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Evaluation of the Injury Impairment Scale, a Tool to Predict Road Crash Sequelae, in a French Cohort of Road Crash Survivors

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2Université de Lyon, Henry Gabrielle Hospital, Rehabilitation and Physical Medicine Unit, Lyon, France

Objective: The objective of the present study was to validate sequelae prediction by the Maximal Injury Impairment Score (M-IIS) in comparison with the Functional Independence Measure (FIM) assessed at 1-year follow-up of severe road crash victims.

Methods: The study population came from “the Etude et Suivi d’une Population d’Accidentés de la Route dans le Rhône” (ESPARR; Rhône Area Road Crash Victim Follow-up Study) cohort: 178 victims (with Maximal Abbreviated Injury Scale ≥ 3) of road crashes in the Rhône administrative department of France, aged ≥ 16 years and with medical examination including FIM scoring 1 year postaccident. Two thresholds were tested for both scores. Firstly, the relation between FIM and M-IIS was assessed on logistic regression models adjusted on age and presence of complications at 1 year postaccident. The predictive capacity of M-IIS was expressed as its negative and positive predictive values and was considered good when 80 percent or better.

Results: Sixty-three of the 178 adult subjects (mean age = 37.7 years; range = 16.1–82.9 years) showed postaccident complications. One-year sequelae prediction on M-IIS was greater in head, spine, and limb lesions but limited to slight impairments (M-IIS = 1). There was a significant correlation between FIM and M-IIS, although age and medical complications were confounding factors on certain multivariate models. The predictive capacity of M-IIS was low for all types of sequelae.

Conclusions: M-IIS, in this severely injured population, failed to predict sequelae at 1 year as measured by the FIM, despite a good correlation between the two. Complications are to be taken into account in assessing the M-IIS’s capacity to predict sequelae. Further evaluation will be needed on larger series or assessment of other indicators and measures of sequelae at 1 year to obtain a robust tool to predict road crash sequelae.

Keywords Injury Impairment Scale; Functional Independence Measure; ESPARR; Road study; Evaluation

INTRODUCTION

Road accidents have long-term impact on victims’ quality of life. Understanding these outcomes will be useful for improving health care quality by applying the most appropriate strategies. According to the World Health Organization (WHO), quality of life incorporates, in one way or another, physical and psychological health, as well as social and physical interactions.

One year after a crash, survivors reported different outcomes in terms of quality of life such as poor recovery (Holbrook and Hoyt 2004), reduced leisure and work activity (Barnes and Thomas 2006), major functional limitations (Schluter and McClure 2006), and non-return to work (Barnes and Thomas 2006; Michaels et al. 2000; Vles et al. 2005). Generally, these outcomes were assessed by a self-report such as the Sickness Impact Profile (Bergner et al. 1981), Short Form 36 (SF-36; Ware et al. 1993), or the World Health Organization Quality of Life Assessment (WHOQOL; WHO 1998). Tools for measuring quality of life or health are generic, more adapted to a notion of disability than to impairments as such. Additionally, clinical assessment tools can be implemented posttrauma to assess medical and/or functional status at a given point in time; such tools are very useful in functional rehabilitation to monitor functional recovery. Among the clinical assessment tools, the Functional Independence Measure (FIM; Calmels 1996; Dodds et al. 1993) provides a uniform system of measurement for disability and indicates
how much assistance is required for the individual to carry out activities of daily living. It is based on the *International Classification of Impairment, Disabilities, and Handicaps* (WHO 1980), which has been succeeded by the *International Classification of Functioning, Disability and Health* (WHO 2001).

