Concours n° 2014-IE-CE-01

Ingénieur d'étude en épidémiologie et /ou statistiques dans le domaine des risques sanitaires liés aux transports

Phase d’admission - Épreuve écrite du 23 juin 2014

L’épreuve (notée sur 60 points) comprend trois exercices indépendants :

- **EXERCICE I - Bases de Données** (12 points)
- **EXERCICE II - Dénombrement, probabilité et statistique** (24 points)
- **EXERCICE III - Lecture critique d’article scientifique** (24 points)

Vous avez 3 heures pour traiter l’ensemble, dans l'ordre qui vous convient.

EXERCICE I - Bases de Données (12 points)

Un passionné de cinéma et de festivals de films décide de réaliser sa base de données personnelle destinée à stocker des informations sur différents grands festivals de cinéma (Venise, Cannes, Berlin, …) pour chaque année où ils se déroulent. Outre le lieu et le nom du directeur du festival, pour chacun d'entre eux il désire également enregistrer les films en compétition (titre, réalisateur), les acteurs (nom, nationalité, film(s) en compétition dans lesquels ils ont tourné) et les réalisateurs (nom, film en compétition qu'ils ont réalisé) présents durant le festival. Enfin, pour chaque festival, il veut encoder à part le film qui a remporté le grand prix, et l'acteur et l'actrice ayant remporté le prix des meilleurs rôles masculin et féminin.

1) Réalisez le schéma relationnel de cette base de données.
2) Écrire en langage SQL les requêtes sur cette base permettant d'obtenir les réponses aux questions suivantes :

- Quelle est la liste des directeurs successifs du festival de Berlin (avec les années) ?
- Quel est le nom du film qui a remporté la palme d'or à Cannes en 1993 ?
- Quel est le titre du film en compétition à Venise en 1933 pour lequel l'actrice Katharine Hepburn a été primée meilleure actrice ?

EXERCICE II - Dénombrement, probabilité et statistique (24 points)

Aux Etats-Unis, et d'après la NHS, 10% de la population des 18-24 ans sont gauchers.

1. **Dénombrement :** On tire au sort 10 individus dans cette population.
   (a) Combien existe-t-il de façons d'ordonner ces 10 individus ? (ou combien existe-t-il de permutations [1] de l'ensemble $\{1, \ldots, 10\}$?)
   (b) Sans se soucier de l'ordre maintenant, combien de sous-échantillons de taille 4 existe-t-il dans cet échantillon de taille 10 ?
2. **Probabilité**
   (a) Soit Y la variable aléatoire qui représente, pour un individu donné, le fait d'être gaucher (*i.e.*, qui vaut 1 si l'individu est gaucher, et 0 sinon).
      i. Quelle est la loi de probabilité de Y ?
      ii. En rappelant que pour une variable aléatoire discrète Z, à valeur sur un ensemble $\mathcal{Z}$, on a $\mathbb{E}(Z) = \sum_{z \in \mathcal{Z}} z \, \mathbb{P}(Z = z)$, calculer $\mathbb{E}(Y)$.
      iii. Quelle est la loi de probabilité de la variable aléatoire $Y_2 = Y^2$? En déduire l'espérance de $\mathbb{E}(Y_2)$, et par suite la variance de Y.
   (b) On considère une paire constituée de 2 individus successivement tirés au sort dans la population.
      i. Sachant que l'un des 2 individus de la paire (au moins) est gaucher, quelle est la probabilité pour que l'autre soit droitier ?
      ii. Sachant maintenant que le premier individu est gaucher, quelle est la probabilité pour que le deuxième soit droitier ?
3. **Statistique**
   (a) Quelle est la probabilité que 2 individus, dans un échantillon de taille 10 de notre population, soient gauchers ?
   (b) Sans effectuer le calcul numérique, et en supposant ne disposer que des tables statistiques usuelles, expliquer comment procéder pour calculer la probabilité qu'au moins 263 individus soient gauchers sur un échantillon de taille 1387 de notre population des 18-24 ans aux USA.
   (c) Des chercheurs veulent étudier la liaison entre le fait d'être gaucher et la mutation de 2 gènes, G_1 et G_2. Ces mutations sont chacune de prévalence 15% dans la population. Pour leur étude, les chercheurs constituent un échantillon de 2000 individus tirés au sort dans la population. Ils envisagent de construire un modèle de régression logistique pour étudier la relation entre Y, H_1, H_2 et l'interaction $H_{12} = H_1 \times H_2$, où, pour $k = 1, 2$, la variable aléatoire H_k vaut $H_k = 1$ si le gène G_k est muté, et $H_k = 0$ sinon.
      i. Commenter/critiquer la constitution de l'échantillon ?
      ii. Ecrire l'équation du modèle de régression logistique envisagé par les chercheurs.
      iii. En notant α_0, β_1, β_2 et γ les coefficients théoriques de ce modèle, associés respectivement à l'intercept, H_1, H_2 et H_{12}, que valent les probabilités d'être gaucher pour

