Motor Vehicle Accidents and IDDM

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A case-control study examining the 1-yr motor vehicle accident experiences of 158 insulin-dependent diabetes mellitus (IDDM) cases and 158 nondiabetic siblings was undertaken to evaluate the risk of motor vehicle accidents among drivers with IDDM. In multivariate analyses the overall accident risk of the cases and control subjects did not differ significantly. Female diabetic drivers, however, showed a marked increased risk for motor vehicle accidents. The accident risk among female cases was five times higher than among the female control subjects ($P < .05$). Age and marital status were also significantly associated with accident probability in the multivariate model. The results suggest that IDDM could have an effect on the accident rate of diabetic drivers, particularly women. However, the traditional risk factors for automobile accidents, i.e., age and marital status, appear to have an equally strong influence on accident occurrence. Further studies are needed to *1)* document the role of IDDM in accidents among representative samples of the IDDM population and *2)* properly evaluate the licensing restrictions recommended for diabetic drivers. *Diabetes Care* 11:701–707, 1988

There is the common belief that individuals with insulin-dependent diabetes mellitus (IDDM) have an increased risk for traffic accidents because of their increased susceptibility to hypoglycemic reactions, visual impairments, neurologic handicaps, and cardiovascular complications. However, a review of the literature reveals little information concerning whether drivers with IDDM have a higher risk of accidents than nondiabetic drivers (1–17).

Several case reports (1–5) and surveys of police-reported accidents (6,7) have shown that hypoglycemic reactions among diabetic drivers were related to traffic accidents. These reports provided essentially no data on the risk of accidents for a group of diabetic drivers. Other studies comparing the rate of traffic incidents (both accidents and moving-vehicle violations) between a group of diabetic drivers and a control group of nondiabetic drivers have reported both an increased (8–10) and decreased (11,12) frequency of traffic incidents among diabetic drivers. Among the many other limitations, these reports did not distinguish the drivers with IDDM from those with non-insulin-dependent diabetes mellitus (NIDDM). Only one study has discussed the accident rate of an IDDM cohort. Frier et al. (13) reported a 13% overall cumulative risk for accidents among drivers with IDDM. Their report, however, did not include a comparison group of nondiabetic drivers.

Clearly, there is little reliable information concerning the risk of motor vehicle accidents in the IDDM population. Despite this lack of data, transportation departments around the world recommend operating restrictions on heavy goods, emergency, and public-transport vehicles for IDDM drivers (18,19) and require that individuals declare they have diabetes when applying for a driver's license (8,13,20).

Our research, therefore, evaluated the rate of motor vehicle accidents in a well-defined population of IDDM cases and a matched population of sibling control subjects to determine whether individuals with IDDM have an increased risk for traffic accidents.

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MATERIALS AND METHODS

The study population was identified from a cohort of 723 individuals who were enrolled in the Children's Hospital of Pittsburgh insulin-dependent diabetes mellitus registry (21,22) and were diagnosed during the years 1950–1964. Eligibility criteria for the Children's Hospital registry include age <17 yr at diagnosis of IDDM, discharge from the hospital on insulin therapy, and having received medical care at Children's Hospital at diagnosis or within 1 yr of diagnosis. The descriptive characteristics of the cases in the Children's Hospital registry from 1965 to 1980 are similar to the characteristics of those cases in the population-based Allegheny County insulin-dependent diabetes mellitus registry during the same time period (21). Thus, the Children's Hospital cohort is probably representative of newly diagnosed cases in 1950–1964.