However, the question is which tool should be used at the moment of the accident to predict one-year outcomes. The need for a tool to predict which patients will show sequelae after trauma has long been expressed; this would enable specific management by health care professionals to limit such consequences. Few predictive tools have been devised. The Association for the Advancement of Automotive Medicine (AAAM) recommended the Injury Impairment Scale (IIS; States and Viano 1990), an indicator derived from the Abbreviated Injury Scale (AIS; AAAM 1990), predicting one-year posttrauma impairment for each specific lesion. Mackenzie et al. (1996) introduced the Functional Capacity Index (FCI) in 1996 to predict functional impairment in everyday life one year postaccident. However, it is not easy to obtain access to the FCI. The Glasgow Outcome Scale (Jennett et al. 1981) is a global tool that was drawn up basically with severe cranial trauma in mind and poorly assesses moderate long-term impairment, even in its extended version (Brooks et al. 1986; Satz et al. 1998). Tools targeted to a disease (with therefore very limited use) are also available, such as the Madras Head Injury Prognostic Scale (Ramesh et al. 2008) or the Neck Disability Index (Miettinen et al. 2004). Among these predictive tools, the IIS was created specifically for road accidents and is a widely used predictive tool, notably in France. Since it was introduced in 1990 (States and Viano 1990), several research teams (Bradford et al. 1994; Campbell et al. 1994; Koch et al. 1994; Yates et al. 1994) have validated the IIS: results were varied and hard to compare, and none confirmed a good predictive capacity. MacKenzie (1994) reviewed the various assessment methods used, which showed limitations: either the data used for validation were not one-year posttrauma or the study populations were not selected based on the same criteria used in constructing the IIS (young healthy adults). The IIS has also been applied several times to predict long-term impairment in road trauma victims (Amoros et al. 2008; Barnes and Morris 2009; Bradford et al. 1994; Massoud and Wallace 1996; O’Connor 2004). There is, however, a question regarding the use of the IIS in road accidentology: victims tend to have multiple trauma, and the IIS can only score lesion by lesion. By analogy with the AIS, probable one-year sequelae are considered as resulting from the lesion predictive of maximal sequelae; that is, the highest IIS score, or M-IIS; however, none of the studies using M-IIS (Bradford et al. 1994; Campbell et al. 1994; Ross 1995) have validated this general underlying principle from observation of sequelae at one year posttrauma. A new evaluation, using real data and respecting the original criteria as far as possible, thus seems required to determine the predictive capacity of the IIS in a general injury population.

“The Etude et Suivi d’une Population d’Accidentés de la Route dans le Rhône” (ESPARR, Rhône Area Road Crash Victim Follow-up Study; Hours et al. 2010) is a study conducted in the Rhône administrative department of France. It involves a follow-up of a cohort of road crash victims and assesses the medical, social, and psychological consequences of the crashes on the victims and their families at 1, 3, and 5 years. The present study therefore sought to evaluate the predictive capacity of the M-IIS for sequelae in severe injury. We chose the FIM as a comparison tool for the one-year follow-up of ESPARR victims because the FIM is closer to the notion of impairment found in the IIS.

**MATERIAL AND METHODS**

**Population**

The study population came from the ESPARR cohort of victims of road traffic accidents in the Rhône administrative department (France) between October 2004 and July 2006.

Inclusion criteria in ESPARR included having been in a road crash, involving at least one mechanical means of transport, and occurring in the Rhône administrative area; having been admitted to one of the area’s hospital emergency departments; having survived the crash until hospital admission; and being a resident in the same area (to facilitate follow-up). Because recovery processes and assessment tools differ between children and adults, participants had to be aged 16 years or more, and they (or their parents or legal representatives) had to give informed consent to the follow-up. Medical examination results one year after the crash had to be available. Further details regarding patient contact, recruitment, and interview for collection of baseline and clinical characteristics may be found in a previous publication (Hours et al. 2010).

Three hundred and twenty-four of the 1168 cohort subjects aged 16 or over had severe injuries—that is, M-AIS $\geq 3$ and underwent a one-year follow-up consisting of a general questionnaire and a medical examination including FIM assessment. Complete data were available for 178 of these 324 adult M-AIS $\geq 3$ subjects; this group constitutes the present study population (Figure 1).