[1]. Une permutation est une façon de mettre les éléments d'un ensemble dans un certain ordre : pour l'ensemble $\{1, 2, 3\}$ des permutations possibles sont donc $\{1, 2, 3\}$, $\{3, 1, 2\}$, etc.

A. les individus ne portant aucune mutation ;

B. les individus portant une seule mutation, pour le gène G_1 ;

C. les individus portant une mutation sur chacun des deux gènes ?

iv. On note maintenant $\widehat{\alpha}_0$, $\widehat{\beta}_1$, $\widehat{\beta}_2$ et $\widehat{\gamma}$ les coefficients du modèle estimés sur l'échantillon de taille 2000. On note de plus $s^2_{\widehat{\alpha}_0}$, $s^2_{\widehat{\beta}_1}$, $s^2_{\widehat{\beta}_2}$ et $s^2_{\widehat{\gamma}}$ les variances empiriques associées.

A. Quel est le principe général d'estimation dans les modèles de régression logistique ? (indiquer par exemple la méthode statistique d'estimation, l'algorithme classiquement utilisé pour résoudre le problème d'optimisation associé, etc.).

B. Quelles sont les propriétés statistiques de ces estimateurs (type de loi asymptotique, propriétés en terme de biais et variance) ?

C. Donner la forme d'un intervalle de confiance approché à 95% pour le coefficient γ. Supposons que l'application numérique donne l'intervalle $[0.05, 0.25]$. Quelle est la probabilité que la vraie valeur γ appartienne à cet intervalle ? En quoi cet intervalle peut-être utile pour conclure quant à l'existence d'une association entre Y et H_{12} ?

D. On suppose que tous les coefficients théoriques α_0, β_1, β_2 et γ sont différents de 0. Sans nécessairement faire l'ensemble des calculs, indiquer comment construire un intervalle de confiance approché à 95% pour la probabilité d'être gaucher chez (i) les individus ne portant aucune mutation, et (ii) les individus portant une seule mutation, pour le gène G_1. En quoi l'hypothèse selon laquelle les coefficients théoriques α_0, β_1, β_2 et γ sont différents de 0 vous est-elle "utile" ici ? L'énoncé vous fournit-il l'ensemble des quantités nécessaires ?

EXERCICE III – Lecture critique d’article scientifique (24 points)

Redelmeier, D.A., and Tibshirani, R.J., Association between Cellular-Telephone Calls and Motor Vehicle Collisions, N Engl J Med 1997; 336:453-458, February 13, 1997.

(une copie de cet article est jointe au présent énoncé, en fin de document)

Cet article est paru en 1997, au début de la diffusion du téléphone portable, et de son utilisation éventuelle en conduisant. Nous vous invitons à en faire une lecture critique en répondant à des **questions (1)**, puis à en écrire le **résumé en français (2)** en environ 300 mots. Pour faciliter la compréhension du texte, certains mots sont traduits dans le glossaire ci-dessous.