In 1980–1981, the 1950–1964 Children's Hospital registry cohort was contacted for a follow-up study of life-style factors and complications. Individuals were asked to complete a medical questionnaire to assess mortality, morbidity, family history of diabetes, and family structure. Data were obtained from 93% (n = 671) of the cohort (22). In 1984, a case-control study was designed to investigate the effect of diabetes on the lifestyle of IDDM patients. The cases were identified from the cohort of 671 individuals who completed the medical questionnaire. IDDM cases were eligible for the case-control study if they were 21 yr of age by November 1984 and had a living nondiabetic sibling of the same sex and age (±5 yr). The sibling control, identified from the family-structure data, also had to be ≥21 yr old. Social parameters, including disability, socioeconomic status, and difficulties in obtaining life and health insurance, were then assessed by questionnaire. In addition, driving patterns, including mileage driven, driving experience, license history, and the frequency of motor vehicle accidents during the previous 12 mo, were also ascertained. Complete information was obtained from 87% (n = 158 pairs) of the 181 case-control pairs who fulfilled the eligibility criteria. The demographic characteristics of the participants are presented in Table 1.

Previous reports have noted that many nonfatal accidents are not reported to state and local authorities (23–25). Therefore, the term *motor vehicle accident* was not specifically defined in the questionnaire to assess all accidents, excluding fatal accidents, in which the respondents were the drivers. The type and the severity of accident(s), including information on human injury and property damage, were not solicited from the cases and controls.

Sample sizes were sufficient to detect a 10% difference in the proportion of subjects with a motor vehicle accident between the case-control pairs with an overall power of 0.80. Matched-pair analyses employing the McNemar's test (26), the paired t test, and Wilcoxon's matched-pairs signed-ranks test were used to evaluate the univariate differences, overall and sex specific, between the cases and controls. Unpaired analyses, including the unpaired t test and the Mann-Whitney U test, were conducted within each age, marital, and mileage stratum to allow for the inclusion of all accident data in the analyses. In the marital-status category, participants were classified as currently married or not married (never married, divorced, or separated individuals). Given the nonnormal distribution of accidents in the study population, nonparametric analyses were completed on the accident and accident per 1,000,000 miles driven data. The figures for accident per 1,000,000 miles driven represent the experience of the entire group and not an average of the individual means. All univariate analyses were completed with the SPSS statistical package for mainframe computers (27). Multiple logistic regression analysis was conducted with the BMDP statistical package (28) to simultaneously evaluate the independent associations of diabetes status, age, sex, marital status, and mileage driven and the interactive contribution of diabetes and sex to accident prevalence (yes/no) in the past year. In the multivariate analysis, the case-control matching was broken, and a diabetic status variable (yes/no) was created to numerically assess the contributions of age and sex to accident occurrence. Diabetes status was the variable of primary interest in the modeling. Age, sex, marital status, mileage driven, and the interaction term of diabetes and sex were included because of their suggested association with accidents in the univariate analyses.

TABLE 1
Demographic characteristics of IDDM cases and nondiabetic sibling controls

Characteristics	Cases		Controls	
	n	Percent	*n*	Percent
Age (yr)				
21–29	35	22.2	41	25.9
30–39	106	67.1	92	58.2
40–49	17	10.7	25	15.9
Sex				
Male	88	55.7	88	55.7
Female	70	44.3	70	44.3
Race				
White	154	97.5	154	97.5
Black	4	2.5	4	2.5
Age of IDDM onset (yr)				
0–5	62	39.2		
6–9	46	29.1		
10–16	50	31.7		

RESULTS

Driving patterns. IDDM appeared to be significantly associated with differences in driving capability among

TABLE 2
Driving patterns of IDDM cases and nondiabetic controls at risk for accidents

Characteristic	IDDM cases (n = 127)	Nondiabetic siblings (n = 127)
Miles driven in past year	11,824 ± 12,467	13,978 ± 13,342
By sex		
Men	15,581 ± 14,911*	18,134 ± 14,268*
Women	7607 ± 6977	9311 ± 10,513
By age		
21–29 yr	16,503 ± 19,631	14,650 ± 9712
30–39 yr	10,708 ± 9297	14,417 ± 15,607
40–49 yr	9427 ± 6681	10,700 ± 8214
Years driving	16.4 ± 5.3	16.9 ± 5.7
Age at which licensed	16.7 ± 1.5	16.5 ± 1.3

Values are means ± SD.
*$P < .001$ difference between men and women. P = NS for case vs. control for each characteristic.