**Definition of Variables and Scores**

- Lesions were categorized as present/absent according to 8 body regions: head, face, neck, spine, thorax, abdomen, upper limbs, and lower limbs.
- The Abbreviated Injury Scale is a severity scale based on anatomical lesions, scored from 1 (*minor injury*) to 6 (*maximum injury*). The M-AIS is the maximum AIS (AIS for the most severe lesion).
- The New Injury Severity Score (NISS; Osler et al. 1997) equals the sum of the squares of the AIS severity scores of the 3 most severe lesions, enabling multiple trauma to be taken into account.
- The Injury Impairment Scale is an international index that, associated with lesion description, predicts one-year sequelae, taking into account mobility, cognitive, aesthetic, sensory, and sexual/reproductive aspects and pain. Like the AIS, the IIS
EV ALUATION OF THE INJURY IMPAIRMENT SCALE

ESPARR cohort adult (aged ≥ 16 years)
N = 1168

Mild road trauma victims in ESPARR
(aged ≥ 16 years, MAIS <3)
N = 844 (72.3%)

Incomplete data for FIM
N = 146 (45.0%)
• 98 respondents at 1-year follow-up but incomplete data for FIM
• 35 non-respondents but alive
• 12 lost to follow-up
• 1 death at 6 months

Major road trauma victims in ESPARR
(aged ≥ 16 years, MAIS ≥ 3)
N = 324

Complete-data participants
N = 178
(63 subjects with post-accident complication)

Figure 1 Flowchart showing the process of patient inclusion.

has 6 levels of severity (plus a level-0 for lesions without foreseeable sequelae):

0 = Normal function, no impairment
1 = Detectable impairment without limitations of normal function
2 = Impairment level compatible with most but not all normal functions
3 = Impairment level compatible with only some usual functions
4 = Impairment level significantly impairing some normal functions
5 = Impairment level preventing most essential functions
6 = Impairment level preventing all essential function

• The M-IIS is the highest IIS predicted for the subject.
• The FIM was completed by the investigator at the one-year medical examination. This scale assesses functional autonomy by measuring limitation of activities and the need for assistance. It comprises 18 items in 2 basic domains: motor function (13 items) and cognitive function (5 items). For each item, autonomy is assessed on a 7-point scale (1 = total dependence; 7 = total independence); a score of ≤5 on a given function indicates need for greater or lesser third-party help in performing the function. Total score may range from 18 to 126, but the grid can also display subscores for personal care, sphincter control, mobility, locomotion, communication, and social cognition. This scale has been widely used since 1987 (Keith et al. 1987), with a French-language version since 1996 (Calmels 1996). It has good psychometric properties (Dodds et al. 1993; Hsueh et al. 2002; Ottenbacher et al. 1996). We chose the FIM to test the predictability of the IIS because the purpose of the 2 tools seemed closer (impairment for IIS and functional independence for FIM) than global quality of life as explored in the WHOQOL or the SF-36.

Statistical Analysis
The statistical analysis assessed whether M-IIS was a good predictor of functional incapacity (as medically assessed on the FIM) one year postaccident in the population of severe road accident victims.

Kendall’s tau-b correlation coefficient tested coherence between M-IIS in 3 classes (M-IIS = 0, M-IIS = 1, and M-IIS > 1) and FIM in 3 classes (total FIM = 126, total FIM < 126 with no function scores ≤ 5, and total FIM < 126 with at least one function score ≤ 5; Figure 2).

Due to the small number of high-score subjects, we constructed 4 variables from the M-IIS and FIM scores to test various thresholds and determine those for which M-IIS was a good predictor of FIM:

• For M-IIS, 2 thresholds were tested:
  • A subject is predicted to show no detectable impairment at one year if M-IIS = 0; conversely, a subject is predicted to show detectable impairment of whatever level at one year if M-IIS > 0 (variable M-IISDEFI).

Figure 2 Correspondence between M-IIS and FIM according to disability and functional impairment (color figure available online).
A subject is predicted to show no impairment significantly impacting any everyday function at one year if M-IIS \( \leq 1 \); conversely, M-IIS \( > 1 \) predicts impairment significantly impacting at least one everyday function at one year (variable M-IISFUNC).