Glossaire

Collision	Accident
Cellular telephone	Téléphone portable
Property damage	Dommage matériel
Billing record	Dossier de facturation (relevé d'appels)
Feature	Caractéristique
Invoice	Facture
Spurious	Fausse, impropre
Acknowledge	Reconnaître
To yield	Conduire à
In the aftermath	À la suite

1) Répondez de manière concise aux questions suivantes

Contexte de la Recherche	
Q1	A quoi servent à votre avis les études expérimentales évoquées en introduction, et en quoi cette étude épidémiologique apporte-t-elle d'autres éléments de connaissance ?
Methode	
Q2	Comment l'utilisation du téléphone et l'instant de l'accident sont-ils estimés dans cette étude ? Quels problèmes cela peut-il poser ?
Q3	Que voyez-vous comme avantages-inconvénients du design utilisé (case-crossover) ?
Q4	Pourquoi définir plusieurs périodes de comparaison ?
Q5	Que pensez-vous de la prise en compte de l'intermittence de la conduite ? Est-ce indispensable, et si oui pouvez-vous imaginer une autre technique ?

Analyse	
Q6	Les auteurs ont-ils raison d'utiliser un modèle de régression logistique ? Expliquez pourquoi.
Q7	Pourquoi les auteurs utilisent-ils la technique du Bootstrap pour estimer les intervalles de confiance ?
Résultats	
Q8	Pourquoi les auteurs parlent-il de risques relatifs plutôt que de odds-ratios ?
Q9	Au vu du 2ème paragraphe de la page 455, faîtes le calcul pour retrouver le RR brut (= 6,5).
Q10	Que pensez-vous de l'incidence sur les résultats de la durée moyenne des conversations telle qu'indiquée dans les résultats ? Cela intervient-il dans l'interprétation de la figure 2 ? Êtes-vous d'accord avec la dernière phrase de la légende de cette figure ?
Q11	Les RR associés aux appels entrants et sortants sont respectivement de 3,0 et 3,8. Que pensez-vous ou que diriez-vous de ce résultat ?
Discussion	
Q12	Selon les auteurs quels sont les points forts et les points faibles de cette recherche ?
Q13	Et vous, en voyez-vous d'autres ?

2) **Écrivez le résumé de cet article en français** (en 300 mots environ)

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ASSOCIATION BETWEEN CELLULAR-TELEPHONE CALLS AND MOTOR VEHICLE COLLISIONS

DONALD A. REDELMEIER, M.D., AND ROBERT J. TIBSHIRANI, PH.D.

ABSTRACT

MOTOR vehicle collisions are a leading cause of death in North America; they are the single most frequent cause of death among children and young adults and account for one fatality every 10 minutes.[1-3] During an average year, about 1 person in 50 will be involved in a motor vehicle collision; 1 percent of them will die, 10 percent will be hospitalized, and 25 percent will be temporarily disabled.[4,5] Motor vehicle collisions often injure persons who are otherwise in good health. The causes of motor vehicle collisions are complicated, but error on the part of drivers contributes to over 90 percent of events.[6]

Cellular telephones can be used for placing and receiving telephone calls while in a motor vehicle. North American sales are enormous; for example, in 1995 the number of new subscribers in the United States exceeded the birth rate.[7,8] Many believe that telephones may contribute to collisions by distracting drivers,[9] and a few countries (such as Brazil, Israel, and Australia) have laws against using a cellular telephone while driving. Research with simulators suggests that use of the telephone can impair some aspects of driving performance.[10-14] However, industry-sponsored surveys have found no increased risk associated with car telephones.[15,16]

The most rigorous experimental method for testing the effects of cellular telephones on motor vehicle collisions is to assess outcomes for persons randomly assigned to use or not use the devices, but such a study would be very difficult to perform and possibly unethical. Instead, we used an epidemiolog-

From the Departments of Medicine (D.A.R.), Preventive Medicine and Biostatistics (R.J.T.), and Statistics (R.J.T.) and the Program in Clinical Epidemiology and Health Care Research (D.A.R.), University of Toronto, Toronto; and the Division of Clinical Epidemiology, Sunnybrook Health Science Centre, North York, Ont., Canada (D.A.R.). Address reprint requests to Dr. Redelmeier at Sunnybrook Health Science Centre, G-151, 2075 Bayview Ave., North York, ON M4N 3M5, Canada.

ic method, the case–crossover design, to evaluate potential associations between the use of a cellular telephone and the risk of a motor vehicle collision in real-world circumstances.