the respondents. Overall, fewer IDDM cases (n = 131) than nondiabetic controls (n = 152) reported that they drove a motor vehicle in the previous year (83 vs. 96%, $P < .001$). The characteristics of the 27 nondriving cases and the 131 driving cases were compared to investigate the factors related to driving status. No significant age or sex differences were observed. Four cases had never driven in their lives (2 men, 2 women). The possible reasons for driving cessation among the remaining 23 nondriving cases were then investigated. None had lost his/her driver's license due to an accident, and there was no difference in the cumulative history of health-related accidents between the driving and nondriving cases. Thirty-five percent (n = 8) of the nondriving cases, however, reported that their health had prevented them at some point from maintaining a driver's license on expiration. The presence of diabetic complications (7 reported eye problems, 1 reported a leg amputation) was the reason for nonrenewal cited by these 8 nondriving cases. Most nondriving cases, it appears, voluntarily abstained from driving.

Factors unrelated to driver's license revocation or nonrenewal were also investigated as possible reasons for driving cessation. Overall, nondriving individuals, both those with driver's licenses and those without, were significantly more likely to report the presence of diabetic complications that restrict activity than were the cases who drove (82 vs. 15%, $P < .001$). Eye complications, primarily blindness, were more frequent among the nondriving cases than the driving cases. Neuropathy was more frequent in the cases who drove. Of the 18 nondriving cases reporting the presence of complications, 14 had eye problems (9 were blind), 5 reported a kidney disorder, 2 had heart problems, and 1 had undergone a leg amputation. Of the 19 driving cases reporting activity-limiting complications, 9 had eye problems, 6 reported neuropathy, 5 reported a kidney disorder, and 1 had heart problems. Comorbidity was evident in both groups but was much more prevalent among the nondrivers. Thus, poor health appears to be the strongest factor related to driving status in this IDDM cohort.

Overall, 127 case-control pairs had driven within the last year and were at risk for an automobile accident. Table 2 presents the driving patterns of this group. No difference between the cases and controls was found in the mean number of miles driven during the past 12 mo (11,824 vs. 13,978 miles). However, there was a significant ($P < .001$) difference by sex in the mean number of miles driven for both the cases and controls. Men, on average, drove twice the distance of women during

TABLE 3
Number of accidents in IDDM cases and nondiabetic siblings overall and by age, sex, mileage, and marital status

	Number of drivers		Number of accidents per 100 drivers		
	IDDM cases	Nondiabetic siblings	IDDM cases	Nondiabetic siblings	P (case vs. control)
Total cohort	127	127	14.17	7.09	.17
Sex					
Men	68	68	14.71	10.29	.64
Women	59	59	13.56	3.39	.09
Age (yr)					
21–29	29	32	27.59	15.63	.55
30–39	83	74	12.05	5.41	.64
40–49	15	21	0.00	0.00	.98
Mileage (per yr)					
1–9999	55	46	7.27	4.35	.80
10,000–19,999	47	45	14.89	8.89	.74
≤20,000	24	31	29.17	6.45	.36
Marital status					
Married	92	92	9.78	3.26	.61
Not married	35	35	25.71	17.14	.66

TABLE 4
Number of accidents per 1,000,000 miles driven per year in IDDM cases and nondiabetic siblings by age, sex, mileage, and marital status

	Number of drivers		Number of accidents per 100 drivers · $1{,}000{,}000^{-1}$ miles driven		
	IDDM cases	Nondiabetic siblings	IDDM cases	Nondiabetic siblings	*P* (case vs. control)
Total cohort	121	121	10.40	3.91	.12
Sex					
Men	64	64	17.58	8.08	.94
Women	57	57	32.38	6.61	.03
Age (yr)					
21–29	29	30	57.64	30.33	.46
30–39	82	72	13.89*	5.35	.64
40–49	15	20	0.00	0.00	.98
Mileage					
1–9999	55	46	39.51	25.11	.81
10,000–19,000	47	45	25.13	15.50	.70
≥20,000	24	31	40.43	6.83	.33
Marital status					
Married	91	88	9.52	2.84	.62
Not married	35	34	55.99	29.92	.52

*$P < .05$ difference between age strata.

the past year. The driving experiences of the cases and controls were similar overall and by age and sex categories.

