Sensation-Seeking, Criminality, and Spinal Cord Injury: A Case-Control Study

Anthony R. Mawson,1,2 Joseph J. Biundo, Jr.,3 Dorothy I. Clemmer,4 Keith W. Jacobs,5,6 Virginia K. Ktsanes,4 and Janet C. Rice4

A retrospective case-control study was performed in New Orleans, Louisiana, in 1985-1986 to test the hypotheses that 1) criminality is a risk factor for severe injury, and 2) the association between criminality and injury can be explained in terms of a common underlying factor—increased sensation-seeking tendencies. A total of 140 males with spinal cord injury were individually matched with 140 driver's license holders on age, race, sex, educational attainment, and zip code of residence and were interviewed by telephone. Criminality prior to spinal cord injury was measured by self-report and police records, and sensation seeking was measured by the Disinhibition and Boredom Susceptibility subscales of Zuckerman's Sensation-Seeking Scale (Form V). Those with spinal cord injuries were significantly more likely than controls to report a history of juvenile delinquency, adult criminality, and incarceration prior to the time of spinal cord injury. Statistically significant but modest differences were also found between cases and controls with respect to Disinhibition, Boredom Susceptibility, and the combined Sensation-Seeking Scale score. Matched-pairs logistic regression analysis indicated that the association between sensation seeking and spinal cord injury remained significant after controlling for criminality, with an estimated relative risk of 2.05 (95% confidence interval 1.67–2.53). However, the association between criminality and spinal cord injury also remained significant after controlling for sensation seeking (estimated relative risk = 2.04, 95% confidence interval 1.09–3.82). On the basis of these results, criminality and sensation seeking may be statistically significant but independent predictors of spinal cord injury. Am J Epidemiol 1996;144:463–72.

This investigation was prompted by the informal observation that a high proportion of patients with spinal cord injuries admitted to the Louisiana Rehabilitation Institute, New Orleans, Louisiana, had histories of criminality and/or narcotics addiction. Reports from rehabilitation centers serving other inner-city populations (1, 2) suggested a similar patient profile. However, since patients with spinal cord injuries at the Institute are mostly young, indigent, and male—the population groups at greatest risk of criminality—many would be expected to have histories of criminality. Common sense might suggest that the apparent link between criminality and spinal cord injury in this population is due to the fact that patients are injured while engaging in crime (3). However, a review of the literature indicated that adult criminals and juvenile delinquents are at increased risk of injury in general, not only crime-related injury. Moreover, juvenile delinquents are at increased risk of injury prior to becoming delinquent (4) and not only of deliberately inflicted injuries (5). Conversely, people with a history of "accidents" are at increased risk of subsequent criminality (5-7). The literature thus suggests a complex association between criminality and injury.

We hypothesize that increased vulnerability to injury and to criminality are related to a common factor, increased sensation-seeking behavior, which manifests itself very early in life. It is known that criminality is related to sensation seeking (8). We suggest that increased sensation-seeking behavior, manifested as a tendency to place oneself in potentially hazardous situations, heightens the risk of occurrence of either
criminality or injury, with the actual outcome depending on situational exigencies and/or opportunities for obtaining sensory stimulation.

The purpose of this investigation was to test the hypotheses that spinal cord injury is associated with criminality and sensation seeking and that a tendency toward increased sensation seeking accounts for the association between criminality and spinal cord injury.

MATERIALS AND METHODS

Study population

Cases eligible for the study were individuals with acute, traumatic spinal cord injuries admitted to the Louisiana Rehabilitation Institute between January 1, 1965, and December 31, 1984, who were male, English speaking, and currently alive. Only those patients who could be reached by telephone and who consented to be interviewed were included. The study was restricted to English-speaking males because there were too few females to allow analysis and because the study involved English-speaking telephone interviewers.

