of the New York Academy of Sciences, 896*, 120-30.

Kennedy, B. P., Isaac, N. E., & Graham, J. D. (1996). The role of heavy drinking in the risk of traffic fatalities. *Risk Analysis, 16*, 565-569.

Kunreuther, H., & Slovic, P. (1999). Coping with stigma's challenges and opportunities. *Risk: Health, Safety and Environment, 10,* 269-280.

Lamble, D., Kauranen, T., Laakso, M., & Summala, H. (1999). Cognitive load and detection thresholds in car following situations: safety implications for using mobile (cellular) telephones while driving. *Accident Analysis and Prevention, 31*, 617-623.

Lebanon. (2000). City of Lebanon, PA. Bill No. 5, Sessions 2000-2001.

Magliozzi, T., & Magliozzi, R. (2000). *Drive now, talk later.* [online]. Available: http://www.cars.com/carsapp/national/?srv=parser&act=display&tf=/features/drivenow/states/states_index.tmpl (February 12, 2000)

McKnight, A. J., & McKnight, A. S. (1993). The effect of cellular phone use upon driver attention. *Accident Analysis and Prevention, 25 (3)*, 259-265.

Min, S. T., & Redelmeier, D. A. (1998). Car phones and car crashes: an ecologic analysis. *Canadian Journal of Public Health, 89 (3)*, 157-161.

National Highway Traffic Safety Administration (NHTSA). (1997a). *An investigation of the safety implications of wireless communications in vehicles.* [online]. Available: http://www.nhtsa.dot.gov./people/injury/research/wireless/ (October 25, 1999)

National Highway Traffic Safety Administration (NHTSA). (1997b). *Relationships between vehicle size and fatality risk in model year 1985-1993 passenger cars and light trucks*. [DOT HS 808 570 NHTSA Technical Report]. Washington, DC: NHTSA.

National Highway Traffic Safety Administration (NHTSA). (1998). *Traffic safety facts 1998: A compilation of motor vehicle crash data from the fatality analysis reporting system and the* *general estimates system*. [online]. Available: http://www.nhtsa.dot.gov/people/ncsa/tsf-1998.pdf (March 2, 2000)

National Highway Traffic Safety Administration (NHTSA). (1999). *Observed safety belt use in 1998*. [online]. Available: http://www.nhtsa.dot.gov/people/injury/airbags/buckleplan/buckleup/RNMT98.WP8. html (March 2, 2000)

Personal Communications Industry Association (PCIA). (1999). *National poll on wireless issues and concerns, July 29, 1999*. Presentation by Penn, Schoen, & Berland Associates, Inc.

Peltzman, S. (1975). *Regulation of Automobile Safety*. American Enterprise Institute for Public Policy Research, Washington, DC.

Putnam, R. (1995). Bowling alone: America's decline of social capital. *Journal of Democracy, 6,* 65-78.

Redelmeier, D. A., & Tibshirani, R. J. (1997). Association between cellular-telephone calls and motor vehicle collisions. *New England Journal of Medicine, 336 (7),* 453-458.

Redelmeier, D. A., & Weinstein, M. C. (1999). Cost-effectiveness of regulations against using a cellular telephone while driving. *Medical Decision Making, 19,* 1-8.

Roth E., Morgan M. G., Fischhoff B., Lave L., & Bostrom, A. (1990). What do we know about making risk comparisons? *Risk Analysis, 10,* 375-388.

Rothman, K. J., Loughlin, J. E., Funch, D. P., & Dreyer, N. A. (1996). Overall mortality of cellular telephone customers. *Epidemiology, 7(3),* 303-305.

Serafin, C., Wen, C., Paelke, G., & Green, P. (1993). *Car phone usability: a human factors laboratory test.* Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting, 220-224.

Stein, A. C., Parseghian, Z., & Allen, R. W. (1987). A simulator study of the safety implications of cellular mobile phone use. Hawthorne, CA: Systems Technology, Inc. Paper No. 405 (March). Hawthorne, CA: Systems Technology Inc. (See also 31st Annual Proceedings, American Association for Automotive Medicine, New Orleans, LA, September 1987.)

Sundeen, M. (1999). Cell phones and driving: 1999 state legislative update. *National Conference of State Legislatures.* [online]. Available: http://www.ncsl.org/programs/esnr/celphone.htm (June 5, 2000)

Tengs, T. O., Adams, M. E., Pliskin, J. S., Gelb-Safran, D., Siegel, J. E., Weinstein, M. C., & Graham, J. D. (1995). Five-hundred life-saving interventions and their cost-effectiveness. *Risk Analysis*, *15*, 369-90.

Tengs, T. O., & Graham, J. D. (1996). The opportunity costs of haphazard social investments in life-saving. *Risks, Costs, and Lives Saved: Getting Better Results from Regulation* (RW Hahn). New York, NY: Oxford University Press, 167-182.

Violanti, J. M. (1998). Cellular phones and fatal traffic collisions. *Accident Analysis and Prevention, 30 (4)*, 519-524.

Violanti, J. M., & Marshall, J. R. (1996). Cellular phones and traffic accidents: an epidemiological approach. *Accident Analysis and Prevention, 28 (2)*, 265-270.

Vuong, A. (February 21, 2000). Car-phone limits ring true for many. *The Denver Post.* [online]. 2D Edition, p. A-01 (1093 words). Available: http://www.denverpost.com/archive/simple.htm (February 29, 2000)

U.S. Bureau of the Census. (1999). *Statistical Abstracts of the United States.* [online]. No.3. Available: http://www.census.gov/prod/99pubs/99statab/sec01.pdf (March 18, 2000)

Yomiuri Shimbun (December 16, 1999). Ban on cell phone use by drivers having impact. *The Daily Yomiuri.* [online]. Available: http://www.yomiuri.co.jp/newse/1216so04.htm (June 22, 2000)

Zador, P. L., Krawchuk, S. A., & Voas, R. B. (2000). Alcohol-related relative risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: an update using 1996 data. *Journal of Studies on Alcohol*, *61*, 387-395.

APPENDICES

Appendix A. Calculations To Determine Annual Fatality Risks

This appendix details calculations of both voluntary risks, for the purpose of establishing a context for the risks incurred by drivers who use cellular phones while operating their vehicle, and involuntary risks, for the purpose of establishing a context for risks due to cellular phone use while driving incurred by passengers riding in other vehicles, pedestrians, and cyclists. We have purposely omitted from our calculations passengers traveling with a driver who uses a cellular phone from our calculation because, as explained in Section 3 of this report, it is not clear whether these passengers incur risks associated with the driver's use of a cellular phone voluntarily or involuntarily.