Accident experience. The proportion of individuals who had been driving in the previous 12 mo and had reported at least one motor vehicle accident was slightly increased in the diabetic cases than in the nondiabetic siblings (12 vs. 7%, $P = .29$). When stratified by sex, similar results were obtained for male cases and controls (10 vs. 10%), but the proportion of IDDM women reporting an accident was higher than for the nondiabetic women (14 vs. 3%, $P = .10$) but was not significant.

An evaluation of the number of accidents reported by the case-control population is presented in Table 3. Overall, IDDM cases had slightly more accidents per 100 drivers than did the nondiabetic controls (14.2 vs. 7.1 accidents), but the degree of increase was not significant. No difference in the number of accidents between male cases and controls was detected (14.7 vs. 10.3 accidents), whereas female cases reported an increased number of accidents that approached significance (13.6 vs. 3.4 accidents/100 drivers, $P = .09$). Tendencies for accidents were seen among younger, unmarried, and high-mileage drivers but were not significant in either the cases or the controls. Two cases reported multiple accidents in the last year.

Because the difference in accidents could be a reflection of exposure (the distance driven by each individual), the accident data were adjusted to determine the collision rate per 1,000,000 miles driven (Table 4). Again, the number of traffic accidents per 100 drivers was slightly higher in the IDDM cases than in the nondiabetic controls (10.4 vs. 3.9 accidents/100 drivers per 1,000,000 miles, $P = .12$) but was not significant. A marked difference was seen between female cases and controls, where IDDM women had nearly five times more accidents than the nondiabetic women (32.4 vs. 6.6 accidents per 100 drivers/1,000,000 miles, $P = .03$). The difference in accidents between male cases and controls was not significant (17.6 vs. 8.1 accidents/100 drivers per 1,000,000 miles, $P = .94$). A strong age association also emerged within the IDDM cases where individuals 21–29 yr of age had a markedly increased accident rate compared with those 30–39 and 40–49 yr of age ($P < .05$). Sibling controls displayed a similar relationship, but the degree of association was not statistically significant.

The large increase in automobile accidents among IDDM women was investigated further. There was no difference in accidents by age or mileage driven between the female cases and controls. Marital status, however, appeared to be a factor related to motor vehicle accidents among IDDM women. Unmarried female cases reported more accidents per year (344.2 accidents/100 drivers per 1,000,000 miles, $n = 12$) than did the unmarried female controls (0.0 accidents/100 drivers per 1,000,000 miles, $n = 14$, $P = .08$) and the married female cases (21.8 accidents/100 drivers per 1,000,000 miles, $n = 46$, $P < .01$). Age was not a significant confounding variable in these marital status associations, and the proportion of unmarried women was similar in the cases and controls.

Given the number of variables studied and the suggested association with accidents among these variables, it is important to determine the independent contributions of the various factors for predicting automobile accidents. Therefore, a multivariate model was analyzed to evaluate the independent contributions of diabetes status, sex, age, marital status, and mileage driven and the interactive contribution of diabetes and sex to accident occurrence (yes/no) in the last year (Table 5).

In the analysis, diabetes status was not a significant independent determinant of accident risk when the effects of the other variables were held constant. The interaction term of diabetes and sex did appear to have some influence on the accident risk of individuals (P = .10 by percentiles of the normal distribution). The univariate analyses suggested that female IDDM cases were at a marked increased risk of accidents compared with the nondiabetic female controls, but this result could have been influenced by the effects of other confounding factors, such as age, marital status, and mileage driven. Therefore, it was of interest to focus on the interaction of sex and diabetes in the multivariate model by examining accident risk in the female diabetic population while simultaneously controlling for the contributions of these other risk factors. Schlesselman (29) has outlined the estimation of odds ratios from the logistic model with interaction terms. Again, female diabetic drivers were at a particularly increased risk of motor vehicle accidents compared with female control subjects (odds ratio 5.73, $P < .05$), even while simultaneously considering the effects of age, marital status, and mileage driven. Thus, the association of motor vehicle accidents among female drivers with IDDM was a significant relationship independent of the role of the other risk factors for motor vehicle accidents.