METHODS

The study was conducted in Toronto, an urban region of 3 million people with no regulations against using a cellular telephone while driving. Persons who came to the North York Collision Reporting Centre between July 1, 1994, and August 31, 1995, during peak hours (10 a.m. to 6 p.m.) on Monday through Friday were included in the study if they had been in a collision with substantial property damage (as judged by the police). Drivers do not report to the center if the collisions involve injury, criminal activity, or the transport of dangerous goods. Drivers were excluded if they said they did not have a cellular telephone or if their billing records could not be located by May 1, 1996.

Use of Cellular Telephones

Consenting subjects completed a brief questionnaire about their personal characteristics and the features of the collision. We collected telephone records through each person's cellular-telephone number and verified each invoice by checking the subject's full name, mailing address, and calls made to his or her home telephone number. For each record, we analyzed all telephone activity on both the day of collision and the preceding seven days, with particular attention to the time, duration, and direction (incoming or outgoing) of each call. Special note was made of contact with ambulance personnel, police, or other emergency services.

Time of the Motor Vehicle Collision

The time of each collision was estimated from the subject's statement, police records, and telephone listings of calls to emergency services. We classified the times of collisions as "exact" when information from all three sources was available and consistent or when one source supplied no data but the remaining two agreed. Otherwise, we classified the times as "inexact" and used the earliest of the available two or three times to avoid misclassifying calls made after the collision as contributing to the event. Selecting the earliest listed time reduced the chance of finding spurious associations between telephone use and collisions. However, selecting an excessively early time could lead to the underestimation of the magnitude of any association.

Analytic Method

We used case–crossover analysis, a technique for assessing the brief change in risk associated with a transient exposure. According to this method, each person serves as his or her own control; confounding due to age, sex, visual acuity, training, personality, driving record, and other fixed characteristics is thereby eliminated.[17] We used the pair-matched analytic approach to contrast a time period on the day of the collision with a comparable period on a day preceding the collision.[18] In this instance, case–crossover analysis would identify an increase in risk if there were more telephone calls immediately before the collision than would be expected solely as a result of chance.

Definitions of Time Periods

We defined the hazard interval to include any telephone calls occurring during the 10 minutes before the estimated time of the collision, and tested the robustness of our results by analyzing intervals of 1, 5, and 15 minutes.[19] In the primary analysis, we compared each person's telephone activity immediately before the collision (case) to his or her activity during a control period at the same time as the hazard interval on the day before the collision (crossover). In supplementary analyses we evaluated alternative comparison days and considered intervals of an hour leading up to the collision.

Alternative Comparison Days

We checked our estimates by repeating the calculations using four other control intervals. In the workday comparison we selected the day of the workweek preceding the collision; for example, the period just before a collision on Monday was compared with the same period on the preceding Friday. In the weekday comparison, we selected the same day one week before the collision; for example, Monday was compared with the preceding Monday. In the matching-day comparison, we selected the nearest day of the preceding week on which there was cellular-telephone activity in the predefined lead-up period before the collision. For the maximal-use-day comparison, we used the control interval from the preceding three days in which there was the greatest amount of cellular-telephone activity.

Accounting for Intermittency of Driving

Evaluating telephone activity on the day before a collision is appropriate only if driving occurred during the control interval on that day. A pilot survey involving 100 subjects indicated that 35 percent of them did not drive during the selected period; the rules of conditional probability suggested that this degree of intermittency of driving would inflate the apparent relation between cellular-telephone use and motor vehicle collisions by a factor of 1.5 ($1 \div 0.65$).[20,21] Our estimates of relative risk were therefore divided by this factor as one way of adjusting for the intermittency of driving.

To examine the robustness of our analysis, we also tested a different adjustment that relied on individual driving patterns. To do so, between October 25 and November 28, 1996, we attempted to contact all subjects who had used their cellular telephones in the 10 minutes before the collision or the 10-minute control period. We asked each person to remember his or her driving pattern on both the day of the collision and the day before the collision. We then recalculated relative risks by limiting the analysis to subjects who were confident that they had driven a motor vehicle during both periods on both days.