1. Voluntary Factors Affecting Driver Fatality Risks

1.1 Use of a Cellular Phone While Driving

1.1.1 Relative Risk

Redelmeier and Tibshirani (1997) concluded that use of a cellular phone while driving increases the relative risk of a collision by a factor of 4.3. The effect was somewhat more pronounced during the morning than at other times of the day.

1.1.2 Annual Incremental Fatality Risk

The annual risk of being killed while using a cellular phone and driving (PF_{cp}) is the product of the annual risk of being in a collision while driving and using a cellular phone (PC_{cp}) and the conditional probability of being killed due to a collision(F_{Fatal}). The value of PC_{cp} is the product of the annual number of minutes spent using the cellular phone while driving (M_{cp}) and the collision rate per minute while driving and using a cellular phone (RC_{cp}). Using the Redelmeier and Tibshirani (1997) results, the value of RC_{cp} can be estimated to be $4.3 \times RC_b$ (the "baseline" collision rate per minute while driving and not using a cellular phone). We can estimate the value of RC_b as the annual number of collisions (N_c) divided by the time spent driving (T_d) for the U.S. population. The value of T_d is estimated as the distance driven per year by all drivers (D) divided by the average speed (S). Table A-1 lists the parameters used in this computation and the basis for their values.

Table A-1. Parameters Used to Compute Driver Fatality Risk Associated with Cellular Phone Use.

Quantity	Units	Value	Comment
T_d	min/year	4.03×10^{12}	Assumes highway miles equal interstate miles (6.25×10^{11}) (1998 value) (Federal Highway Administration (FHWA), 1998), Highway speed averages 61 mph (1993 value) (FHWA, 1998), Other miles are the difference between highway miles and total miles of 2.62×10^{12} (1998 value) (NHTSA, 1998), Average speed for other driving is 35 mph (estimate)
N_c	collisions/year	6.335×10^{6}	1998 value (NHTSA, 1998)
RC_b	collisions/min	1.571×10^{-6}	Calculated as $N_c \div T_d$
RC_{cp}	collisions/min	6.755×10^{-6}	Product of RC_b and the relative risk value of 4.3 calculated by Redelmeier and Tibshirani (1997)
M_{cp}	min/year	317.6	Average value calculated from PCIA (1999, slides 20-21)
PC_{cp}	collisions/year	2.15×10^{-3}	Product of M_{cp} and RC_{cp}
F_{Fatal}	Driver fatalities/ collision	3.81×10^{-3}	1998 driver fatalities (24,729 – NHTSA, 1998, Table 53) divided by 1998 collisions (6,335,000 –NHTSA, 1998).
PF_{cp}	Fatalities/year	8.14×10^{-6}	Product of PC_{cp} and F_{Fatal}

The incremental fatality probability attributable to cellular phone usage while driving is the difference between the value of PC_{cp} just calculated (8.37×10^{-6}) and the baseline probability of being killed while driving for 317.6 minutes (i.e. the probability of being killed while driving without using a cellular phone). The baseline probability is calculated in the same way that PF_{cp} is calculated, with the omission of the multiplication by the cellular phone collision relative risk value of 4.3. The result is $8.37 \times 10^{-6} \div 4.3$, or 1.95×10^{-6}. Hence, the annual incremental fatality risk attributable to using a cellular phone while driving averages $8.37 \text{ x } 10^{-6} - 1.95 \text{ x } 10^{-6}$, or 6.43×10^{-6}.

Several factors that may potentially bias this calculation should be noted. First, the calculation assumes that the average conditional fatality probability of a collision is applicable when individuals use their cellular phones while driving. However, 1988 fatality statistics reported by Baker *et al.* (1992) indicate that the probability of being fatally injured in a car collision is much higher during the late night period than it is during the morning rush hour, and somewhat higher than it is during the afternoon rush hour. FARS data confirm these relationships. In contrast, it is easy to imagine that cellular phone usage while driving is far more frequent during rush hour periods than at other times of the day, and certainly more frequent than it is during late night periods. Hence, use of an average fatality probability value may lead to the overstatement of the incremental fatality risk associated with using a cellular phone while driving.

Second, the calculation assumes that the average rate at which collisions occur (collisions per minute of driving) is applicable when individuals tend to use their cellular phones while driving. It is not clear whether this value should be higher or lower for this calculation than the average value.

Third, the calculation presented here assumes that the elevation in risk is limited to the duration of the actual call. However, the Redelmeier and Tibshirani statistical analysis indicated that this risk may persist after the call is terminated. That is, while the average duration of all calls in their study was only 2.3 minutes, and while 76% of all calls were less than two minutes in duration, this elevation in collision risk persisted for 10 minutes following the initiation of the call. Assuming that the reported average call duration is representative of calls occurring prior to a collision, the Redelmeier and Tibshirani findings indicate that use of a cellular phone while driving elevates risks even after the call has terminated. The calculations in this report do not reflect this potential contribution. On the other hand, the apparent persistent risk induced by a cellular phone call may be an artifact due to confounding. For example, it is possible that individuals are more likely to initiate cellular phone calls during circumstances that induce stress or present more dangerous driving conditions (*e.g.*, when the driver is late or caught in a traffic congestion). If the driver were more likely to be in an accident in such situations even without the use of a cellular phone, then the increased collision risk inherent in these situations will appear to be in part attributable to cellular phone use. At this time, it is not possible to quantitatively evaluate the impact of omitting the potentially elevated collision risk after the termination of a cellular phone call.

