Longitudinal Assessment of Quality of Life and Its Change in Relation to Motor Vehicle Crashes: The SUN (Seguimiento Universidad de Navarra) Cohort

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Background: Despite the prevailing notion that injury victims are healthy subjects, there is scarce evidence on their preinjury health status, particularly for motor vehicle crash (MVC) victims, where changes between their preinjury health status (or age- and sex-adjusted standards) have seldom been compared with their postinjury status.

Methods: This longitudinal study recorded pre-event self-reported health status (as measured by Short Form-36 scores) of cohort participants who were followed up for 4 years. Differences at the beginning and the end of follow-up as well as differences in Short Form-36 scores changes over time were compared according to the occurrence of a MVC during that time.

Results: From 3,361 participants included for analysis, 64 had an incident MVC. At baseline, those participants who would not have subsequently a MVC had better health than those who would have it. In addition, those who reported being in a crash lost more health after the crash than their noncrash counterparts, although these differences were only seen in adjusted analyses. Adjusted analyses showed a significantly greater worsening of health in MVC victims, particularly in regards to role physical (adjusted difference in 4 years change, −7.7; 95% CI, −13.6 to −1.9), bodily pain (−5.9; 95% CI, −11.4 to −0.3), and role emotional (−6.2; 95% CI, −12.5 to −0.02).

Conclusions: In this cohort, participants who eventually suffered a crash had a worse health status before their MVC than those who did not suffer a MVC. They lost even further health after the injurious event. These findings bear particular relevance when assessing the burden of disease, or when conducting effectiveness evaluation studies at the individual and population level.

Key Words: Injury, Motor vehicle crash, Quality of life, SF-36.

( J Trauma. 2010;XX: 000 – 000)

The effect of motor vehicle crash (MVC) injuries on the health status of patients and populations has been previously described mostly in terms of the impact on mortality and health services use, as in for example, hospitalization events. Impact on health-related quality of life (HRQL) among nonfatal victims has also been investigated, and a number of studies have reported that injured patients exhibit worse health than their noninjured counterparts. We have conducted a longitudinal study to assess health status before and after a MVC to compare values before and after the event within subjects who had a MVC and between subjects who had and those who did not have a MVC. Previous publications have reported on the impact of MVCs on general health. For example, McCarthy et al. used a retrospective study to compare Short Form (36) Health Survey (SF-36) scores of 233 women between the ages of 16 years to 44 years with pelvic fracture, lower extremity fracture, or both (excluding those with Glasgow Coma Scale score <13) with age-specific population norms. Mean time from injury at the time of the interview in the population was 6 1/2 years. In 90% of these women, the mechanism of injury was a motor vehicle or motor cycle crash. The injured group significantly scored lower (meaning worse quality of life) on all SF-36 dimensions except for mental health. Average differences were greater for physical function, role limitations because of physical health, bodily pain, and general health. MacKenzie et al. compared disabilities in exclusively MVC-injured patients with noninjured patients. Patients included were 18 years to 59 years of age. They found significantly worse scores in all SF-36 dimensions in the injured group except in vitality and mental health. Sluys et al. compared SF-36 scores between trauma patients series aged 15 years or older with Injury Severity Score ≥9 at 5 years after injury with a sex- and age-matched reference group. They found significantly lower scores in the trauma group in all eight SF-36 dimensions.

Ameratunga et al. conducted a case-control study. Cases were 218 car drivers sustaining nonfatal crashes. Outcomes at 5 months and 18 months were compared between these and a representative sample of 254 car drivers. Among the drivers reporting worsened health, SF-36 scores revealed greater reductions in physical health in those admitted after the crash, but these scores improved from 5 months to 18 months. Fitzharris et al. followed up 62 patients at 2 months and 8 months after a MVC-related hospital admission. The results from the SF-36 indicated significant reductions in health status at 2 months and 8 months postcrash relative to
precrcas health, with domain scores up to 26% lower than precrcas scores.\(^6\) Wang et al. followed up 64 injured patients at 1 week and 6 weeks after MVC. They found that depression, anxiety, and posttraumatic stress disorder explained the decline in quality of life in these patients.\(^7\) Maraste et al. compared two cohorts of MVC adult patients admitted to hospital (one from the 1960s and another from the 1990s). The 1990s cohort showed that 1 year after the event, 38% of the participants with nonfatal crashes were suffering of some functional disability, pain, and distress, but this loss of health was not as serious as in the 1960s cohort.\(^8\)