Ethical Issues

The protocol was approved by the University of Toronto Human Ethics Committee, and all participants provided informed consent. Private industry supplied telephone records but otherwise had no involvement in data collection or analysis or funding the study. Individual billing records were obtained directly from cellular-telephone carriers who provided records for 100 consecutive days of telephone use for each person and who were not told which particular date was the day of the collision. Police reports were obtained directly from police departments; they, in turn, were not provided copies of the drivers' cellular-telephone records.

Statistical Analysis

The sample size was calculated to provide an 80 percent chance of detecting a doubling or halving of collision rates. Relative risks were estimated with methods for matched-pairs studies on the basis of exact binomial tests and conditional logistic-regression analyses.[22] Confidence intervals for the relative risks were derived with the bootstrap bias-corrected method and accounted for the uncertainty in the adjustment for intermittency of driving.[23,24] Modifications of the relative risks were assessed by comparing different subgroups, with particular attention to the prespecified contrast between hand-held cellular telephones and models that leave the hands free. All P values were two-tailed, and all relative risks were computed with 95 percent confidence intervals.

RESULTS

We approached 5890 drivers, of whom 1064 acknowledged having a cellular telephone and 742 consented to participate in the study; the billing records of 699 of these drivers were located (Table 1). The collision times were exact for 231 subjects and inexact for 468. The group placed a total of 16,870 cellular-telephone calls and received 3643 calls during the week before the collisions (average, 3.4 calls placed and 0.7 call received per person each day). The average duration of the calls was 2.3 minutes, and 76 percent lasted 2 minutes or less (similar to cellular-telephone calling patterns elsewhere[25]). The monthly bill in U.S. currency for the average participant was $72, which was greater than that for the average subscriber in Toronto or the average subscriber in North America ($53 and $51, respectively).[26-28]

Overall, 170 subjects (24 percent) had used a cellular telephone during the 10-minute period immediately before the collision, 37 (5 percent) had used the telephone during the same period on the day before the collision, and 13 (2 percent) had used the telephone during both periods. The crude analysis indicated that cellular-telephone activity was associated with a relative risk of a motor vehicle collision of 6.5 (95 percent confidence interval, 4.5 to 9.9). The primary analysis, adjusted for intermittent driving, indicated that cellular-telephone activity was associated with a quadrupling of the risk of a motor vehicle collision (relative risk, 4.3; 95 percent confidence interval, 3.0 to 6.5).

At follow-up in 1996, we located 145 subjects, of whom 72 (50 percent) were confident that they had driven during both the hazard period and the control period. Restricting our analysis to this subgroup yielded an estimated relative risk of 7.0 (95 percent confidence interval, 3.7 to 15.5) associated with cellular-telephone use. An analysis that included the entire cohort of 699 drivers and used alternative comparison days yielded similar estimates of the relative risk of a collision (Fig. 1). All the alternative estimates of relative risk were adjusted for intermittent driving, and all were statistically significant ($P<0.001$).

The relative risk of a collision associated with using a cellular telephone was consistent among subgroups with different characteristics (Table 2). Younger drivers were at a somewhat higher relative risk when using a cellular telephone than older drivers, although the trend was not significant. In no group did cellular-telephone use have a protective effect. In particular, subjects with many years of experience in using a cellular telephone still had a significant increase in risk. The highest relative risk was found among subjects who had not graduated from high school. Telephones that allowed the hands to be free did not appear to be safer than hand-held telephones.

The increase in risk appeared to be greatest for calls made near the time of the collision, and was not statistically significant for calls made more than 15 minutes before the event (Fig. 2). The relative risk was 4.8 for calls within 5 minutes before the collision, as compared with 1.3 for calls more than 15 minutes before the collision ($P<0.001$). The risks were similar at different times of the day and of the week (Fig. 3). Estimates appeared robust when calculated with use of hazard intervals of 1, 5, or 15 minutes before the collision (relative risks, 4.7, 4.8, and 4.3, respectively), for data including exact rather than inexact times of collisions (4.0 and 4.5, respectively), and with only incoming calls or only outgoing calls included (3.0 and 3.8, respectively). The association appeared stronger for collisions on high-speed roadways than for collisions in parking lots, at gas stations, or in other low-speed locations (5.4 vs. 1.6, $P=0.014$).