1.2 Driving with a Blood Alcohol Concentration of 0.10%

1.2.1 Relative Risk

Zador *et al.* (2000) estimated the relative risk of a driver being fatally injured in a car accident as a function of blood alcohol concentration (BAC) based on 1996 weekend night surveillance data and data from FARS. Their statistical analysis indicated that among women, the relative risk of being fatally injured in a car accident increased by a factor of 1.6 to 1.7 for every 0.02% increase in BAC. Among men, this relative risk ranged from 1.6 (drivers 35 years and older) to 2.3 (drivers ages 16 to 20). These findings suggest that a BAC of 0.10% increases the relative risk of fatality by a factor of approximately 10 to 14 (*i.e.*, 1.6^5 to 1.7^5) among women, and by a factor of approximately 10 to 64 (*i.e.*, 1.6^5 to 2.3^5) among men. An earlier study by Zador (1991, as cited in Baker *et al.*, 1992) estimated that for each BAC increase of 0.02%, driver fatality risk doubles, thus implying that driving with a BAC of 0.10% is associated with a fatality relative risk of 32 (2^5). This estimate is consistent with, or implies an even smaller risk than research conducted by McCarroll and Haddon (1962, as cited in Baker *et al.*, 1992), who found that driving with a BAC of 0.15% is associated with a fatality relative risk of 300 to 600. We conclude that the relative risk of fatality associated with driving with a BAC of 0.10% has a central value of 15.

1.2.2 The Annual Incremental Fatality Risk

The annual incremental fatality risk depends on the amount of time an individual drives while having an elevated BAC. We assume here that an individual drives once per month with a BAC of 0.10%, and that the driving duration (M_{BAC10}) is 30 minutes. The probability of being killed while driving with this elevated BAC (P_{die}) is

$$P_{die} = RR_{BAC10} \times RF_b \times M_{BAC10},$$

where RR_{BAC10} is the relative risk of being fatally injured while driving with a BAC of 0.10%, and RF_b is the baseline rate at which fatalities occur (driver fatalities per driver minute) among drivers who have no alcohol in their blood. Table A-2 details the values for these parameters.

Table A-2. Parameters Used to Compute Driver Fatality Risk Associated with Alcohol Consumption.

Quantity	Units	Value	Comment
RR_{BAC10}	Dimensionless	15	See preceding text (Section 1.2.1)
RF_b	driver fatalities/min	6.13×10^{-9}	1998 driver fatalities (24,729- NHTSA, 1998, Table 53) divided by total driving duration per year (4.03×10^{12}), documented in Table A-1 in Section 1.1.2.
M_{BAC10}	min	360	Represents an individual who drives with an elevated BAC once per month for 30 minutes each time, reflecting evidence that problem drinkers are responsible for the majority of alcohol-related traffic fatalities (Kennedy *et al*., 1996).

Note that the relative risk value selected (RR_{BAC10}) is towards the low end of the range of values described in Section 1.2.1 of this appendix. Given these assumptions, the value of P_{die} is 3.31×10^{-5}. Subtracting the baseline risk of 2.21 x 10^{-6} (*i.e.*, the risk in the absence of alcohol usage) yields an incremental risk of 3.09×10^{-5}.

1.3 Failure to Use Safety Belts

1.3.1 Relative Risk

Evans (1991, p. 244) quantifies the extent to which various occupant protection devices, when used, decrease the risk of fatality among front seat passengers. For front seat drivers and passengers in a vehicle with airbags, wearing a seat belt decreases fatality risk by 29%[13] (see Table 9-6 in Evans, 1991). This reduction implies that the fatality relative risk associated with not wearing a belt is 1 ÷ (1-29%), or 1.41.

1.3.2 The Annual Incremental Fatality Risk

There were 182.6 million licensed drivers in the United States in 1997 (NHTSA, 1998, Table 5), the most recent year for which this statistic is available. In 1998, there were 24,729 driver fatalities in the United States U.S. DOT, NHTSA, (Traffic Safety Facts 1998, 1999, Table 53), suggesting that the average annual fatality risk is 1.35×10^{-4}. Based on the information outlined above, it is possible to calculate fatality risk for individuals wearing seatbelts (R_{Belts}) and for individuals not wearing seatbelts. In 1998, NHTSA (1999) estimated that 69% of all drivers wear seat belts. Hence, the total number of fatalities of 24,729 is equal to $N_{Drivers} \times (31\% \times RR_{NoBelts} \times Risk_{Belts} + 69\% \times R_{Belts})$, where $RR_{NoBelts}$ (the fatality relative risk associated with not wearing a belt) is 1.41. This equation implies that R_{Belts} is 1.20×10^{-4}. The corresponding value for drivers who do not wear their belts is 1.69×10^{-4}. Hence, the incremental annual fatality risk for drivers who do not wear seat belts is 4.93×10^{-5} (1.69 x 10-4 – 1.20 x 10-4.

1.4 Driving a Small Vehicle Instead of a Large Vehicle

NHTSA (1997b) estimated for various types of crashes the statistical change in the fatality rate associated with a 100-pound decrease in passenger car vehicle weight. The results appear in Table A-3.

[13] The corresponding figure for vehicles without airbags is a 41% reduction.

Table A-3. Passenger Cars: Effect of 100-Pound Weight Reduction on All Fatalities. (Light Truck Weights Unchanged)

Crash Type	Fatalities in 1993 Crashes	Effect of 100-Pound Weight Reduction	Net Fatality Change
Principal rollover	1,754	+4.58%	+80
Hit object	7,456	+1.12%	+84
Hit ped/bike/motorcycle	4,206	-0.46%	-19
Hit big truck	2,648	+1.40%	+37
Hit another passenger car	5,025	-0.62%	-31
Hit light truck	5,751	+2.63%	+151
Total	**26,840**	**+1.13%**	**+302**

Source: NHTSA (1997b), Table 6-7.

The values in Table A-3 must be adjusted to eliminate from consideration those fatalities that represent individuals other than the driver of the vehicle, who is the main focus of this section.

- This analysis assumes that the fatalities in the "hit ped/bike/motorcycle" category represent almost exclusively deaths among the pedestrians, bicyclists and motorcyclists involved in those crashes. This category is eliminated from consideration because it does not represent driver fatalities.

- This analysis assumes that one-half of the fatalities in "hit another passenger car" category represent fatalities among individuals in other vehicles. The baseline fatality rate in this category is therefore reduced by 50%.

- This analysis assumes that all of the fatalities in the "hit light truck" category represent fatalities among individuals in the passenger car. This assumption reflects the fact that light trucks are more aggressive in multiple vehicle collisions than are passenger vehicles. Likewise, the analysis assumes that all fatalities in the "hit big truck" category represent fatalities among individuals in the passenger car.

- In 1998, 70% of all vehicle occupant fatalities represented driver fatalities (NHTSA, 1998, Table 53). Therefore, the analysis reduces baseline risk values by 30%.