Controls were selected from holders of Louisiana driver’s licenses, matched with individual cases on age, sex, race, zip code of residence, and educational attainment. Computer tapes, obtained free of charge from the Louisiana Department of Public Safety, contained the names, current addresses, dates of birth, sexes, and races of all Louisiana driver’s license holders. A COBOL program was written (by K. W. J.) to select every individual who matched one or more of the cases on age, race, sex, and zip code of residence. Potential controls were further screened by telephone to ensure that cases and controls were matched on educational level (high school graduation or its equivalent and beyond high school graduation).

Definitions and measures

Spinal cord injury was defined as “an acute, traumatic lesion of the spinal cord, including trauma to nerve roots that results in sensory or motor deficit, or both” (9, p. 126). Injuries due to chronic degenerative, neoplastic, bone, and central nervous system diseases were excluded. The diagnosis of spinal cord injury and the level of lesion were accepted as recorded by an attending physician in the hospital admission or discharge summary. The term “paraplegia” refers to paralysis of the lower limbs, “quadriplegia” refers to paralysis of all four limbs, with a “complete” lesion being one in which there is a total loss of sensation and motor ability below the level of the lesion. The level of the spinal cord injury is classified in terms of the associated spinal vertebrae, i.e., C (cervical), T (thoracic), L (lumbar), and S (sacral).

Sensation-seeking preferences were measured by two subscales of the Sensation-Seeking Scale (Form V) of Zuckerman (8): Disinhibition and Boredom Susceptibility, with each subscale consisting of 10 binary-choice items. To control for the possible effect of spinal cord injury on sensation-seeking preferences, we asked cases and their matched controls to respond to the questions as they felt they would have before the date of the case’s spinal cord injury. Estimates of internal consistency (split-half reliability) of the total score of the Form V Sensation-Seeking Scale ranged from 0.83 to 0.86 (8). The 10-item Disinhibition and Boredom Susceptibility subscales had internal consistencies for US males of 0.74 and 0.57, respectively. The test-retest reliability of Form V was 0.94 for the total score at 3 weeks and 0.91 and 0.71 for Disinhibition and Boredom Susceptibility, respectively, at the same 3-week intervals. The decision to use Disinhibition was based on the fact that it is the subscale most closely associated with psychopathy and hence with criminality (8). The Boredom Susceptibility subscale reflects “an aversion for repetitive experiences of any kind, routine work, or dull and boring people and extreme restlessness under conditions when escape from constancy is impossible” (8, p. 103).

Criminality was measured by self-report and official records. Subjects were asked if they had ever been arrested, convicted of a crime, or placed in a correctional institution at age 16 years or younger and at age 17 or older, but before the date of their spinal cord injury (or, for controls, before the date of the spinal cord injury of the patient with whom they had been matched). To supplement the self-report data, criminal arrest records were supplied by the New Orleans Police Department for consenting cases and controls who had always lived in Orleans Parish.

