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Is Using a Car Phone Like Driving Drunk?

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Talking on a cellular telephone while driving can be productive and glamorous. Is it also dangerous? Some people say "yes" and tell stories about using a telephone and getting into an accident. Other people say "no" and support their position by three arguments. First, cellular telephones allow drivers to call ahead when running late and travel with increased peace of mind, thereby decreasing their risk of a collision. Second, the huge growth of this technology in recent years (with the number of subscribers increasing from 0% to 10% of the population in less than a decade) has not been accompanied by a dramatic increase in collision rates. Finally, drivers face many other distractions (such as eating and talking with passengers) so that singling out cellular telephones seems unjustified. In this article we describe a study that examined whether cellular telephones are hazardous. At the end we rebut these three arguments and answer the provocative question in the title.

Background

We were motivated to do this research for several reasons. Motor vehicle collisions are a leading cause of mortality, disability, and other forms of suffering throughout the world. Cellular telephone conversations are one of the few driving behaviors that can be studied in a scientific manner because an objective record of activity is produced outside of the vehicle. Moreover, even a small change in risk might have substantial public health importance and explain why some countries have enacted regulations restricting cellular telephone usage while driving. Some of our friends, however, cautioned us about initiating a research effort because it might threaten the enormous financial interests of private industry. The cellular telephone industry in North America, for example, has daily revenues of over $60 million (substantially more than the daily revenues of $25 million for the Microsoft Corporation) (Value Line Investment Survey 1997; Cellular Telecommunication Industry Association 1996).

We decided to go forward, and our first inclination was to conduct a case-control study. To do so, we planned to survey drivers who had car telephones and drivers who did not and compare the number of collisions each person experienced during a one-year interval. A brief look at the literature, however, revealed that such a study had already been completed in 1978 evaluating an early generation of mobile telephone (Smith 1978). This survey of 498 individuals found that the overall frequency

What's wrong with this picture?

of traffic collisions was marginally lower among mobile telephone subscribers than among members of the general public (11% vs. 12%). The difficulty in interpreting these data was the possibility of biases in favor of mobile telephone owners. In particular, prior to the 1990s most mobile telephone owners were young, intelligent urban professionals who would otherwise be expected to have very low collision rates and very safe driving patterns.

Our next idea was to consider a before-and-after trial comparing individuals' driving records in the year before purchasing a cellular telephone to their driving records in the year after purchasing a cellular telephone. Doing so would allow each person to serve as his/her own control and reduce confounding due to characteristics such as intelligence, personality, and eyesight. Another trip to the library uncovered a study of this sort involving cellular telephone subscribers in 1985 (Canete 1985). This study of 305 individuals found a significantly lower collision rate in the year following the purchase of a cellular telephone (8.2% vs. 6.6%). We were impressed by these data but still worried about residual confounding. People's driving might generally improve over time. Additionally, perhaps some individuals used the fact of a recent collision to justify the purchase of a new telephone. If true, the apparent protective association might be misleading.

We realized that there was only one way to eliminate confounding (Moore 1977)—namely, a controlled experiment that removed any self-selection. We again returned to the library looking for a randomized trial that assigned individuals to either use or not use a cellular telephone while driving. This time we found nothing, presumably because it is unethical to deliberately expose individuals to potential hazards. What we did find were studies that used driving simulators and reported worsening performances on some indirect measures. In one study, for example, the average participant's reaction time increased significantly when using a hands-free cellular telephone (1.6 ms vs. 2.2 ms) (Alm and Nilsson 1995). We weren't convinced, however. Data obtained in artificial circumstances that involve hypothetical risks and unnatural conversations might not provide an accurate assessment of the real relationship between cellular telephone calls and motor vehicle collisions.