In addition, the analysis must eliminate from the NHTSA calculations the <u>decrease</u> in fatality risks accruing to non-occupants. Specifically, decreasing vehicle weight leads to a decrease in fatalities among pedestrians, bicyclists, and motorcyclists involved in crashes, and among occupants in light trucks and other cars involved in crashes. These benefits are addressed as follows.

- The elimination of the "hit ped/bike/motorcycle" category from the calculations, discussed above, addresses fatality rate benefits accruing to pedestrians, bicyclists, and motorcyclists.

- The 0.62% decrease in fatalities in the "hit another car" category has been replaced with an increase of 1.12%. This adjustment reflects the assumption that for a vehicle occupant, a 100-pound decrease in vehicle weight has the same impact on the fatality rate for multi-vehicle crashes as it has on the fatality rate for crashes in which the vehicle hits an immobile object.

- There is no information available to adjust the fatality rate change estimated by NHTSA for the "hit light truck" category. However, since light trucks are relatively aggressive vehicles compared to passenger cars, a relatively small proportion of the fatalities in these crashes represent occupants of the light truck. Hence, it is unlikely that the fatality rate change estimated by NHTSA has a substantial benefit component reflecting decreased fatalities among light truck drivers.

This analysis further adjusts the baseline fatality rate to reflect the decline in total motor vehicle fatalities since 1993. Specifically, the analysis reduces the assumed baseline fatality rate by 1%, the amount by which total motor vehicle fatalities decreased between 1993 and 1998. Table A-4 outlines these computations.

Table A-4. Passenger Cars: Effect of 100-Pound Weight Reduction on Driver Fatalities. (Light Truck Weights Unchanged)

Crash Type	Total Fatalities in 1993 Crashes	Total Fatalities in 1998 Crashes	Fatalities Among Occupants of Primary Vehicle	Driver Fatalities -- Primary Vehicle	Effect of 100-Pound Weight Reduction	Net Fatality Change
Principal rollover	1,754	1,736	1,736	1,215	4.58%	56
Hit object	7,456	7,381	7,381	5,167	1.12%	58
Hit big truck	2,648	2,622	2,622	1,835	1.40%	26
Hit another passenger car	5,025	4,975	2,487	1,742	1.12%	20
Hit light truck	5,751	5,693	5,693	3,985	2.63%	105
Total	**22,634**	**22,407**	**19,920**	**13,944**		**265**

In 1997, there were 182.6 million licensed drivers in the United States (NHTSA, 1998, Table 5). Hence, a 100-pound decrease in car weight increases the annual fatality risk by 265 ÷ 182.6 million, or by 1.45×10^{-6}. Assuming that risk is a linear function of car weight, driving a 2,000 pound car rather than a 3,000 pound car increases a driver's fatality risk by 1.45×10^{-5}. Since the baseline annual fatality risk for a driver is 1.35×10^{-4}, the relative fatality risk is 1.11.[14]

[14] The baseline risk is the annual number of driver fatalities (24,729) (NHTSA, 1998, Table 53) divided by the total number of licensed drivers (182.6 million). This quotient is 1.35×10^{-4}. The annual fatality risk for a driver in a car that is 1,000 pounds lighter than baseline is (24,729+2,650) ÷ 182.6 million drivers, or 1.50×10^{-4}.

1.5 Driving on a Non-Interstate Roadway Rather than On the Interstate

The U.S. Department of Transportation's Federal Highway Administration (1987) estimated that the fatality rate on rural interstates was 1.40 deaths per 100 million vehicle miles. On other rural highways, this rate was 3.89 deaths per 100 million vehicle miles. The ratio of these two rates is 2.78.

The incremental risk per 100 million miles is 3.89 – 1.40, or 2.49 deaths per 100 million miles. Assuming that the applicable travel represents 60 miles per year, the incremental annual fatality risk is 1.49×10^{-6}.

2. Involuntary Factors Affecting Fatality Risks

This section details the assumptions made in the calculation of fatality probabilities among individuals affected by factors that they do not control. Examples include being killed by the following agents:

- A driver using a cellular phone,
- A driver with a non-zero blood alcohol concentration (BAC),
- A large truck,
- An airplane that falls out of the sky, and
- Automobiles (as a pedestrian).

All the computations assume that the population of the United States is 275,000,000[15].

2.1 Use of a Cellular Phone While Driving

The expected number of fatalities among individuals involved in collisions with drivers using cellular phones is the product of the following quantities:

- The number of individuals who use cellular phones while driving;
- The annual probability of being in a collision while driving and using a cellular phone (PC_{cp}); and

[15] This value is the estimated U.S. population for the year 2000 (U.S. Bureau of the Census, 1999).

- The average number of fatalities per collision to individuals not riding in the vehicle driven by the cellular phone user.

Number of individuals using cellular phones while driving

As of June, 2000, there were 94.2 million cellular phone subscribers in the U.S. (CTIA, 2000b). PCIA found that 90% of all cellular phone subscribers report they use their cellular phone to some degree while driving. Hence, there are approximately 84.8 million individuals who use a cellular phone while driving.

Annual Collision Risk

Recall from Section 1.1.2 that for individuals who use cellular phones while driving, the average annual risk of being involved in a collision while driving and using their cellular phone is 2.15×10^{-3}.

Fatalities Per Collision to Individuals Not Riding In the Vehicle Driven by the Cellular Phone User

Evans (1991) reported that in 1988, 55.26% of all accident fatalities involved multiple-vehicle collisions. In the case of collisions involving drivers using cellular phones, we assume that half these fatalities represent the driver using the cellular phone, while the other half represent individuals in other vehicles. This assumption is very uncertain. In any case, one-half of 55.26% of all accident fatalities during 1998 amounted to 11,458 deaths. In 1988, another 16.68% of all accident-related fatalities represent pedestrians and bicyclists (Evans, 1991, p. 45). Applying this proportion to the 1998 total fatality rate yields 6,917 deaths. Since there were 6,335,000 accidents in 1998 (NHTSA, 1998), the expected number of fatalities per accident to individuals not riding in the vehicle driven by the cellular phone user is (11,458+6,917) ÷ 6,335,000, or 2.90×10^{-3}.

The product of the three quantities is 529. That is, this calculation implies that 529 individuals are killed each year by individuals using a cellular phone while driving. Subtracting out the 23.3% (1÷4.3) of these fatalities attributable to the baseline risk (i.e. fatalities that would have occurred in the absence of all phone use) yields an incremental death rate of 406 individuals per year. Dividing 406 by 275 million yields a population risk of 1.48×10^{-6}.