Data collection

Demographic, social, and diagnostic information on patients with spinal cord injuries was abstracted from the medical records of the Louisiana Rehabilitation Institute and its affiliated Charity Hospital. Attempts to contact the cases began with telephone calls and written inquiries to the telephone numbers and addresses listed in the medical records and continued with a variety of methods for those who were not reached. Written requests for information were made to the Department of Social Security, the Louisiana Power and Light Company, and New Orleans Public Service, Incorporated (all of which were denied) and to the Louisiana Department of Corrections, which resulted in locating one patient at a state correctional...
always lived in Orleans Parish requesting written present to cases and controls who said that they had the case's spinal cord injury. Then outlined the nature of the study and screened the potential controls when 6-20 telephone numbers had been found. The first person who completed the interview served as the matching control. When the telephone call to a potential control was answered, the interviewer began by verifying that the speaker was the person whose name was listed as the control and assured of the confidentiality of their replies. A consent form, approved by the University's Institutional Review Board, was read to them. Since telephone numbers are not provided on the driver's license record, the telephone numbers of the potential controls who had originally been selected for these patients were then assigned to the patients who lacked them. For comparability with regard to exposure to criminality and sensation seeking before the date of the spinal cord injury, controls who were not of the same age as the case were given a reference date (i.e., an upper month/year cutoff point) that would have placed them at the same age as the patient when the latter was injured; the controls were then asked about their sensation-seeking preferences and criminality before the date in question. The interviews were conducted by the first author and 12 part-time student assistants, all but one of whom were female. Patients and controls were telephoned and invited to participate in the study. They were told that the interview would take about 20 minutes and that the confidentiality of their responses would be assured. A consent form, approved by the University's Institutional Review Board, was read to them. Since telephone numbers are not provided on the driver's license record, the telephone numbers of the controls were obtained from directories in the New Orleans Public Library. Interviewers began calling potential controls when 6-20 telephone numbers had been found. The first person who completed the interview served as the matching control. When the telephone call to a potential control was answered, the interviewer began by verifying that the speaker was the person whose name was listed as the control and then outlined the nature of the study and screened the speaker on educational attainment prior to the date of the case's spinal cord injury. To check the validity of self-reports, a letter was sent to cases and controls who said that they had always lived in Orleans Parish requesting written permission to examine their criminal record (if any) with the New Orleans Police Department. Enclosed with the letter was a stamped addressed envelope and two copies of a consent form, one of which the subjects were asked to sign and return. Statistical analyses were performed using standard software packages (10, 11) on a DEC-2060 computer (Digital Equipment Corporation, Framingham, Massachusetts). Odds ratios and confidence intervals were computed to compare the extent of criminality among persons with spinal cord injuries and controls prior to the date of spinal cord injury. After we determined whether patients differed from controls on the subscales of the Sensation-Seeking Scale by using Student's \( t \) test, we tested the hypothesis that the expected association between sensation seeking and spinal cord injury would remain significant after controlling for the effect of criminality using matched-pairs logistic regression (12).

The number of pairs needed to provide an adequate sample size for the survey was calculated using appropriate formulae for a matched-pairs case-control study. A total of 136 pairs were required for the survey to detect a threefold increased risk of criminality with a statistical power of 90 percent in the patients with spinal cord injuries compared with the controls.

RESULTS

A total of 526 persons with spinal cord injuries were admitted to the hospital during the 20-year study period, of whom 453 (86 percent) were males. Of these males, 169 (37 percent) were lost to follow-up, and 14 (3 percent) were living outside Louisiana; hence, both groups were ineligible for inclusion. Of the remaining 270 males, 91 (34 percent) could not be contacted; 55 of the 91 were known to be alive but could not be reached despite numerous attempts to contact them, 24 were known to be deceased, and 12 were too ill at the time of the study to participate. Of the 179 patients actually contacted, 28 (16 percent) refused, and 151 patients gave their informed consent. Eleven of the 151 were interviewed but did not have a matching control. The remaining 140 male patients were interviewed and formed the population for the survey. A total of 140 matching Louisiana driver's license holders were contacted and interviewed. On average, six persons were contacted before a successful match was found.

Of the 140 male patients interviewed, over half (56 percent) were admitted to the hospital after January 1, 1980. The mean age at injury was 28.6 years (standard deviation (SD) = 11.0 years), and the majority (55 percent) were black. Diagnostically, the greatest proportion (40 percent) consisted of complete paraplegics.
injured between spinal levels T1 and T12. Fifty-five percent of the cases had not graduated from high school, and 75 percent had received no additional education since their spinal cord injury (14).

To ensure that the survey participants were representative of the male patients with spinal cord injuries admitted to the Louisiana Rehabilitation Institute (i.e., to compare respondent and nonrespondent cases), the 140 respondents were compared with 1) all 453 male patients minus the 140 interviewed, and 2) nonparticipant but study-eligible males who were living in Louisiana who were not lost to follow-up and who were known to be alive, less the 140 survey participants (n = 106). No significant differences (p < 0.05) were found for either comparison with respect to race, education, diagnosis, or age of onset of the spinal cord injury.