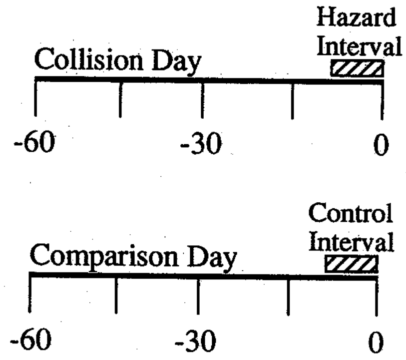


Figure 1. Essential features of the case-crossover design. Each individual is evaluated on two intervals, one in which the event occurs (hazard interval) and one in which the event does not occur (control interval). Potential exposures are then measured during each interval. Similar to a case-control design, possible associations are tested by comparing the exposures in the hazard interval to the exposures in the control interval.

At the library, we also noticed an interesting article on whether episodes of heavy exercise triggered heart attacks in middle-aged people (Mittleman et al. 1993). The design was fascinating and seemed to provide a novel method for testing the transient effects of a brief exposure on the onset of an acute condition. In this medical study, investigators interviewed heart attack survivors and asked each what they were doing just before the heart attack began. Of the 1,228 patients, more had been exercising during the hour before the heart attack than during the same hour on the day before the heart attack (54 vs. 13). After taking into account self-matching, Bayes's formula, and the near equivalence of probability and odds for rare events, the investigators inferred that heavy exercise was associated with a fivefold increase in the risk of a heart attack. This design is called the case-crossover design, and the statistical approach is called McNemar's test (Maclure 1991).

Our Study

We decided to carry out a case-crossover study to assess whether cellular telephone calls were associated with motor vehicle collisions (Fig. 1) (Redelmeier and Tibshirani 1997). We identified drivers between July 1994 and August 1995 in Toronto who had been in a collision involving significant damage but no personal injury (persons involved in injury collisions were not accessible). In total, 5,890 were screened, of which 1,064 acknowledged having a cellular telephone, 742 consented to our reviewing their cellular telephone records, and 699 provided accurate telephone numbers that could be linked to detailed billing records. The data showed that drivers were more likely to have made a cellular telephone call during the 10-minute interval immediately before the collision than during a similar interval on the day before the collision (24% vs. 5%). The summary results from this study suggested that drivers were at a 157/24 = 6.5-fold increased risk of a motor vehicle collision when they were using a telephone compared to when they were not using a telephone (Fig. 2).

These results were interesting, but we believed that more detective work

		Cellular telephone call during Control Interval? yes	no
Cellular telephone call during Hazard Interval?	yes	13	157
	no	24	505

Relative risk: 157/24 = 6.5
95% confidence interval: (4.5 - 10.0)

Figure 2. Results of primary analysis using data from 699 drivers according to whether they had a telephone call during the Hazard Interval immediately prior to the collision and whether they had a telephone call during the Control Interval on the day before the collision. Relative risk measures the probability of a collision when using a telephone compared to the probability of a collision when not using a telephone. Confidence interval is calculated using exact techniques.

was needed. In particular, we still had doubts because of the potential for residual confounding. For example, selecting the day prior to a collision for the control interval might be inappropriate if it meant comparing Monday morning driving to Sunday morning driving. Perhaps the individual never drove on the weekend. More generally, people drive intermittently, rather than every day at the same time. To address this issue, we reinterviewed the individuals in our study and recomputed the relative risk based only on those individuals who were confident that they had been driving a motor vehicle at the time of the collision on the day before the collision. The analysis of this highly selected group revealed a relative risk of 56/8=7.0. This result was encouraging, but we still had some concerns and wondered whether there might be another method for adjusting for driving intermittence as a double check.

For an alternative approach we considered the probability that an individual would drive on two consecutive days and appealed to the logic of conditional probability. That is, if people have only a 50% chance of driving a vehicle at a given time on two consecutive days then, by random chance alone, we should expect only half as many cellular telephone calls in the control interval as in the hazard interval. Therefore, a crude analysis might detect a relative risk of 2 but an adjusted analysis would reveal a relative risk of 1. We could not find a good estimate of this probability in the literature so we conducted our own survey of drivers involved in a collision (not necessarily cellular telephone owners) and obtained an estimate of .65 for the probability of driving on the day before the collision at the same time as the collision. Adjusting the results of the primary analysis by this factor yielded a relative risk of 4.3.