2.2 Driving With an Elevated BAC

Evans (1991, p. 185) estimated that alcohol contributes to 45% of the fatalities resulting from two-vehicle collisions. Of these fatalities, 62.2% are the drivers with BACs exceeding zero, while the remaining 37.8% are drivers who have a BAC of zero.

For alcohol-related accidents involving three or more vehicles, Evans did not report the proportion of individuals killed who had a BAC of zero, but the purpose of this calculation, this analysis assumes that this proportion is 37.8%, as in the case of two-vehicle alcohol-related accidents. Because a relatively small proportion of all automobile-related fatalities result from accidents involving three or more vehicles, the error introduced by this assumption is unlikely to be substantial.

In the case of non-occupant fatalities, Evans (1991) concluded that accidents involving a driver with an elevated BAC and a pedestrian, bicyclist, or motorcyclist with a BAC of zero represent 26% of all non-occupant fatalities.

Finally, Evans reported that two-vehicle accidents cause 37.00% of all motor vehicle related fatalities, accidents involving three or more vehicles cause 6.03% of all motor vehicle related fatalities, and non-occupants deaths represent 16.73% of all motor vehicle related fatalities. Along with the assumption of an annual fatality rate of 41,471 (NHTSA, 1998), this information can be used to calculate the number of deaths among individuals with a BAC of zero caused by individuals driving with elevated BACs. The calculations appear in Table A-5.

Table A-5. Fatalities Among Individuals with BACs of Zero Caused by Individuals Driving with Elevated BACs.

Fatality Category	Pct of All Motor-Vehicle Related Fatalities[a]	Total Number of Fatalities	Pct Among Individuals with BAC=0 Caused by Drivers with BAC>0	Number Among Individuals with BAC=0 Caused by Drivers with BAC>0
All Fatalities	100%	41,471[b]		
1-vehicle crashes	40.24%	16,688	0%	0
2-vehicle crashes	37.00%	15,344	17%[c]	2,609
≥ 3-vehicle crashes	6.03%	2,501	17%[c]	425
Non-Occupants	16.73	6,938	26%	1,804
Total				4,838

Notes: *a.* *Source: Table 7-6 in Evans (1991, p. 186).*

b. *Source: NHYSA, 1998.*

c. *The proportion of two-vehicle crashes involving alcohol is 45%. Of these fatalities, 37.8% represent an individual whose BAC is zero. Hence, 45% $\times$ 37.8%, or 17%, of all two-vehicle fatalities represent an individual with a BAC of zero killed in an accident involving alcohol. The analysis assumes that the same assumptions apply in the case of accidents involving three or more vehicles.*

d. *Dividing these 4,838 fatalities by the size of the U. S. population (275 million) yields an annual risk of 1.76 x 10^{-5}.*

2.3 Fatalities Caused by Large Trucks

Fatalities to other vehicle occupants and to non-motorists resulting from accidents involving large trucks totaled 4,646 individuals in 1998 (NHTSA, 1998, Table 11). The population risk is therefore 4,646 ÷ 275 million, or 1.68 x 10^{-5}.

2.4 Fatalities to Individuals on the Ground Resulting from Airplane Crashes

Goldstein *et al.* (1992) estimated that the lifetime risk of being struck and killed on the ground by an airplane is 4 in 1 million. Assuming a 70 year lifetime, this figure corresponds to an annual fatality risk of 5.7×10^{-8}. However, this estimate apparently reflects both airplane crashes and fatalities associated with accidents that occur when individuals on the tarmac (*e.g.*, passengers walking to or from a plane) are injured by getting too close to hazardous areas, such as the engines. We characterize this latter category as fatalities associated with a voluntary risk – *i.e.*, traveling on an airplane, and contrast it with the involuntary risk associated with being struck by a falling plane. After subtracting these "voluntary risk" fatalities and updating the data, it has been estimated that the annual fatality risk associated with being struck and killed by an airplane is 1.27×10^{-8} (personal communication with Robert Frank Robouw, Harvard Center for Risk Analysis, Boston, MA, April 14, 2000).

2.5 Fatalities Among Pedestrians Resulting from Motor Vehicle Accidents

In 1998, there were 6,112 fatalities among non-motorists involved in motor vehicle accidents (NHTSA, 1998, Table 53). The population risk is therefore $6{,}112 \div 275$ million, or 2.22×10^{-5}.

Appendix B. Methods and Participant Characteristics for Focus Groups with Consumers and Emergency Services Personnel

Axiom Research, LLC, a marketing research firm based in Cambridge, MA, was commissioned by the Harvard Center for Risk Analysis to conduct a total of six focus groups in two markets (Springfield, MA and Los Angeles, CA). Three groups were conducted in each market: one among emergency services personnel and dispatchers (*e.g.*, police dispatchers, AAA, tow truck personnel, *etc.*), and two among consumers. The groups were conducted in early March, 2000. Each session was approximately 1½ hours in length.

Methods. Participants in the emergency services personnel groups were recruited in several ways, including: from various databases of potentially eligible professionals, from local phone books, and through exploratory calls to related organizations. Consumer recruits were obtained through the use of recruitment facility databases. The two consumer groups were divided so that one group consisted of "commuters" (defined as individuals with at least a 20-30 minute drive to work every day in Springfield, or at least 30-45 minutes in Los Angeles) and the other consisted of "non-commuters" (individuals whose commute was less than the durations defined for commuters). All participants were required to meet additional criteria. For example, only consumers who own cellular phones and have used them while driving could participate.

The findings were derived through several stages of analysis. In addition to the moderator, a second member of the Axiom team observed groups in both markets. Debriefing sessions among Axiom and Harvard personnel were held immediately after each group. With the help of notes taken during the groups and debriefing sessions, project staff held a "white board" session, in which major findings and conclusions were discussed. Finally, videotapes of the groups were reviewed.

Participant Characteristics

Emergency Services Personnel. Professionals in the two markets represented a number of positions and titles – most prominently, police dispatchers and deputies, but also included tow truck company dispatchers and AAA dispatchers. Eight individuals attended the group in Los Angeles, whereas 6 attended the group held in Springfield. The Springfield group was predominantly comprised of women age 25-34. All had a high school degree, but none had graduated from college. The men in the group varied in age and education level. The Los Angeles group was evenly divided across gender and age categories, with approximately half of the participants age 25-34 and half age 35-44. Los Angeles participants varied greatly in terms of their educational background, from one participant who had not graduated from high school to two who were college graduates.