Criminality

Self-reported criminality was significantly more common among those with spinal cord injuries than among matched controls prior to spinal cord injury (table 1). The cases were more likely than the controls to report being arrested by the police before age 17 years (29 vs. 17 percent; odds ratio (OR) = 2.06, 95 percent confidence interval (CI) 1.05–4.12), being convicted (14 vs. 6 percent; OR = 2.50, 95 percent CI 0.97–6.89), and being placed in a correctional institution before age 17 years (14 vs. 4 percent; OR = 3.33, 95 percent CI 1.17–10.75). Similarly, at age 17 years or older, prior to injury, the cases were significantly more likely than the controls to have been arrested (48 vs. 19 percent; OR = 4.55, 95 percent CI 2.19–9.92), convicted (24 vs. 5 percent; OR = 5.33, 95 percent CI 1.99–16.38), and placed in a correctional institution (25 vs. 3 percent; OR = 31.0, 95 percent CI 30.86–38.33).

The odds ratios are significant in all but one comparison, convictions before age 17 years; they are greater in the comparisons for those over age 17 than in the comparisons for those under 17, and they increase progressively within each age/group as comparisons are made in terms of arrests, convictions, and imprisonment.

Former patients were also interviewed about the circumstances of their spinal cord injury. One question was whether the subject was committing a crime at the time of his spinal cord injury. Contrary to what had been expected, only seven (5 percent) responded in the affirmative. Of these, four said they were dealing or buying drugs, one was “drinking and driving,” one was gambling, and one was committing a robbery. Among the 65 cases with self-reported histories of criminal arrest, only six (9.2 percent) said they were committing a crime at the time of their spinal cord injury. Hence, the association between criminality and spinal cord injury cannot be explained simply as a direct outcome of criminal behavior.

Official arrest data

We had originally hoped to compare the self-report data on criminality with official arrest data supplied by the New Orleans Police Department. Unfortunately, this was impossible, as only 12 respondents (nine of

<table>
<thead>
<tr>
<th>TABLE 1. Paired comparisons of spinal cord-injured males and controls in terms of self-reported criminality before and after age 17 years, prior to spinal cord injury*, New Orleans, Louisiana, 1985–1986</th>
<th>Cases</th>
<th>Controls</th>
<th>Odds ratio</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before age 17 years</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrests</td>
<td>Yes</td>
<td>7</td>
<td>33</td>
<td>2.06</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convictions</td>
<td>Yes</td>
<td>0</td>
<td>20</td>
<td>2.50</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incarcerations</td>
<td>Yes</td>
<td>0</td>
<td>20</td>
<td>3.33</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>114</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age 17 years or older</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrests</td>
<td>Yes</td>
<td>15</td>
<td>50</td>
<td>4.55</td>
</tr>
<tr>
<td>No</td>
<td>11</td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convictions</td>
<td>Yes</td>
<td>1</td>
<td>32</td>
<td>5.33</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incarcerations</td>
<td>Yes</td>
<td>3</td>
<td>31</td>
<td>31.00</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Odds ratios for matched pairs are calculated by using the two discordant pairs of cells only in each of the 2 x 2 tables.
34 cases and three of 40 controls) returned their consent forms. No police record could be found for five of the six who reported no arrests, while reports were confirmed for four of the six patients who said they had been arrested at least once.

Sensation seeking

The literature indicates that criminality is associated with an increased risk of injury as a whole, not just of injuries linked to violent crime, and that the risk exists from an early age (4–6). This suggests that some as yet unidentified factor accounts for both the increased risk of criminality and the increased risk of injury. Our suggestion is that this factor may be a proclivity toward high levels of sensory stimulation. If this hypothesis is correct, 1) persons with spinal cord injuries would be expected to have higher Sensation-Seeking Scale scores than would matched controls; 2) persons with spinal cord injuries who had criminal backgrounds would be expected to have higher Sensation-Seeking Scale scores than those lacking such backgrounds; and 3) if increased sensation-seeking tendencies explain the association between criminality and spinal cord injury, the association between sensation seeking and spinal cord injury would be expected to remain significant after controlling for the effect of criminality.

We turn now to the evidence for each of these three predictions.