None of these studies included preinjury stated assessment of health among the injury victims. In fact, they used age- and sex-matched comparisons or general population external standards as substitutes for the lack of preinjury information on the injury victims. Whether injury patients are equal in health to their age and sex counterparts or even better than them has been speculated about in the literature, but the only empirical investigations of this question rely on self-assessment of the health status by injured individuals immediately after injury (e.g., In the weeks before the injurious event—where you able to...?), a procedure vulnerable to recall bias.\(^1,9,10\)

The SF-36 is a general health scale widespread used and thoroughly validated.\(^11\) It defines health along eight dimensions or scales (physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health) that can be summarized into two scores: the physical component score and the mental component score. In all dimensions, the scales range from a lowest score of 0 to a perfect score of 100.

The SF-36 has been translated into a number of languages, including Spanish and there exist populational norms for many countries, including Spain.\(^12,13\) The scale has been shown to be sensitive to changes in health status after injury.\(^14\)

In the context of a prospective and dynamic cohort of university graduates,\(^15–17\) we have gathered SF-36 data in a 4-year interval. The purpose of our study was twofold: (i) to compare the pre-event self-reported health status (as measured by the SF-36 scores) of those who would subsequently have a MVC with those who would not, and (ii) to compare the change during follow-up in SF-36 status of those who had a MVC with those who did not.

**MATERIALS AND METHODS**

The Seguimiento Universidad de Navarra (SUN) cohort is an open enrolment prospective cohort of university graduates. It started at the end of year 1999. Participants answer a baseline questionnaire (Q0) assessing multiple exposures such as nutritional habits, physical exercise, and other risk factors. Every 2 years, the participants answer to follow-up questionnaires (i.e., Q2, Q4, Q6, and Q8) assessing changes in exposures and new events of interest. To keep the questionnaires as brief as possible, some issues are asked in every questionnaire, whereas others are asked in alternating times. In fact, a more concise questionnaire (Qb) is sent since September 2006 to participants who have not answered to any of the follow-up questionnaires. A more detailed description of the cohort development is available elsewhere.\(^15–17\)

MVC events are assessed in each SUN questionnaire. For Q2, this is done through two questions framed as follows: “Since you answered the [previous] questionnaire, have you suffered... (1) a motor vehicle crash requiring hospitaliza- tion of at least 24 hours? and (2) other traffic accident without hospitalization but with work leave?” The SF-36 was assessed for the first time in Q4 and then again in Q8. Thus, for a complete follow-up, at least 8 years should have elapsed since the participant initially had answered the baseline questionnaire. In this study, we have selected participants who had answered Q0 at least 8 years and 9 months before the time of analysis. The additional 9 month lapse from the eligibility date is used to avoid selection biases related to the inclusion of participants of each wave who respond very early to the follow-up questionnaire because they may tend to be being overly conservative in their health-related behavior. From these, we excluded participants who had had a MVC at Q4 or previously. SF-36 values at Q4 were compared between those who subsequently reported suffering a MVC and those who did not report such event during the same period of time (from Q4 to Q8). We also compared changes in the SF36 scores from Q4 to Q8 between the two groups: those which declared an incident MVC after Q4 and those declaring not to have had any MVC after Q4.

Differences in SF-36 by scales can be assessed along two concepts: clinical and statistical differences. Clinically significant differences are defined as a 5-point difference in the 0 to 100 scale,\(^16\) whereas statistically significant differences were defined as two-tailed \(p<0.05\). Statistical analyses included (i) paired comparisons of mean within-subject differences in SF-36 change from Q4 to Q8, (ii) between-subject (those who had a MVC vs. those who had not) differences in baseline SF-36 (Q4), and (iii) between-subject (MVC vs. no MVC) differences in change in SF-36 (change from Q4 to Q8). Regression models for differences in the change of SF-36 dimensions between both groups were done to adjust differences for age, sex, and the preinjury corresponding SF-36 dimension. STATA was used for analyses (STATA Version 9.2, Stata Corporation, College Station, TX; 2007).