Consumers. Eight consumers attended each of the Los Angeles groups, while 11 attended each of the groups in Springfield. Consumers were evenly distributed across gender in both markets. In Springfield most respondents fell into the 35-44 age group, although the 25-34 and 45-54 age groups were also represented. In Los Angeles, consumers were more evenly divided across the 35-44 and the 45-54 age groups, with very few younger or older participants. In the Springfield commuter group, all participants had at least some college experience, and most were college graduates. In the non-commuter group, most participants had no more than a high school education. In Los Angeles, all of the participants had at least some college experience, with slightly more than half having a college degree.

Appendix C. State-by-State Review of Recent Legislation[16]

ALABAMA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

ALASKA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

ARIZONA
SB 1017 (2000): *Under Consideration*
What it says:
The bill would make it illegal to use a cellular phone or computer while operating a motor vehicle. The Arizona Department of Transportation would also begin keeping record of all the traffic accidents in which cellular phones or computers were a contributing factor.
Status:
The bill is currently under consideration and will be voted on during the second regular session of 2000.

ARKANSAS
No wireless-phone-related legislation as of the end of the 1998-1999 session.

CALIFORNIA
SB 1131 (1997): *Failed*
What it says:
This bill would have outlawed anyone from driving on California highways while using any hand-held cellular phone.
Status:
The bill did not pass and was returned to the Secretary of State on Feb. 2, 1998.
Related laws:
California Vehicle Code Section 28090 requires car renters to be provided with instructions for the safe operation of a cellular phone while driving.

COLORADO
HB 1061 (1998): *Failed*
What it says**:**
This bill would have made talking on the phone while driving a misdemeanor, akin to not wearing a seatbelt. Violators would have been fined $15 to $200, and could only be charged if they were also caught violating another traffic law as well.
Status:
Send to committee January 23, 1998 and held up there.

CONNECTICUT
No cellular phone-related bills as of the end of the 1998-1999 session.

DELAWARE
No cellular phone-related bills as of the end of the 1998-1999 session.
Related laws:
Delaware's state code, Chapter 21, section 4176, bans inattentive driving.

[16] Magliozzi T. & Magliozzi R., 2000

WASHINGTON, D.C.
No wireless-phone-related legislation as of the end of the 1998-1999 session.

FLORIDA
No cellular phone-related bills as of the end of the 1998-1999 session.

Related laws:
Florida Statute 314.306 (1993) outlawed the use of headsets in cars… one exception of which was a headset hooked up to a cellular phone that provided sound through only one ear.

GEORGIA
House Bill 310 (1999): *Pending*
What it says:
This bill would outlaw the use of radios, cellular phones or CBs while driving, unless those devices could be operated one-handed.
Status:
HB310 was read twice on the Senate floor, then sent to the Motor Vehicles Committee, where it remained for the rest of the 1999 legislative session.

Senate Resolution 167 (1999): *Passed*
What it says:
SR167 declared March 8, 1999, "Safe Drivers Day" in the state of Georgia. Among other safety tips, the bill requests that drivers:

> *Exercise good judgment when using cellular telephones while driving by using hands-free telephones, if available, or by postponing the use of the telephone until the vehicle is safely stopped and out of traffic.*

Status:
SR167 passed, but because it was only a resolution, it did not change any of the state laws.

HAWAII
House Bills 284 and 341 (1995): *Failed*
What it says:
Both bills proposed to make it a misdemeanor, punishable by fine, to use hand-held electronic devices (including cellular phones) while driving. Hands-free models would have been considered fine, as long as the driver exercised due caution.
Status:
Neither bill passed. Another bill was proposed during the most recent January 2000 session of the Hawaiian legislature.

IDAHO
No cellular phone-related bills introduced as of the end of the 1998-1999 session.

ILLINOIS
House Bill 562 (1997): *Failed*
What it says:
This bill would have outlawed the use of cellular phones while driving, except for hands-free models. A later amendment said that people who had been certified by their doctors as hearing-impaired would have been exempt from the law.
Status:
This bill made it to a second reading on the House floor and was put on the calendar for a third before it

was sent to the House Rules Committee on April 25, 1997. It remained there until the session ended in January 1999.

INDIANA
No cellular phone-related legislation introduced as of the end of the 1998-1999 session.

IOWA
House File 2406 (1998): *Failed*
What it says:
This bill would have made it a misdemeanor to use a cellular phone for more than one minute on state highways. 911 calls made with a cellular phone would have been exempt.
Status:
HF2406 was sent to the Judiciary Committee, where it sat until the end of the legislative session.

KANSAS
No wireless-phone-related legislation as of the end of the 1998-1999 session.

KENTUCKY
BR 966: *Under Consideration*
BR 1014: *Under Consideration*
What it says:
The bills would make it illegal for non-emergency personnel to use cellular phones while driving. Violators are fined $30.
Status:
The bills were prefiled and will be voted on in 2000.

LOUISIANA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

MAINE
Legislative Document 81 (1999): *Failed*
What it says:
This bill would have banned the use of all hand-held telephones while driving.

MARYLAND
House Bill 37 (1999): *Failed*
What it says:
This bill would have prohibited the driver of any motor vehicle in motion from using a telephone.
Status:
HB37 was sent to the Commerce and Government Matters Committee, where it received an unfavorable report on March 8, 1999. The senate took no action, and the bill died.

MASSACHUSETTS
HB 4810 (1999): *Pending*
What it says:
This bill would ban the use of cellular phones by drivers of school buses.
Status:
04/28/99 Referred to the committee on House Rules -HJ 213
09/16/99 Reported, referred to the committee on Joint Rules, reported, rules suspended and referred to the committee on Public Safety -HJ 860
10/07/99 S Senate concurred -SJ 784

House Docket 4526 (1999): *Pending*
What it says:
This bill would ban the use of cellular phones by drivers of any motor vehicle.
Status:
Currently in the House Rules committee, where it will carry over into the next legislative session.

House Docket 4738 (1999): *Pending*
What it says:
This bill would ban the use of cellular phones or CB radios by drivers of any motor vehicle.
Status:
Currently in the House Rules committee, where it will carry over into the next legislative session.