A total of 5325 calls were placed and 960 calls

Table 1. Characteristics of 699 Drivers and Collisions.

Characteristic	No. (%)*
Age (yr)	
<25	67 (10)
25–39	346 (49)
40–54	227 (32)
≥55	59 (8)
Sex	
Male	502 (72)
Female	197 (28)
High-school graduation	
Yes	615 (88)
No	84 (12)
Type of job	
Professional	168 (24)
Other	531 (76)
Driving experience (yr)	
0–9	137 (20)
10–19	246 (35)
20–29	188 (27)
≥30	128 (18)
Cellular-telephone experience (yr)	
0 or 1	223 (32)
2 or 3	174 (25)
4 or 5	158 (23)
≥6	144 (21)
Type of cellular telephone	
Hand-held	551 (79)
Hands free	148 (21)
Time of collision	
Dawn	19 (3)
Morning	268 (38)
Afternoon	248 (35)
Evening	145 (21)
Night	18 (3)
Late night	1 (<1)
Day of collision	
Sunday	20 (3)
Monday	133 (19)
Tuesday	126 (18)
Wednesday	159 (23)
Thursday	136 (19)
Friday	113 (16)
Saturday	12 (2)
Location of collision	
High-speed location	597 (85)
Low-speed location	102 (15)

*Because of rounding, percentages do not always total 100.

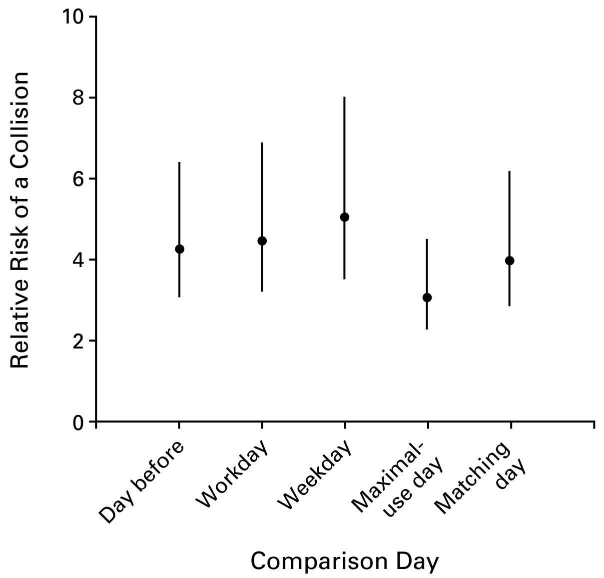

Figure 1. Relative Risk of a Collision for Different Control Periods.

Relative risks were calculated for five different control intervals. In the day-before comparison, we used the control period on the day immediately before the collision; in the workday comparison, the period on the preceding day of the workweek; in the weekday comparison, the period on the day one week before the collision; in the maximal-use-day comparison, the day with the most cellular-telephone activity of the three days preceding the collision; and in the matching-day comparison, the period on the nearest day of the preceding week in which there was cellular-telephone activity in the lead-up period. The vertical lines indicate 95 percent confidence intervals. Bars entirely above 1 indicate statistically significant associations ($P<0.05$).

TABLE 2. RELATIVE RISK OF A MOTOR VEHICLE COLLISION IN 10-MINUTE PERIODS, ACCORDING TO SELECTED CHARACTERISTICS.*

CHARACTERISTIC	NO. WITH TELEPHONE USE IN 10 MIN BEFORE COLLISION	RELATIVE RISK (95% CI)
All subjects	170	4.3 (3.0–6.5)
Age (yr)		
<25	21	6.5 (2.2–∞)
25–39	95	4.4 (2.8–8.8)
40–54	44	3.6 (2.1–8.7)
≥55	10	3.3 (1.5–∞)
Sex		
Male	123	4.1 (2.8–6.4)
Female	47	4.8 (2.6–14.0)
High-school graduation		
Yes	153	4.0 (2.9–6.2)
No	17	9.8 (3.0–∞)
Type of job		
Professional	34	3.6 (2.0–10.0)
Other	136	4.5 (3.1–7.4)
Driving experience (yr)		
0–9	40	6.2 (2.8–25.0)
10–19	67	4.3 (2.6–10.0)
20–29	36	3.0 (1.7–7.0)
≥30	27	4.4 (2.1–17.0)
Cellular-telephone experience (yr)		
0 or 1	51	7.8 (3.8–32.0)
2 or 3	39	4.0 (2.2–12.0)
4 or 5	36	2.8 (1.7–6.7)
≥6	44	4.1 (2.3–12.0)
Type of cellular telephone		
Hand-held	129	3.9 (2.7–6.1)
Hands free	41	5.9 (2.9–24.0)