**RESULTS**

There were 5,786 eligible participants who had entered the cohort 8 years and 9 months before the present analysis. The overall retention rate for these participants of the SUN cohort was 91.1%, as seen in Figure 1. Those who had died (\(n=27\)) or had answered any of the previous questionnaires but not Q8 (\(n=1,358\)) were not considered lost to follow-up. There were 4,738 participants who had answered Q8 (end of follow-up). Of these, we further excluded those who had had a MVC at Q6, Q2, or Q4 (\(n=357\)) and those who had not answered any of the SF-36 questions at Q4 (i.e., missing pre-event SF-36 values; \(n=172\)). Final analysis included 3,361 participants, and their mean age was 40.0 years (95% CI, 39.6–40.3). There were 37.6% men and 62.4% women. Sixty-four participants reported at least one MVC during the follow-up period.
Some participants did not answer some of the SF-36 related questions. Missing values in Q4 through SF-36 dimensions ranged from 2 to 32 participants (0.0005%–0.009% of all possible scales), whereas in Q8, these missing values ranged from 0 to 91 participants (0.0%–0.02% of all possible scales). No imputation method was used, missing cases were treated as such, and a complete-subject analysis was done. Thus, the specific number of cases included in the comparisons varies slightly between scales. Because of these exclusions, the sample size ranges from 61 to 64 in participants with an incident MVC and between 3,119 and 3,287 in participants with no MVC (Table 1).

The SF-36 scales average score and 95% CI for both Q4 (beginning of follow-up) and Q8 (end of follow-up) according to the incidence of MVC during the 4-year follow-up are shown in Table 1 along with the p values of the paired t test of the within-subject Q4 versus Q8 comparisons for both groups (having or not a MVC). Among patients who eventually suffered a MVC, there seems to be a decline in SF-36 scores along all physical scales together with an increase in mental health dimensions, but none of these changes reached clinical or statistical significance. Among participants who were free of a MVC after the follow-up period, a decline on bodily pain and general health that did not reach clinical significance but reached statistical significance was present. In addition, in this same group of MVC-free participants, there seemed to be improvements on mental health dimensions that also reached statistical significance while lacking sufficient clinical magnitude (Table 1).

These changes are further evaluated on the last two columns of Table 2, where the individual differences within subjects in scores are summarized. Although none of the
differences reached the 5-point benchmark for clinical relevance (the closest we get to this was a 3.6 drop in bodily pain), all differences were larger for patients who suffered a MVC over time than among those who did not, although it was in this group that the differences in physical functioning and bodily pain reached significance again and the improvement on mental health dimensions reached statistical significance.

Table 2 also presents the individual differences in SF-36 scores at baseline (Q4) between individuals who suffered MVC and those who did not in the first two columns. Patients who did not suffer any MVC during this period had clinically—>5 points—better bodily pain and mental health scores, and these differences were statistically significant. The same comparison at Q8 (end of follow-up) showed that patients who did not have any MVC were clinically better than those who suffered a MVC on role physical, bodily pain, general health, and role emotional scores, and these differences were also statistically significant, whereas they were better from a statistical, but not from a clinical perspective (<5-point difference), in mental health and the physical component scores.

To adjust for general confounding factors, for each SF-36 scale, we performed two linear regression analyses using the change in dimension-specific differences for each score as dependent variables. The independent variable of interest was whether the subject had a MVC during the 4-year follow-up period. In one of the regression models, we adjusted for age at baseline and sex, whereas in the second model, we also adjusted for the Q4 (pre-event self-reported) values of the SF-36 for that dimension. Table 3 summarizes the coefficients and 95% CI of these models. Although the majority of point estimates showed a negative effect, i.e., sustaining a MVC decreased the Q8 (end of follow-up) scores of all SF-36 scales, the models that only adjusted for age and sex never reached statistical significance. Table 3 summarizes the coefficients and 95% CI of these models. Although the majority of point estimates showed a negative effect, i.e., sustaining a MVC decreased the Q8 (end of follow-up) scores of all SF-36 scales, the models that only adjusted for age and sex never reached statistical significance, whereas the models adjusting for Q4 (beginning of follow-up) values of SF36 not only showed coefficients with larger magnitude of effect (in fact three of the coefficients were above the 5-point clinical significance benchmark) but they also reached statistical

TABLE 1. SF36 Average-Paired Values for Participants at Q4 and Q8 Stratified for Event Incidence During Follow-Up Period (MVC at Q6, Q8)