Selecting the day immediately prior to the collision was still somewhat bothersome because it was arbitrary. Fortunately, we had collected several consecutive days of data on each driver and were able to test other comparison days, each adjusted for driving intermittence using the conditional probability approach. In one analysis, we used the preceding day of the work week; that is, a collision on Monday was compared to the previous Friday. In another analysis, we used the day exactly seven days prior; that is, a collision on Monday was compared to the preceding Monday. In a third analysis, we used three consecutive days before the collision and selected whichever day yielded the most conservative estimate. In other analyses we used other comparison days. All of the analyses yielded a relative risk of about 4, thereby giving us some faith in the robustness of our findings.

We next considered biases arising from not knowing the precise moment of every collision. We reasoned that individuals might use their cellular telephone immediately after a collision to make an emergency call. It would be a blunder to mislabel these calls made after the fact as having contributed to the collision. To tackle this question, we reviewed our technique for establishing the time of collision; namely, by retrieving the individuals' statements, police records, and telephone listings of emergency calls. In cases in which three sources agreed (or when one source was missing but the other two agreed) we classified the collision times as exact. Otherwise, we classified the collision times as inexact and used the earliest available time in our analysis. This seemed reasonable but imperfect. When we reran our analysis on the 231 individuals who had exact collision times we obtained a relative risk of 4.0. When we reran our analysis based on the 272 who later made an emergency telephone call, we obtained a relative risk of 7.6. Both results were statistically significant and both were adjusted for driving intermittence.

The data showed that drivers were more likely to have made a cellular telephone call during the 10-minute interval immediately before the collision than during a similar interval on the day before the collision...

We next explored some potential explanations for the apparent association between cellular telephone calls and motor vehicle collisions. When we restricted the analysis to the 144 who had owned a cellular telephone for more than five years we still obtained a relative risk of 4.1. This suggested that the association was not just a reflection of inexperience but, instead, might indicate a more basic limitation in driver performance. We then analyzed the 148 who used a hands-free cellular telephone and obtained a relative risk of 5.9. This suggested that hands-free cellular telephones offered no large safety advantage and implied that the main factor in a collision was a driver's limitations in attention rather than in dexterity. A false sense of security, however, could also have led people to have a liberal attitude toward hands-free cellular telephones and thereby to expose themselves to greater risk than if they had a hand-held cellular telephone.

The apparent association seemed to implicate what drivers were doing with their brains, not what they were doing with their hands. What about vision or hearing, though? In the mid-1990s voice-activated dialing was not generally available and was not directly evaluated in our study. To examine potential safety advantages, we reanalyzed the data based only on incoming cellular telephone calls. The results showed a relative risk of 3.0, suggesting that the act of dialing was not the main contributor to the observed association. The acoustical quality of cellular telephone calls in the mid-1990s was less than ideal and may have been particularly poor in hands-free units compared to hand-held units. We had no way to test this hypothesis, but we recognize that it may also explain the absence of a large safety advantage associated with hands-free cellular telephones if annoying noises are especially distracting.

We next wondered whether there were any circumstances in which talking on a cellular telephone was more or less risky than average. To test this, we reran

Figure 3. One of many cartoons inspired by the research.

the analyses for collisions occurring in the morning, afternoon, and evening and found consistent results throughout. We concluded that no particular time of the day was especially dangerous or protective. Similarly, we recalculated the association for collisions occurring in the winter and the summer and again found consistent results. We concluded that the potential hazards might apply to other regions that are warmer or colder than Canada. Finally, we compared collisions occurring at high-speed locations to collisions occurring at low-speed locations and obtained a significantly greater relative risk in locations with significantly greater relative speeds (5.4 vs. 1.6). We formed no strong conclusions from this comparison, however, because we did not know the actual speed of the vehicle at the time of impact or the type of roadways traveled during the control interval.