1. Paired t test analysis indicates that those with spinal cord injuries and controls differ significantly with respect to Disinhibition (mean difference = 1.057, \( p = 0.0003 \)), Boredom Susceptibility (mean difference = 0.529, \( p = 0.007 \)), and the two subscales combined (mean difference = 1.6, \( p = 0.0001 \)).

2. Two sample t tests (table 2) indicate that persons with spinal cord injuries who had self-reported histories of arrest at age 17 years or older, before their spinal cord injury, had significantly higher Disinhibition scores than the did those who were not arrested (\( p = 0.04 \)), but did not differ significantly on Boredom Susceptibility from those who were not arrested (\( p = 0.45 \)). Arrestees also had higher scores on the combined Sensation-Seeking Scale, but the difference (1.01 units) was only marginally significant (\( p = 0.07 \)).

3. Matched-pairs logistic regression analysis was used to test the hypothesis that sensation seeking accounts for the association between criminality and spinal cord injury by determining whether the association between sensation seeking and spinal cord injury remained significant after controlling for the effect of criminality. The predictor variables were 1) other injury before the spinal cord injury of sufficient severity to result in an emergency room visit or hospitalization; 2) self-reported arrests at age 17 years or older, before the spinal cord injury; and 3) the total Sensation-Seeking Scale score (Disinhibition and Boredom Susceptibility combined).

Table 3 presents the strength of the association between each predictor (other severe injury, criminal arrest, sensation seeking) and spinal cord injury, with and without adjustment for the effect of the other predictors. The unadjusted analysis shows that, with respect to other severe injury prior to spinal cord injury, the difference between cases and controls did not attain statistical significance (OR = 1.52, 95 percent CI 0.92–2.52). On the other hand, cases and controls differed significantly in self-reported arrests (OR = 2.13, 95 percent CI 1.17–3.85) and sensation seeking (OR = 2.15, 95 percent CI 1.75–2.64). The odds ratios for sensation seeking are based on a 1 standard deviation (SD) difference of approximately five units on the 20-unit combined scale.

Regarding the association between each predictor variable and spinal cord injury, after adjustment for the effect of the other variables, the main hypothesis of the study was supported by the finding that the association between sensation seeking and spinal cord injury remained significant after controlling for the

### Table 2. Sensation-Seeking Scale scores of arrested and never-arrested spinal cord-injured males, New Orleans, Louisiana, 1985–1986

<table>
<thead>
<tr>
<th>Variable</th>
<th>Arrested (n = 65)</th>
<th>Never arrested (n = 72)</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinhibition</td>
<td>Mean (SD)*</td>
<td>Mean (SD)</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>4.86 (2.09)</td>
<td>4.07 (2.36)</td>
<td></td>
</tr>
<tr>
<td>Boredom Susceptibility</td>
<td>3.43 (1.71)</td>
<td>3.21 (1.74)</td>
<td>0.45</td>
</tr>
<tr>
<td>Combined Sensation-Seeking Scale†</td>
<td>8.29 (3.27)</td>
<td>7.28 (3.29)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* SD, standard deviation.
† Zuckerman (8).
TABLE 3. Strength of association between each predictor variable (prior injury, criminal arrests, and sensation seeking) and spinal cord injury, by multiple logistic regression analysis, with and without adjustment for the effect of other predictors, New Orleans, Louisiana, 1985–1986

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted odds ratio</th>
<th>Adjusted odds ratio</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury (yes/no)</td>
<td>1.52</td>
<td>1.66</td>
<td>0.95–2.89</td>
</tr>
<tr>
<td>Criminal arrest (yes/no)</td>
<td>2.13</td>
<td>2.04</td>
<td>1.09–3.82</td>
</tr>
<tr>
<td>Sensation seeking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(per 5-unit increase in a 20-unit scale)*</td>
<td>2.15</td>
<td>2.05</td>
<td>1.67–2.53</td>
</tr>
</tbody>
</table>

* Zuckerman (8).