Age and marital status were also independently associated with accident prevalence in the multivariate model. Young drivers and unmarried drivers had roughly three times the accident risk than their older and married counterparts.

Hypoglycemic episodes in motor vehicle accidents. The role of medical factors, e.g., hypoglycemia, in motor vehicle accidents was also evaluated in the case-control population. When asked whether a health-related problem had ever caused them to be involved in a motor vehicle accident, 11 (7.3%) of the cases reported yes, whereas only 1 (0.67%) of the nondiabetic siblings responded affirmatively ($P < .01$). Nine of the 11 IDDM cases who responded yes to the question reported that a hypoglycemic episode while driving had resulted in an accident. Two individuals indicated that limited vision was the cause. Eight of the 9 cases reporting hypoglycemic casuality were men, and multiple accidents related to hypoglycemia were reported by 3 cases. Thus, hypoglycemic episodes appeared to be related to a past history of traffic accidents, particularly among the male cases. The extent to which the reported hypoglycemic incidents were related to the accidents in our report, however, is unknown.

DISCUSSION

This study suggests that the overall accident experience of the IDDM population does not appear to differ significantly from the accident experience of the nondiabetic population. Diabetes status was not independently associated with motor vehicle accident probability in multivariate analyses. However, the interactive effect of having IDDM and being female was strongly associated with accident occurrence: women with IDDM experienced five times the number of accidents as their nondiabetic sisters. Previous studies have reported an increased rate of motor vehicle accidents among male diabetic drivers (8,15). However, it is difficult to generalize from these studies because neither focused exclusively on an IDDM population in their case-control analyses.

Possible explanations for the increased risk of traffic accidents among female cases remain obscure. Elevated risk was seen, overall, among younger and unmarried drivers, a finding previously known to motor vehicle accident insurers and investigators (24,30,31). The in-

TABLE 5
Estimated parameters, standard errors of parameters, odds ratios, 95% confidence intervals around odds ratios, and *P* values for logistic model depicting motor vehicle accident probability (yes/no) among 254 cases and controls

	b	SE_b	Odds ratio*	95% Confidence interval	P
Diabetic status (diabetic:control)	−0.012	0.645	0.99	(0.28, 3.50)	.98
Sex (f:m)	−0.891	0.886	0.41	(0.07, 2.33)	.31
Age (young:old)	0.113	0.052	3.10	(1.12, 8.58)	.03
Mileage/yr (high:low)	0.000011	0.000019	1.12	(0.77, 1.62)	.55
Marital status (not married:married)	1.273	0.517	3.57	(1.30, 9.84)	.01
Diabetic status/sex interaction	1.757	1.083			.10
Female cases:female controls	1.745	0.872	5.73	(1.04, 31.6)	.045
Female cases:male cases	0.866	0.658	2.38	(0.65, 8.64)	.19
Female cases:male controls	0.854	0.675	2.35	(0.63, 8.82)	.21

b, Estimated parameters; SE_b, standard errors of the parameters.

*In the continuous variables, the odds ratios are based on a 10-yr interval for age and a 10,000-mile interval for mileage per year.

creased risk for female cases, however, was seen independent of the effect of these parameters in the multivariate model. Factors such as urban versus rural driving, the time of day when driving, and the type of vehicle driven may have had an influence on the accident rates reported, but they were not available for analysis.

One potential difficulty of this study is that the accident experience of the IDDM cases and nondiabetic controls was examined over 1 yr. Given the sporadic nature of traffic accidents among most drivers and the limited sample size of the cohort, the 1-yr period of assessment may not represent the actual driving and/or accident patterns of the 127 case-control pairs. Accident type and severity also were not documented in our report. It is possible that one type of accident (i.e., fender benders, tow-away accidents, injury-producing accidents) may have prevailed among the IDDM cases rather than the nondiabetic control subjects. Few studies in the accident literature or even the diabetes literature have investigated this possibility, leaving the issue up to debate.