<table>
<thead>
<tr>
<th>Participants With MVC (N = 64)</th>
<th>Participants Without MVC (N = 3,297)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q4</td>
<td>Q8</td>
</tr>
<tr>
<td>N</td>
<td>Mean (95% CI)</td>
</tr>
<tr>
<td>63</td>
<td>94.8 (93.0–96.6)</td>
</tr>
<tr>
<td>87.0 (79.6–94.4)</td>
<td>83.3 (75.1–91.5)</td>
</tr>
<tr>
<td>73.5 (67.9–79.0)</td>
<td>68.8 (63.3–76.2)</td>
</tr>
<tr>
<td>73.0 (68.5–77.4)</td>
<td>70.6 (66.7–74.4)</td>
</tr>
<tr>
<td>64.6 (60.5–68.6)</td>
<td>63.1 (59.7–66.6)</td>
</tr>
<tr>
<td>89.2 (84.9–93.6)</td>
<td>90.6 (87.0–94.3)</td>
</tr>
<tr>
<td>80.4 (72.0–88.7)</td>
<td>82.0 (74.4–89.5)</td>
</tr>
<tr>
<td>70.8 (66.5–75.0)</td>
<td>72.9 (69.2–76.5)</td>
</tr>
<tr>
<td>52.9 (51.3–54.5)</td>
<td>51.3 (49.5–53.0)</td>
</tr>
<tr>
<td>46.5 (43.7–49.2)</td>
<td>47.8 (45.5–50.1)</td>
</tr>
</tbody>
</table>

* p value of Q4 vs. Q8 paired t test for within-subjects comparisons.

TABLE 2. Between-Subjects and Within-Subjects Differences According to the Incidence of MVC in SF-36 Dimensions

<table>
<thead>
<tr>
<th>Difference in Q4 Between Subjects (MVC vs. No MVC)</th>
<th>Difference in Q8 Between Subjects (MVC vs. No MVC)</th>
<th>Change From Q4 to Q8 Within Subjects With MVC</th>
<th>Change From Q4 to Q8 Within Subjects Without MVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Mean (95% CI)</td>
<td>N</td>
<td>Mean (95% CI)</td>
</tr>
<tr>
<td>3,359</td>
<td>0.04 (–2.2 to 2.2)</td>
<td>3,308</td>
<td>1.4 (–1.0 to 4.0)</td>
</tr>
<tr>
<td>3,357</td>
<td>3.9 (–2.0 to 10.0)</td>
<td>3,307</td>
<td>8.4 (2.4–14.4)</td>
</tr>
<tr>
<td>3,351</td>
<td>5.6 (0.8–10.4)</td>
<td>3,361</td>
<td>7.7 (1.9–13.6)</td>
</tr>
<tr>
<td>3,329</td>
<td>2.7 (–1.1 to 6.7)</td>
<td>3,282</td>
<td>5.5 (1.6–9.4)</td>
</tr>
<tr>
<td>3,354</td>
<td>1.0 (–2.8 to 5.4)</td>
<td>3,304</td>
<td>2.5 (–1.5 to 6.5)</td>
</tr>
<tr>
<td>3,341</td>
<td>2.9 (–4.3 to 6.4)</td>
<td>3,270</td>
<td>3.0 (–0.2 to 6.4)</td>
</tr>
<tr>
<td>3,352</td>
<td>5.8 (–1.3 to 13.0)</td>
<td>3,303</td>
<td>7.8 (1.3–14.3)</td>
</tr>
<tr>
<td>3,353</td>
<td>5.0 (1.5–8.5)</td>
<td>3,300</td>
<td>3.4 (0.4–6.9)</td>
</tr>
<tr>
<td>3,392</td>
<td>0.5 (–1.0 to 2.0)</td>
<td>3,246</td>
<td>1.8 (0.2–3.3)</td>
</tr>
<tr>
<td>3,392</td>
<td>2.3 (0.1–4.6)</td>
<td>3,246</td>
<td>1.7 (–0.3 to 3.9)</td>
</tr>
</tbody>
</table>
The decline in SF-36 scores within subjects suffering a MVC were greater in all physical scales than in their counterparts, but statistical significance was not found, possibly because of a lack of statistical power as a result of the low sample size of this subgroup. Statistical significance was found for smaller differences within subjects not suffering a MVC because of the higher sample size.