Our results suggested that cellular telephones may distract drivers and thereby contribute to an increased risk of a motor vehicle collision. On this basis, we recommend that cellular telephones be used sparingly. That is, drivers should avoid unnecessary calls, keep the conversations brief, and suspend dialogue during particularly hazardous circumstances. Late at night when roads are wet is not the time for drivers to multiply their risk of a collision by a factor of 4. Because one of us is a medical doctor, we also repeated here the established advice that all drivers should abstain from alcohol, avoid excessive speed, and minimize other distractions. For people who do not have cellular telephones but converse with those who do, we suggest an awareness of the potential distracting effect and encourage both parties to interrupt dialogue any time during hazardous driving circumstances.

In our study we also directed some effort to assessing positive aspects of using a cellular telephone. For example, we were able to show that cellular telephones offered benefits because people could use them to make emergency calls swiftly. Apparently, the technology is reasonably durable, is able to withstand the initial impact of most motor vehicle collisions, and thereafter can be useful for summoning help. Overall, 39% of the people in our study made at least one emergency call immediately after a collision. Additionally, cellular telephones seemed to be convenient during the rest of the day for making calls either to home, the office, the insurance company, the repair shop, or other persons.

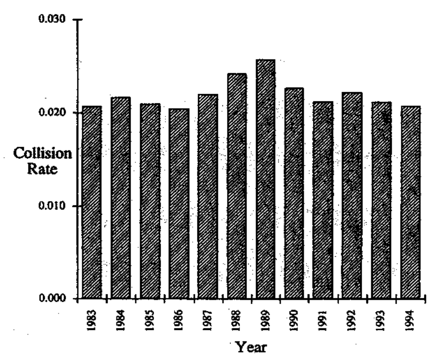


Figure 4. Per capita collision rates for each year. Data are for Ontario, Canada. For example, in 1983 the population was 8,816,000, the total collisions were 181,999, and the per capita collision rate was .021 (181,999/8,816,000).

Some people in our study only used their cellular telephone for emergencies and never made a call otherwise. For these few individuals (14 out of 699), the technology offered some potential benefits and no potential risks.

Aftermath

After publishing our main results in the scientific literature (Redelmeier and Tibshirani 1997), we have been approached by many journalists and can now anticipate several common questions. As insinuated by the title of this article, some people have interpreted our research as indicating that using a cellular telephone is equivalent to driving drunk (Fig. 3). This is not true. Driving with a blood alcohol level at the legal limit is associated with a relative risk of 4 (Simpson 1985), which is about the same as what we found for using a cellular telephone. Driving with a blood alcohol level 50% above the legal limit, however, is associated with a factor of 10 (Simpson 1985). And greater degrees of intoxication must surely be associated with even higher relative risks. Furthermore, alcohol stays in the bloodstream for several hours, whereas a typical cellular telephone call lasts only one or two minutes. The cumulative risks associated with alcohol intoxication are much greater than those associated with using a cellular telephone.

The brief duration of most cellular telephone calls also helps explain why the increased popularity has not been accompanied by a dramatic increase in the number of collisions. Consider a driver who has about a 1 in 50 annual chance, or .020, of being in a collision. The relative risk of 4 for cellular telephones means that if the driver was always on the telephone the annual chance of a collision would increase to about .080. Spending only one-third of the time on the telephone, perhaps a more realistic estimate, would amount to a .040 annual chance of a collision (.33 x .08 + .67 x .02). And a population where 5% of drivers suddenly acquired cellular telephones would show an increase from a .020 to a .021 annual chance of a collision (.05 x .04 + .95 x .02). The difference between .020 and .021 would be imperceptible when compared to overall trends in collision rates (Fig. 4) (Ontario Ministry of Transport 1996).