*Relative risks indicate the probability of having a collision when using a cellular telephone at any time during a 10-minute interval as compared with the probability of having a collision when not using a cellular telephone at any time during a 10-minute interval. Relative risks have been adjusted to account for the intermittence of driving. CI denotes confidence interval.

were received on the collision days, of which the majority occurred after the event (68 percent and 64 percent, respectively). About 39 percent of the subjects used their cellular telephone at least once to contact emergency services immediately after the collision. The median number of calls made during the remainder of the day after the collision was substantially greater than the median number of calls made during an entire day before the collision (four vs. two, $P<0.001$). Of those who had not used their telephone on any day before the collision, 14 of 39 (36 percent) made at least one call in the aftermath of the event.

DISCUSSION

We found that using a cellular telephone was associated with a risk of having a motor vehicle collision that was about four times as high as that among the same drivers when they were not using their cellular telephones. This relative risk is similar to the hazard associated with driving with a blood alcohol level at the legal limit.[29-31] We also found that cellular telephones have benefits, such as allowing drivers to make emergency calls quickly. A few drivers used their telephones only in the aftermath of a collision, thereby gaining some potential benefits and incurring no potential risks due to telephone use. In general, cellular-telephone calls were brief and infrequent, which explains why the rapid growth of this technology during recent years has not been accompanied by a dramatic increase in motor vehicle collisions.[32]

We observed no safety advantage to hands-free as compared with hand-held telephones. This finding was not explained by imbalances in the subjects' age, education, socioeconomic status, or other demographic characteristics. Nor can it be explained by suggesting that those with units that leave the hands free do more driving. One possibility is that motor vehicle collisions result from a driver's limitations with regard to attention rather than dexterity.[33] Regardless of the explanation, our data do not support the policy followed in some countries of restricting hand-held cellular telephones but not those that leave the hands free.

Three weaknesses of this study should be pointed

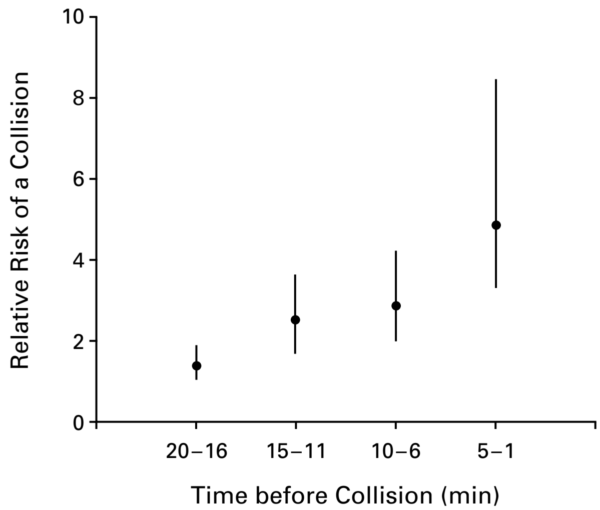

Figure 2. Time of Cellular-Telephone Call in Relation to the Relative Risk of a Collision.

Each minute before the collision was assessed as an independent hazard interval, with these intervals grouped in five-minute periods. Cellular-telephone activity for each hazard interval was evaluated in relation to the same period on the day before the collision. Relative risks greater than 1 indicate an association between telephone use and collisions. The vertical lines indicate 95 percent confidence intervals. Bars entirely above 1 indicate statistically significant associations ($P<0.05$). Calls made 1 to 5 minutes before the collision were significantly riskier than calls made 16 to 20 minutes before the collision ($P<0.001$).