The main strength of this study is its longitudinal design and the characteristics of its participants, which provide validity to the data. It is possible that the relatively low number of MVC incident cases prevented us from finding more differences. This together with the evaluation of the possible explanations for the differential states at baseline merits further analyses because more cohort participants reach the sufficient follow-up time (i.e., Q8) to allow for a larger sample size. This should occur within the next couple of years because of the open enrolment nature of the SUN cohort.

We excluded early respondents to the questionnaires (those who answered in <9 months). To obtain conservative estimates, this has been our most recent policy in our publications of the SUN cohort. This decision emerges from the impression that early respondents and late respondents have different baseline characteristics, as it has been suggested in other publications. As an example, Manjer et al.21 studied differences between early and late respondents to a personal invitation to participate in a study regarding nutrition and cancer. Those who responded late were more prone to be men, older, be in comparatively unfavorable socioeconomic situation and were characterized by a high prevalence of current smoking, obesity, weight change, and prevalent disease.

The clinical implications of the study are large because it is commonly believed that—as MVC victims tend to be younger than other types of patients—their health status is equal or even better than that of the general population. This has over rated the health recovery expectancies based on the fact that—as the MVC-injured population would be younger—their health status is overrated. However, what our study suggests is that MVC-injured patients were initially worse off than their counterparts who would not be involved.

### DISCUSSION

This article presents the first analysis that we are aware of to report preinjury self-stated HRQL in people who will eventually suffer injuries. This is due to the prospective nature of the SUN cohort study. Our findings reveal that those who will be involved in a MVC are slightly worse off at baseline than those who will not be involved in MVC during the same 4-year follow-up. These pre-event differences were only statistically significant for bodily pain and mental health (Table 1, first column). However, this trend is seen in all SF-36 scales. Explanation of this fact requires further studies, which should address possible differences in comorbidities, medication, life style, and other medical and mental conditions between groups. For example, we have already demonstrated that patients with worse health habits, such as smoking, report worse SF-36 scores in this cohort.

Previous publications have assessed how different morbidity conditions put a person in a higher risk to have a MVC. Therefore, it is plausible to say that people who will sustain a MVC are less healthy than their counterparts. This hypothesis, although, has been seldom tested in a longitudinal study.

Our findings also reveal that among those suffering MVCs, their worsening in HRQL is more significant—not only from a statistical point of view but also with clinical criteria—than the change that happens in those not suffering a MVC during this period of time.

Finally, our findings highlight the importance of controlling for pre-event SF-36 scales values. These should be regarded as confounding factors above and beyond the confounding effects of age and sex.

Results from differences adjusted for age, sex, and preinjury SF-36 scales show clinically relevant differences for role physical, bodily pain, and role emotional and statistical differences for general health and physical component score. The other specific dimensions also have a negative trend for those who had a MVC (Table 3).
in a MVC thereafter and that when those crashes occur their health status deteriorates even faster.

We did not assess injury severity in this cohort beyond the fact that, at least, the participant was on a work leave because of the MVC. However, our results show a global impact of MVCs in health.

In sum, the clinical relevance of this study is to know that (i) MVC-injured people are less healthy before the event than those who will not have a MVC, mainly in bodily pain, role emotional, and mental health, and (ii) after the MVC, they worsen more in role physical, bodily pain, and role emotional. This is particularly relevant in clinical settings because the current expectations for full recovery among young-injured individuals may be overestimating the health state that injured patients had before the event. The implications of our findings reach beyond the clinical world into the policy arena because the societal burden of injuries has been traditionally estimated considering the full-health state of injured individuals, and thus, some of the current burden estimates may indeed be overestimations.

ACKNOWLEDGMENTS

The authors thank all members of the SUN Study Group: Alonso A, Basterra-Gortari J, Benito S, Beunza JJ, de Irala J, de la Fuente-Arrillaga C, Delgado-Rodriguez M, Guillen-Grima F, Krafka J, Llorca J, Lopez del Burgo C, Marti A, Martinez JA, Nuñez-Cordoba JM, Pimenta AM, Sanchez D, Sanchez-Villegas A, Serrano-Martinez M and Toledo E. The authors also thank the cohort participants for their willingness to participate in our study. Montserrat Ruiz Perez assisted us with the preparation and submission of the manuscript. Juan Newton Albiñana Cunningham kindly reviewed the final manuscript.

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