DISCUSSION

Prompted by several lines of evidence suggesting an association between criminality and an increased risk of injury (3–7), a retrospective case-control study was undertaken to find out whether this association existed for persons with spinal cord injury. We also sought to test the hypothesis that the association between criminality and spinal cord injury was due to their common association with increased sensation-seeking tendencies. Consistent with previous reports of an association between criminality and injury (3–7), in our study persons with spinal cord injuries were significantly more likely than the controls to report being arrested, convicted of a crime, and incarcerated before the time of the spinal cord injury, both before and after age 17 years. Indeed, the cases were 31 times more likely to have been incarcerated than were the controls after age 17 and prior to spinal cord injury. The number of consenting subjects was too low to allow for case-control comparisons of official arrest records.

In contrast to a report that found no association between sensation seeking and spinal cord injury but that was based on a relatively small sample and did not use a control group (15), our study found that those with spinal cord injuries scored significantly higher than the controls on both the Disinhibition and Boredom Susceptibility subscales of the Sensation-Seeking Scale. Persons with spinal cord injuries arrested at age 17 years or older, before their injury, also had significantly higher Disinhibition scores than did the non-arrested, thus confirming previous findings of an association between self-reported as well as official criminality and the Sensation-Seeking Scale, particularly Disinhibition (16–21).

Logistic regression analysis indicated that criminality and sensation seeking were both significant but independent predictors of spinal cord injury (i.e., both factors remained significant after controlling for the effects of the other).

Potential limitations

Selection of appropriate controls. Several options for control groups were considered during the planning stages of the survey, including neighborhood controls, school controls, hospital controls, and random digit dialing, but all were rejected for various reasons. Louisiana Department of Public Safety driver’s license records seemed most feasible for our purposes, particularly as we were able to obtain all 2.5 million records without charge. An attempt was made to control for socioeconomic status by matching cases and controls on educational attainment; income and occupation were inappropriate indicators since the vast majority of patients had only their disability income and were unemployed.

It could be argued that possession of a driver’s license is itself a basic indicator of socioeconomic status. To check the comparability of cases and controls in this regard, a follow-up telephone call was made to all patients after the interviews had been completed. The results showed that only 13 percent of those recontacted (n = 124) did not have a driver’s license at the time of their injury. Thus, the cases and controls seemed roughly comparable in terms of educational attainment and the possession of a driver’s license.

A potentially more serious problem with regard to comparability was the fact that to be selected as a control the individual had to have a personal telephone number, which implies some degree of social stability. Although no attempt was made to determine what proportion of cases had a telephone listed in their name before the spinal cord injury, at the time of survey it appeared that most patients did not have their
Determination and ascertainment of exposure. The question might be raised about whether asking people over the telephone about such sensitive matters as criminal behavior would be expected to produce reliable and valid results. There has been much discussion about the relative merits of official versus self-reported data on criminality (22) and traffic violations (23, 24). Public records tend to underestimate the actual occurrence of crimes and traffic violations when compared with self-reports, since only the more severe or serious incidents are reported and filed (24). On the other hand, public records are more reliable than self-reports for events occurring more than 5 years before the time of interview (24).

Self-reports have been found to be reliable and valid for measuring criminality among adolescents as a group (22), but they are far less reliable as a measure of the volume of crime, as well as for black males and for more serious delinquents, who are less likely to report offenses known to the police. Although the validity coefficients for black males are smaller than those for white males, black males can be ranked among themselves with marginal validity. Thus, "self-reports may have some utility in studying etiological questions within black male populations ... [but investigators] must stratify by race in sampling and in analyzing self-report data" (22, p. 214). Self-reports are also less useful when accurate counts of the volume of crime are required; the strongest correlations with official data are found with self-report measures that involve asking subjects whether or not they have "ever committed" a given crime. These points (22) were taken into account in our study insofar as cases and controls were matched on race and subjects were asked whether they had ever been arrested, convicted of a criminal offense, or served time in a correctional institution, rather than how many crimes of a particular sort they had ever committed.

An attempt was made to check the validity of self-reported arrests by comparing these data with New Orleans Police Department records for cases and controls who had always lived in Orleans Parish. The number of consenting subjects (n = 12) was too small for valid comparisons, but the results of sensitivity and specificity tests for validity were in the expected direction. The positive predictive value of the self-reports was 80 percent.