For FIM, 2 thresholds, based on the authors’ definitions, were tested:

- A subject is considered free of functional impairment at one year if total FIM is maximal \( (= 126) \); conversely, \( \text{FIM} < 126 \) indicates at least one sequela causing functional impairment, whether or not it requires outside intervention (variable FIMDEFI).
- A subject is able to perform everyday activities without outside help if none of the 18 FIM items score \( \leq 5 \), even if there is some disability; conversely, a subject in whom at least one function requires outside help (score \( \leq 5 \)) is considered to show functional impairment requiring third-party intervention (variable FIMFUNC).

The ability of M-IIS to predict one-year sequelae was expressed as positive (PPV) and negative (NPV) predictive values. M-IIS PPV is the probability of showing at least one sequela at one year on the FIM, with M-IISDEFI or M-IISFUNC \( = 1 \) (presence of one-year sequelae on M-IIS). M-IIS NPV is the probability of showing no sequelae at one year on the FIM according to the criteria described above, with M-IISDEFI or M-IISFUNC \( = 0 \) (absence of one-year sequelae on M-IIS). The authors of the IIS reported valid prediction in at least 80 percent of cases (States and Viano 1990); we therefore considered M-IIS to be a good predictor of functional disability (on the FIM) in the present population if PPV and NPV were 80 percent or higher.

**Analysis strategy.** Firstly, study population medical data were described at inclusion and at one-year follow-up. Secondly, logistic regressions were performed with the dichotomized FIM variables as the variables to be explained. Four initial univariate models were constructed: FIMDEFI = M-IISDEFI; FIMDEFI = M-IISFUNC; FIMFUNC = M-IISFUNC; FIMFUNC = M-IISDEFI. Then, in each model in which M-IIS correlated significantly with FIM, a multivariate model was constructed introducing age and medical complications as variables. Because our objective was to compare the IIS prediction and the clinical observation one year after the accident, we needed to get closer to the requirements of the authors when they built the IIS. This is why the ages of the reference group for studying the impact of age was fixed between 25 and 30 years, to take into account that the IIS was mostly involved only slight impairment (M-IIS \( = 0 \)).

### Table I Study population characteristics

<table>
<thead>
<tr>
<th></th>
<th>( N = 178 )</th>
<th>(100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>44</td>
<td>(24.7)</td>
</tr>
<tr>
<td>Male</td>
<td>134</td>
<td>(75.3)</td>
</tr>
<tr>
<td><strong>Age at crash (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16–24</td>
<td>56</td>
<td>(31.4)</td>
</tr>
<tr>
<td>25–30</td>
<td>16</td>
<td>(9.0)</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>106</td>
<td>(59.6)</td>
</tr>
<tr>
<td><strong>Maximum Abbreviated Injury Scale (MAIS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAIS = 3</td>
<td>126</td>
<td>(70.8)</td>
</tr>
<tr>
<td>MAIS = 4</td>
<td>37</td>
<td>(20.8)</td>
</tr>
<tr>
<td>MAIS = 5</td>
<td>15</td>
<td>(8.4)</td>
</tr>
<tr>
<td><strong>New Injury Severity Score (NISS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NISS [9, 15]</td>
<td>53</td>
<td>(29.8)</td>
</tr>
<tr>
<td>NISS ( \geq 16 )</td>
<td>125</td>
<td>(70.2)</td>
</tr>
<tr>
<td><strong>Body regions involved</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>113</td>
<td>(63.5)</td>
</tr>
<tr>
<td>Face</td>
<td>62</td>
<td>(34.8)</td>
</tr>
<tr>
<td>Neck</td>
<td>3</td>
<td>(1.7)</td>
</tr>
<tr>
<td>Thorax</td>
<td>79</td>
<td>(44.4)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>37</td>
<td>(20.8)</td>
</tr>
<tr>
<td>Spine</td>
<td>52</td>
<td>(29.2)</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>93</td>
<td>(52.3)</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>118</td>
<td>(66.3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean (standard deviation)</th>
<th>Min–Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at crash (years)</td>
<td>37.7 (16.8)</td>
<td>16.1–82.9</td>
</tr>
<tr>
<td>Time to Functional Independence</td>
<td>473.1 (102.0)</td>
<td>339.0–882.0</td>
</tr>
<tr>
<td>Measure (FIM) assessment (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIM score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean total FIM score</td>
<td>122.8 (8.8)</td>
<td>42.0–126.0</td>
</tr>
<tr>
<td>Mean subscore/mobility item</td>
<td>6.8 (0.6)</td>
<td>1.8–7.0</td>
</tr>
<tr>
<td>Mean subscore/cognitive item</td>
<td>6.8 (0.5)</td>
<td>3.0–7.0</td>
</tr>
</tbody>
</table>