Related Laws:
GLA 90-13: Cellular phone use is permitted, provided it does not interfere with the operation of the vehicle and one hand remains on the steering wheel at all times.

MICHIGAN
No wireless-phone-related legislation as of the end of the 1998-1999 session.

MINNESOTA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

MISSISSIPPI
No wireless-phone-related legislation as of the end of the 1998-1999 session.

MISSOURI
No wireless-phone-related legislation as of the end of the 1998-1999 session.

MONTANA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

NEBRASKA
Legislative Bill 338 (1997): *Failed*
What it says:
This bill would have banned the use of cellular phones while driving.
Status:
LB 338 was not supported in committee on Feb. 12, 1997.

NEVADA
Assembly Bill 328 (1998): *Failed*
What it says:
This bill would have made the use of a cellular phone while driving a misdemeanor.
Status:
Though the Transportation Committee introduced the bill, they also failed to take action on it, and it died in committee April 20, 1999.

NEW HAMPSHIRE
LSR 2031 (2000): *Under Consideration*
What it says:
This bill would restrict the use of cellular phones while driving.

Status:
The bill was prefiled and will be taken under consideration in 2000.

NEW JERSEY
S1070 (1996): *Pending*
What it says:
This bill would fund a government study to determine how often the use of a cellular phone is a factor in automobile accidents.
Status:
S1070 remains in the Law and Public Safety Committee, more than three years after its introduction.

S1938 (1997): *Pending*
What it says:
This bill would punish anyone caught driving while using a cellular phone with a $50 fine.
Status:
S1938 is also still in the Law and Public Safety Committee.

NEW MEXICO
No wireless-phone-related legislation as of the end of the 1998-1999 session.
Related laws:
New Mexico statute 66-8-114 prohibits reckless or inattentive driving.

NEW YORK
A50 (1999): *Failed*
What it says:
This bill would have banned driving while using a cellular phone, with the exception of people like paramedics and taxi drivers who use the phone as part of their everyday business.
Status:
Referred to the Transportation Committee as soon as it was introduced, remaining there until the legislative session ended in June.

A1435 (1999): *Failed*
What it says:
This bill would have required the governor's traffic safety committee to conduct a study on the effect of cellular telephone technology on highway safety.
Status:
A1435 passed the Assembly and went to the Senate on May 3, 1999, where it was sent to the Transportation Committee and subsequently died.

S1767 / A3016 (1999): *Failed*
What it says:
This bill would have required police officers and other public officials to gather information on the presence and influence of a cellular phone in their motor vehicle accident reports.
Status:
Both houses sent their version of the bill to their respective Transportation Committees the same day it was introduced, though no action was taken.

A3684 (1999): *Failed*
What it says:
This bill would have banned driving while using a cellular phone, with the exception of people calling 911 or whose lives are endangered. Drivers would have been given a two-minute grace period to pull over

to the side of the road while talking on the phone. All cellular phone companies in the state would have had to notify customers of the new law.
Status:
Sent to the Transportation Committee, where it died.

A4947 (1999): *Failed*
What it says:
This bill would have required all cellular phone makers to include warning labels with their phones, advising consumers of the hazards of driving while using the phone.
Status:
Referred to the Transportation Committee the same day it was introduced, where it died.

Other wireless-phone legislation:
New York City Mayor Rudolph Giuliani and the city's taxi commission banned city car service/cab drivers from using their hand-held or hands-free cellular phones while driving, effective July 1, 1999.

A5838 (1999): *Failed*
What it says:
This bill would have required the office of the Commissioner of Motor Vehicles to add cellular phone-related data to their annual report on motor vehicle accidents.
Status:
After its introduction, A5838 was sent directly to the transportation committee, where no action was taken on it for the rest of the session.

A6120 (1999): *Failed*
What it says:
This bill is nearly identical to A3684. It would have gotten rid of the two-minute grace period and the notification requirement for cellular phone companies, and would have added exceptions for CB radios and speakerphones.
Status:
Also referred to the Transportation Committee as soon as it was introduced, A6120 remained there until the legislative session ended in June.

NORTH CAROLINA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

NORTH DAKOTA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

OHIO
House Bill 251 (1999): *Failed*
What it says:
This bill would have outlawed the use of cellular phones while driving, except to report an emergency. Drivers with temporary instruction permits could not use a cellular phone in any situation. The bill also would have required the State Highway Patrol to compile monthly data and statistics on motor vehicle accidents in which mobile telephone use was a factor.
Status:
The bill was introduced to the transportation committee and it remained there until the session closed.

Other wireless-phone legislation:
In 1999 Brooklyn, Ohio became the first city in the United States to ban the use of hand-held cellular phones while driving. In 1966, Brooklyn was also the first town to require the use of seatbelts.

OKLAHOMA
House Bill 1286 (1999): *Failed*
What it says:
This bill would have prohibited inattentive driving of any kind, imposing a $10 fine on offenders.
Status:
HB1286 was defeated in a 38-58 vote on May 18, 1999.

OREGON
House Bill 3262 (1999): *Pending*
What it says:
This bill would require police to include the possible presence and influence of a cellular phone in accident reports.
Status:
After the end of the 1999 legislative session, HB3262 was listed on the docket of the Judiciary committee.

Senate Bill 514 (1997): *Failed*
What it says:
This bill would have banned driving while using a cellular phone.
Status:
SB514 was held in committee until it died at the end of the 1997 legislative session.

PENNSYLVANIA
Senate Bill 1085 (1999): *Introduced*
What it says:
This bill would ban the use of cellular phones while driving on any road, be it state or federal. Any person who violates this law will be sentenced to pay a $250 fine and will have points assessed on his or her license. This law does not apply to law enforcement and emergency vehicle operators when on duty and acting in their official capacities.
Status:
The bill was referred to committee on transportation in September of 1999. It was then rewritten by Sen. Joseph Conti in December to include hands-free cellular phones and increase penalties. Hearings for the newly rewritten bill are set for February 2, 2000.

House Bill 2112 (1999): *Introduced*
What it says:
This bill would prohibit motorists from using cellular phones while driving on any road. Any person who violates this law will be sentenced to pay $200 for the first conviction. A subsequent conviction of the said law will result in a one year suspension of operating privileges.
Status:
Referred to committee on transportation.

Other wireless-phone legislation:
The following municipalities in Pennsylvania have each passed local ordinances that prohibit the use of hand-held cellular phones while driving: Hilltown, Conshohocken, and Lebanon.