With regard to the reliability and validity of telephone interviews compared with personal surveys, the telephone method is capable of producing generally comparable data and at considerably less cost than the personal interview (25). One study in which the two methods were compared indicated that the telephone method yielded a lower response rate but at less than half the cost of personal interviews. Although there was some evidence of nonresponse bias in the telephone survey and some relatively minor differences in responses between the two methods, there was no conclusive evidence that these differences were due to the mode of data collection (26).

The finding of significant differences in Sensation-Seeking Scale scores between persons with spinal cord injuries and controls (27) is contrary to the controlled study by Ditunno et al. (15), but is consistent with other literature suggesting a tendency toward extraversion and impulsivity in persons with spinal cord injuries, particularly those considered to have played an active role in their injury and those whose behavior was judged imprudent (28–30). Only two of the four subscales were used in this study, compared with all four in the study by Ditunno et al., but Disinhibition and Boredom Susceptibility both yielded significant associations with spinal cord injury. The validity of Disinhibition in particular is supported by the fact that it distinguishes between arrested and nonarrested cases, as is found in previous research on the association between the Sensation-Seeking Scale and criminality (8). This scale is also said to be less valid for blacks than for whites (31, 32), and blacks comprised 55 percent of the present sample of persons with spinal cord injuries. Nevertheless, cases and controls were matched on race, thereby eliminating the possibility of bias due to racial differences.

Although significant differences emerged on the Sensation-Seeking Scale between cases and controls, the magnitude of the differences was generally modest, yielding an overall estimated relative risk of experiencing a spinal cord injury of 2.05 (95 percent CI 1.67–2.53), given a mean difference of 1 SD (4.56 units) on the sensation-seeking scale. Thus, if sensa-
Sensation seeking or some allied concept relating to risk taking, impulsivity, or extraversion accounts for the association between criminality and spinal cord injury, a more robust measure than the Sensation-Seeking Scale is needed.

Suggestions for further research

The major hypothesis of this study was that certain individuals may be at risk both of criminality and injury from an early age because of a tendency, possibly constitutional in origin, to be more active in the environment and intolerant of sensory restriction. This factor, as measured by the Sensation-Seeking Scale of Zuckerman (8), proved to be associated with spinal cord injury after controlling for criminality, but the latter was also associated with spinal cord injury after controlling for sensation seeking.

Several options might be considered regarding the development of a possibly more powerful measure of sensation-seeking tendencies. First, a new scale might be developed that avoids the use of value-laden terms and phrases, includes reference to the frequencies of actual behaviors, and assesses aversions to sensory restriction as well as sensory preferences. Second, an existing measure could be considered as a substitute for the Sensation-Seeking Scale, e.g., extraversion, as measured by the Eysenck Personality Inventory (33), which is closely related to the concept of sensation seeking (34). A study using the Eysenck Personality Inventory to assess 111 patients undergoing rehabilitation (30) showed that traumatically disabled persons with spinal cord injury were significantly more extroverted than persons disabled due to nontraumatic causes. Third, certain presumed surrogates of sensation seeking could be studied in relation to criminality and spinal cord injury. For instance, the medical histories of cases and controls could be studied to determine the prevalence of childhood hyperactivity in each group; early school records could also be used to determine the prevalence of behavioral problems and related indicators of excessive motor activity or impulsivity. Such data would suggest the presence in early childhood of tendencies that potentially reflect sensation seeking and are known to be associated with juvenile delinquency (35) as well as an increased risk of injuries (39), with males having higher rates of various types of accidents than do females (36). Consistent differences between males and females in sensation seeking (8) may help to account for sex differences in the rates of certain types of accidents. The fact that rates of violent criminality and injury both peak in the late teens and early twenties (7) suggests that the presumed underlying causal factor also peaks at this time (40).