The influence of medical factors in motor vehicle accidents was also investigated in the case-control population. Cumulatively, medically related accidents, primarily due to hypoglycemia, were more common among the cases than the controls. Approximately 1 IDDM participant in 17 had a previous traffic accident related to hypoglycemia. Hypoglycemic episodes, however, did not appear to explain the increased accident susceptibility in the female cases. Most hypoglycemic-related accidents were among men with IDDM. Previously, Frier et al. (13) reported that equal proportions of male and female drivers had severe or frequent hypoglycemic incidents in the course of their treatment regimen. Clarke et al. (14) reported a higher proportion of male drivers than female drivers experiencing symptoms of hypoglycemia while driving. It appears that hypoglycemia-related motor vehicle accidents may be more frequent among men than women. However, factors such as the insulin dose of the individual, the mileage driven by the individual, and the frequency of hypoglycemic episodes that do not result in accidents need to be assessed before the risk of hypoglycemia-related accidents can be definitively asserted. Overall, studies have shown that medical factors, including hypoglycemia, in the driver account for ~1 in 1000 road accidents (6,7), suggesting a relatively low rate of occurrence for hypoglycemia-related accidents.

IDDM also appeared to be significantly related to differences in driving capability between the case-control pairs. IDDM cases were four times more likely than their nondiabetic siblings to discontinue driving. Driving cessation in the cases was strongly associated with the presence of activity restricting diabetic complications, primarily blindness. There was no evidence that diabetic complications were related to the accidents reported in the study. Whereas 35% of the nondriving cases reported that their health had prevented them from maintaining a driver's license at some point, it appears that most had voluntarily abstained from driving. Ysander (12) also noted a similar increased frequency of diabetic complications in drivers who abstained from driving and found that the majority voluntarily stopped driving. Thus, it appears that preventive, responsible measures against accident risk may be taken on the part of the driver with IDDM, independent of the licensing authorities.

In summary, there is little evidence regarding the motor vehicle accident risk of the driver with IDDM. Our data suggest that, overall, drivers with IDDM do not have an increased accident risk. However, an excess risk was found among female cases independent of the influence of traditional confounding variables for automobile accidents. Reasons for the excess risk among female cases remain unclear. Hypoglycemia-related accidents were evident among the cases on a cumulative basis but did not appear to explain the accident difference in women. Driving cessation in the IDDM cases was related to the presence of diabetic complications. Given these preliminary findings and the limited data on accident risk, more investigations are needed to evaluate both the accident risk and the relevancy of licensing recommendations, such as restrictions on operating emergency, heavy-goods, and public-transport vehicles, for drivers with IDDM.

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REFERENCES

1. Lasché EM: The diabetic driver. *Diabetes Care* 8:189–91, 1985
2. Haunz EA, Brosseau JD: Nonwarning hypoglycemia in drivers with diabetes. *Am Fam Physician* 30:189–97, 1984
3. Sturner WQ, Sullivan A: Case report: hypoglycemia as the responsible factor in a truck driver accident fatality. *J Forensic Sci* 28:1016–20, 1983
4. Leyshon GE, Elliot RW, Lyons J, Francis HWS: Diabetes and motorway crashes (Letter). *Br Med J* 2:405, 1972
5. Christian MS: Multiple crashers on motor ways (Letter). *Br Med J* 2:295, 1972
6. Herner B, Smedby B, Ysander L: Sudden illness as a cause of motor-vehicle accidents. *Br J Ind Med* 23:37–41, 1966
7. Grattan E, Jeffcoate GO: Medical factors and road accidents. *Br Med J* 2:75–79, 1968
8. Crancer A, McMurray L: Accident and violation rates of Washington's medically restricted drivers. *JAMA* 205:272–76, 1968
9. Waller JA: Chronic medical conditions and traffic safety: review of the California experience. *N Engl J Med* 273:1413–20, 1965
10. Davis TG, Wehling EH, Carpenter RL: Oklahoma's med-