RHODE ISLAND
House Bill 5573 (1999): *Pending*

What it says:
This bill would prohibit the use of headsets or hand-held phones while driving.
Status:
Held in the Joint Committee on Transportation for further study as of the end of the 1998-1999 session.

SOUTH CAROLINA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

SOUTH DAKOTA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

TENNESSEE
No wireless-phone-related legislation as of the end of the 1998-1999 session.

TEXAS
House Bill 994 (1999): *Pending*
What it says:
This bill would have banned the use of a cellular phone while driving.
Status:
The bill is currently in subcommittee.

UTAH
House Bill 48 (1998): *Failed*
What it says:
This bill would have expanded the legal definition of inattentive driving to include the use of cellular phones, among other sources of distraction.
Status:
HB48 was defeated in the Rules Committee on March 4, 1998.

VERMONT
No wireless-phone-related legislation as of the end of the 1998-1999 session.

VIRGINIA
House Bill 737 (1998): *Failed*
What it says:
This bill would have prohibited school bus drivers from using cellular phones while driving, except in cases of breakdown or emergency.
Status:
HB737 was sent to the Transportation Committee, which decided to take no action on it on Dec. 17, 1998.

House Bill 1666 (1995): *Failed*
What it says:
This bill would have prohibited drivers or operators of motor vehicles, mopeds or bicycles from using a cellular phone unless one of their hands was on the wheel (or handlebars) at all times.
Status:
HB1666 was referred to the Transportation Committee, where it was deferred indefinitely by a vote of 18-4 on Jan. 24, 1995.

WASHINGTON
No wireless-phone-related legislation as of the end of the 1998-1999 session.

Related laws:
Washington Code 46.37.480 from 1996 prohibits the use of headphones of any kind while driving.

WEST VIRGINIA
No wireless-phone-related legislation as of the end of the 1998-1999 session.

WISCONSIN
Assembly Bill 680 (1997): *Failed*
Assembly Bill 754 (1998): *Failed*
What they say:
These bills, which have nearly identical wording, both proposed to ban the use of any "mobile telecommunications device" while driving, making an exception for police officers and other public employees who use cellular phones as part of their jobs.
Status:
Both bills were sent to the Highways and Transportation Committee, where they were defeated on April 2, 1998.

WYOMING
No wireless-phone-related legislation as of the end of the 1998-1999 session.

Appendix D. International Legislation[17]

Country	Restriction	Comments
Australia	Australia Road Rules, 1996 (Commonwealth) Draft copy states: No vehicle occupants may use a hand-held phone.	
Victoria	Road Safety (Traffic) Regulations, 1988, Reg. 1505 (1) The driver of a motor vehicle must not, while driving, hold or use a phone, microphone or similar apparatus.	In 1988, the Australian State of Victoria was the first international jurisdiction to specifically ban the use of cellular phones while driving. Two driver's license penalty units are incurred by violators.
New South Wales	Motor Traffic Regulations 1935, as amended, Section 90(d) The driver of a motor vehicle must not, while driving, answer or use, or attempt to answer or use, a hand-held phone.	
Switzerland	Article 5. Section 311: Public Penalty Regulations; (Article 3, par.1 of Traffic Regulations {Verkehrsregelnverordung or VRV}) 1989 [Prohibits] use of a phone that is not a hands-free set while driving.	Drivers must sign a contract with their insurance companies that prohibit phone use while driving. Claims are reduced if it is discovered that the driver was using a phone at the time of an accident.
Spain	"Federal Registrar" No. 63, of March 14, 1990; Amendment No. 185, Article 11, No.2 It is forbidden to drive using any headpiece or phone ear-piece connected to equipment for receiving or reproducing sound.	Spain utilizes primary enforcement. Fines from $80-800 are regularly issued.
Israel	Transportation Regulations 5721-1961/1970 Regulation 28, Section 1-28A Anyone who drives a motor vehicle must hold two hands on the wheel or handlebars as long as that vehicle is in motion. He may remove one hand if necessary to guarantee the proper operation of the vehicle corresponding to the rules of transportation. Regulation 28, Section 1-28B Section 23A will also apply to a person who drives a vehicle in which there is a phone, either permanent or portable, and the driver of a vehicle is allowed to use a phone only through a microphone for the operation of which there is no need to remove a hand from the wheel or handlebar.	
Italy	The Code of the Road – Rules of Behavior. Article 173 The driver is prohibited from using while driving any apparatus (radio, CB, or earphones) with the exception of the armed forces or police as well as the drivers transporting others. It is permitted to use any device that does not require the use of hands.	

[17] NHTSA, 1997a; Cain, 1999.

Country	Restriction	Comments
Singapore	Subsidiary Legislation (Ch. 276, Sections 111 and 140) Road Traffic Act. No. 15 (1) Except with the written permission of the Registrar, no person shall install or use any television, radio or acoustical equipment or cause any television, radio or acoustical equipment to be installed in or on a public service vehicle or any part thereof. Notwithstanding paragraph 1 (above) the following equipment may be installed in a taxi: (a) a radio phone for calling the driver at any time to convey passengers for the purpose of gain; (b) a radio with or without cassette player mounted and secured on the dashboard of the taxi; and (c) a mobile phone mounted and secured in a position as approved by the Registrar.	
France	Driving Code, Title I (“Code de la Route”, Titre Ier) Article R. 3-1, 1961 All drivers must hold themselves constantly in a state and position to execute with comfort and without delay all necessary driving maneuvers.	France considers cellular phone use while driving within the scope of pre-existing, general legislation.
Sweden	Decree on Road Traffice (“Svensk Författningssamling” 1972: 603, as amended in 1985) Motor vehicle drivers must take the necessary caution, care and prudence while on the road to avoid traffic accidents	Sweden broadly construes its revised road law to include cellular phone usage while driving.
United Kingdom	The Highway Code, No. 3 (1992) Do not use a hand-held phone or microphone while you are driving. Find a safe place to stop first. Do not speak into a hands-free microphone if it will take your mind off the road. You must not stop on the hard shoulder of a motorway to answer or make a call, except in an emergency.	The Highway Code is a form of quasi-legislation. While it does not give rise to direct liability, breach of the code is admissible as evidence of negligence. The Highway Code must be learned by drivers in the UK as a part of driving test requirements.