A more fundamental issue is the meaning and definition of the term sensation seeking itself. Organisms have a physiologic need for sensory stimulation (41, 42), but it remains uncertain how sensation seeking relates to other need-related behaviors. Zuckerman (8) considers sensation seeking to be a distinct form of behavior manifested in thrill-seeking activities, tendencies toward substance abuse, and preferences for spicy foods. Traditionally, eating, drinking, sex, and aggression have been considered separate systems, each with a relatively independent set of activating conditions and physiologic mechanisms. An alternative model proposed by the first author (A. R. M.) is that stimulation seeking (a preferred term) is inherent in all forms of motor-motivational activity (43). Stimulation-seeking behavior is defined as any activity that enhances or facilitates contact between an organism's sensory receptors and external objects or surfaces (44). Just as the color green represents an arbitrarily defined wavelength on the spectrum of visible light, so the different forms of motivational behavior represent arbitrarily defined and overlapping "bands" on a continuous spectrum of stimulation-seeking behavior. Thus, activities such as eating and drinking are stimulation-seeking behaviors of relatively mild intensity, while sex, aggression, flight, and self-mutilation represent bands of stimulation seeking at progressively higher levels. According to this view (43), involvement in criminality, substance abuse, and an increased risk of injury are varying manifestations of a chronically elevated level of stimulation-seeking behavior. Consistent with this broader concept of sensation-seeking behavior, there is evidence that, in addition to criminality, persons with spinal cord injury are also at increased risk of alcoholism and other forms of substance abuse prior to injury (45, 46).

With regard to other avenues for research on causation, it would be of interest to explore the role of acute environmental conditions such as situational stress and the availability of supporting social relationships. A large volume of literature attests to the importance of such factors to mental and physical health (47–49).

The results of our study indicate that criminality and sensation seeking are independently associated with spinal cord injury. About 50 percent of those with spinal cord injuries reported being arrested by the police at age 17 years or older, compared with only 19 percent of the controls, and 23 percent reported being imprisoned at age 17 or older, prior to injury, com-

Am J Epidemiol Vol. 144, No. 5, 1996
pared with 3 percent of the controls. In terms of risk estimates, those with spinal cord injuries were nearly five times as likely to have been arrested as an adult and 31 times as likely to have been imprisoned as were the controls. With regard to sensation seeking, patients and controls differed on average by 1.6 units on the combined Sensation-Seeking Scale. Given a 4.5-unit difference in score (corresponding to 1 SD), the estimated relative risk of spinal cord injury, after adjustment for criminality, was 2.05 (95 percent CI 1.67–2.53).

From these observations, one might infer either that the Sensation-Seeking Scale is insufficient as a measure of stimulation-seeking preferences or that criminality may in fact be an independent predictor of spinal cord injury. Reservations have been noted about the Sensation-Seeking Scale, and suggestions have been made for improving it. Even if the association of stimulation with spinal cord injury is independent of stimulation seeking, the question still remains unresolved about how criminality relates to spinal cord injury. There may well be a common antecedent factor that accounts for the association (40), but that is not being adequately “tapped” by the Sensation-Seeking Scale.

Some have argued that the search for behavioral antecedents of injury should be accorded low priority since it had little potential for being translated into practical countermeasures (37). The focus should instead be on environmental factors, since they are more often amenable to change (50) and influence injury rates irrespective of individual differences in susceptibility. Others (36) have suggested that behavioral studies of injury will receive greater attention and analysis. They also thank the Louisiana Department of Public Safety for providing data tapes on Louisiana driver’s licence holders.

The authors are indebted to Deborah Bates, Liz Berzas, Art Borja, Lisa Gansar, Doris Gautier, Jeanette Hill, Julie Levine, Delia Penalba, Diana Webster, and Bronwyn Williams for assistance with data collection and to Yvette Winchester and Jeffrey Williams for assistance with data analysis. They also thank the Louisiana Department of Public Safety for providing data tapes on Louisiana driver’s licence holders.

An earlier version of this paper was presented at the Annual Meeting of the American Public Health Association, Las Vegas, Nevada, October 1986.

REFERENCES