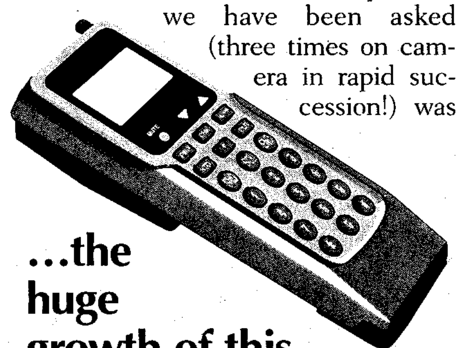
We have sometimes been asked for the number of drivers who were still holding their telephone at the time of impact. An exact answer is difficult because the duration of each call is not recorded to the nearest second. Some drivers in our study might have dropped their telephone a moment before the crash. And a few might have been off the phone for as much as a minute before the crash. Not knowing the precise time each call ended, therefore, adds irrelevant calls. Such irrelevant calls appear in both the hazard and control intervals, with the net effect of having our analysis underestimate the relative risk ratio. Roughly speaking, irrelevant calls dilute the apparent relative risks. Thus, the degree of underestimation depends on when each call stops being relevant. The degree of underestimation would be large if the effects of a call resolved immediately after it ended (and small if drivers need substantial time afterward to return their full attention to the road).

Journalists have wondered how the relative risk associated with using a cellular telephone might compare to the relative risk associated with drinking coffee, applying makeup, or shaving while driving. Our study only involved cellular telephones, and we can only speculate about these other potential distractions. Indeed, speculation may be the only insight available for a long time given that objective records of these activities are unlikely to be available soon. One notable distinction, however, is that taking a sip of coffee only takes a moment and drivers can self-select the moment they think appropriate. In comparison, a cellular telephone conversation is a much more extended exposure during which driving circumstances can change dramatically. Hence, we limit our discussion of relative risks only to conversations occurring on cellular telephones.

We have also been asked whether a conversation with a fellow passenger is identical to a conversation on a cellular telephone. Again, scientific data won't be available soon. There are three reasons to speculate, however, why these two types of conversations may not be the same. First, a fellow passenger contributes not just to distraction but also to vigilance (by pointing out factors such as nearby pedestrians, a missed street sign, or an approaching vehicle). Second, a fellow passenger is unlikely to be a major client or an immediate supervisor or a surprise visitor. Third, a fellow passenger will be somewhat sensitive to roadway conditions and understand, for example, why a driver might have stopped talking when merging into heavy traffic. None of these three factors necessarily applies to the same extent for conversations occurring on cellular telephones.

Many journalists have pressed on the issue of regulation even though our study emphasized individual awareness and decision making. As scientists, we believe our role is to provide reliable estimates of the magnitude of the risks and benefits. Others must decide for themselves whether the benefits outweigh the risks. The most powerful argument in favor of regulation is that bad driving imposes risks on others. The most powerful rebuttal against regulation is that cellular telephones also confer advantages on others (for example the reporting of medical emergencies, criminal activity, and mechanical breakdowns). Public debate is necessary because cellular telephones contribute directly to quality of life, work productivity, and peace of mind for more than 25% of the population in some countries. Scientific data contribute to this dialogue but should not dominate the discussion.

The most outlandish question we have been asked (three times on camera in rapid succession!) was whether cellular telephones are lethal weapons. Such a question betrays an overly dramatic interpretation of our research. We did not examine collisions that resulted in death, and we do not know how the association might change across the spectrum of severity. Cellular telephones are not a sufficient cause given that most calls do not result in a fatal collision. Cellular telephones are not a necessary cause given that the majority of fatal collisions do not involve a cellular telephone call. Even if one accepted that cellular telephones could contribute to collisions, the exact causal mechanism is unknown and the potential would remain for making a change elsewhere (in the driver, vehicle, or environment) that could eliminate risk of death. Statistics offers evidence so that decision makers neither neglect nor exaggerate real-world situations.



...the huge growth of this technology in recent years... has not been accompanied by a dramatic increase in collision rates.

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