ically restricted drivers: a study of selected medical conditions. *J Okla State Med Assoc* 66:322–27, 1973
11. Ysander L: The safety of drivers with chronic disease. *Br J Ind Med* 23:28–36, 1966
12. Ysander L: Diabetic motor vehicle drivers without driving-license restrictions. *Acta Chir Scand* 409:45–53, 1970
13. Frier BM, Matthews DM, Steel JM, Duncan LJP: Driving and insulin-dependent diabetes. *Lancet* 1:1232–34, 1980
14. Clarke B, Ward JD, Enoch BA: Hypoglycaemia in insulin-dependent diabetic drivers. *Br Med J* 2:86, 1980
15. DeKlerk NH, Armstrong BK: Admission to hospital for trauma in patients with diabetes mellitus. *J Epidemiol Community Health* 37:232–37, 1983
16. Steel JM, Frier BM, Young RJ, Duncan LJP: Driving and insulin-dependent diabetes. *Lancet* 1:354–56, 1981
17. Copplestone JF: The employment of diabetics. *Br J Ind Med* 16:170–75, 1959
18. *Guidelines for Motor Vehicle Administrators. Functional Aspect of Driver Impairment. A Guide for State Medical Advisory Boards.* Washington, DC, U.S. Govt. Printing Office, 1980
19. Cockram CS, Dutton T, Sonksen PH: Driving and diabetes: a summary of the current medical and legal position based upon a recent heavy goods vehicle (HGV) case. *Diabetic Med* 3:137–40, 1986
20. Watkins PJ: ABC of diabetes: driving. *Br Med J* 2:866–67, 1982
21. LaPorte RE, Fishbein HA, Drash AL, Kuller LH, Schneider BB, Orchard TJ, Wagener DK: The Pittsburgh insulin-dependent diabetes mellitus (IDDM) registry: the incidence of insulin-dependent diabetes mellitus in Allegheny County, Pennsylvania. *Diabetes* 30:279–84, 1981
22. Dorman JS, LaPorte RE, Kuller LH, Cruickshanks KJ, Orchard TJ, Wagener DK, Becker DJ, Cavender DE, Drash AL: The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study: mortality results. *Diabetes* 33:271–76, 1984
23. World Health Organization Regional Office for Europe: *Road Traffic Accident Statistics. Report on a WHO Ad Hoc Technical Group, Prague, 26–28 September 1978.* Copenhagen, WHO Regional Office of Europe, 1979 (EURO Reports and Studies 19)
24. National Center for Statistics and Analysis: *National Accident Sampling Systems 1982. A Report of Traffic Accidents and Injuries in the U.S. Collected in NASS in the Year 1982.* Washington, DC, Natl. Highway Traffic Safety Admin., November 1984
25. Greenblatt J, Merrin MB, Morganstein D, Schwartz S, Westat Inc: *National Accident Sampling System Nonreported Accident Survey.* Washington, DC, Natl. Highway Traffic Safety Admin., November 1981 (NTIS Doc. PB85–145712)
26. Fleiss JL: *Statistical Methods for Rates and Proportions.* New York, Wiley, 1973
27. Nie NH, Hull CH, Jenkins JG, Steinbrenner K, Bent DH: *SPSS. Statistical Package for the Social Sciences.* 2nd ed. New York, McGraw-Hill, 1975
28. Dixon WJ, Brown MB, Engelman L, Frane JW, Hill MA, Jennvich RI, Toporek JD (Eds.): *BMDP Statistical Software Manual.* Berkeley, Univ. of California Press, 1985
29. Schlesselman JJ: *Case-Control Studies. Design, Conduct and Analysis.* New York, Oxford Univ. Press, 1982
30. National Safety Council: *Accident Facts.* Chicago, IL, Natl. Safety Council, 1986
31. Nakabayashi K, Aronson SC, Siegel M, Sturner WQ, Aronson SM: Traffic fatalities in Rhode Island. Part II. The timing of accidents and the role of marital status, alcohol and psychoactive drugs. *RI Med J* 67:171–78, 1984