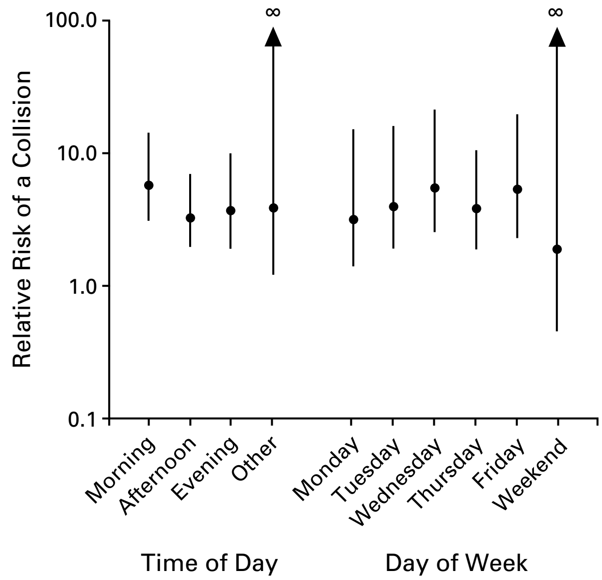

Figure 3. Consistency of Relative Risks Obtained from Different Collision Times.

The graph shows estimates of relative risk for collisions at different times of the day and of the week. Morning was defined as 8 a.m. to 11:59 a.m., afternoon as noon to 3:59 p.m., evening as 4 p.m. to 7:59 p.m., and other as all remaining times. Saturday and Sunday are combined in a single weekend category. The vertical lines indicate 95 percent confidence intervals. Bars entirely above 1 indicate statistically significant associations ($P<0.05$). The vertical scale is logarithmic.

out. First, we studied only drivers who consented to participate. The fact that some persons chose not to consent might have caused us to underestimate the risks associated with telephone use if these people declined because of concern about personal liability. Second, people vary in their driving behavior from day to day — a fact that makes the selection of a control period problematic. However, it would be difficult to explain all our findings on the basis of different driving patterns, and in particular, this factor would not account for the similar results for those who remembered driving during both periods on both days. Third, case–crossover analysis does not eliminate all forms of confounding. Imbalances in some temporary conditions related to the driver, the vehicle, or the environment are possible, but we believe such factors are not likely to account for the magnitude of the association we observed.

Our study indicates an association but not necessarily a causal relation between the use of cellular telephones while driving and a subsequent motor vehicle collision. For example, emotional stress may lead to both increased use of a cellular telephone and decreased driving ability. If so, individual calls may do nothing to alter the chances of a collision. In addition, our study did not include serious injuries; hence, we do not know how — or whether — cellular-telephone use is associated with motor vehicle fatalities. Finally, the data do not indicate that the drivers were at fault in the collisions; it may be that cellular telephones merely decrease a driver's ability to avoid a collision caused by someone else.

We caution against interpreting our data as showing that cellular telephones are harmful and that their use should be restricted. Even if a causal relation with motor vehicle collisions were to be established, drivers are vulnerable to other distractions that could offset the potential reductions in risk due to restricting the use of cellular telephones. Regulations would also mean reducing benefits; in Canada, for example, half a million calls to 911 emergency services are made from cellular telephones each year.[34] Yet proposals for regulation are not unreasonable, since poor driving imposes risks on others. Public debate is needed, given that cellular telephones contribute to improvements in productivity, the quality of life, and peace of mind for more than 30 million people in North America alone.

The role of regulation is controversial, but the role of individual responsibility is clear. Drivers who use a cellular telephone are at increased risk for a motor vehicle collision and should consider road-safety precautions. For them as for all other drivers, these include abstaining from alcohol, avoiding excessive speed, and minimizing other distractions. Additional strategies might include refraining from placing or receiving unnecessary calls, interrupting telephone conversations if necessary, and keeping calls brief — particularly in hazardous driving situations. Physicians should also learn to recognize patients who are at risk for a collision and who may benefit from advice regarding safety.[35-40] Even limited success in reducing risk may prevent some of the death, disability, and property damage related to motor vehicle collisions.

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