SAS software, version 9.1 (SAS Institute, Cary, NC), was used for the analyses.

### RESULTS

#### Description of Study Population

Of the 178 adults (mean age = 37.7 years; range = 16.1–82.9 years) who agreed to the one-year postaccident medical examination, 16 were aged 25 to 30 years (mean = 27.9 years); 63 had posttraumatic medical complications.

Three quarters of the injured victims were male (Table I). A large proportion (70.2%) had NISS \( \geq 16 \). The head and lower limbs were the most frequently involved regions. The correlation between MIISHEAD and MIISLOWER LIMBS was not significant \( (P = .20) \).

Table II presents the M-IIS distribution by body region. There were no predictable sequelae in the neck and few in the face, thorax, or abdomen; one-year sequelae prediction by M-IIS basically concerned head, spine, and limb lesions, and these mostly involved only slight impairment (M-IIS = 1).
There was a significant if limited correlation (Kendall coefficient = 0.27; \( P < .01 \)) between M-IIS and FIM in 3 classes (Table III). There was also a significant correlation between M-IIS and M-AIS (\( P < .001 \)) and between M-IIS and NISS (\( P < .001 \)).

**Table III**  Distribution of M-IIS in 3 classes according to the FIM in 3 classes

<table>
<thead>
<tr>
<th>FIM</th>
<th>Total FIM = 126</th>
<th>Total FIM &lt; 126 and no subscore ( \leq 5 )</th>
<th>Total FIM &lt; 126 and ( \geq 1 ) subscore ( \leq 5 )</th>
<th>Total Kendall coefficient (( P ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-IIS = 0</td>
<td>11 (73.3)</td>
<td>4 (26.7)</td>
<td>0 (0.0)</td>
<td>15</td>
</tr>
<tr>
<td>M-IIS = 1</td>
<td>51 (50.0)</td>
<td>41 (40.2)</td>
<td>10 (9.8)</td>
<td>102</td>
</tr>
<tr>
<td>M-IIS ( \geq 2 )</td>
<td>17 (27.9)</td>
<td>32 (52.5)</td>
<td>12 (19.7)</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>77</td>
<td>22</td>
<td>178</td>
</tr>
</tbody>
</table>

**Logistic Regression**

Three of the 4 univariate models showed significant correlations: between FIMDEFI and M-IISDEFI (\( OR = 3.8, P = .03 \)); between FIMDEFI and M-IISFUNC (\( OR = 2.9, P = .04 \)); and between FIMFUNC and M-IISFUNC (\( OR = 2.6, P < .01 \)).
In modeling FIM<sub>DEFI</sub>–M-IIS<sub>DEFI</sub> and FIM<sub>DEFI</sub>–M-IIS<sub>FUNC</sub>, the age variable did not affect the relation between M-IIS and FIM, whereas medical complications emerged as an explanatory factor (Tables IV and V). Conversely, age and medical complications emerged as confounding factors in modeling the relation between FIM<sub>FUNC</sub> and M-IIS<sub>FUNC</sub> (most severe thresholds; Table VI).

**Positive and Negative Predictive Values**

In the study population as a whole, 73.3 percent of subjects predicted by M-IIS to be impairment-free at one year (M-IIS<sub>DEFI</sub> = 0) did indeed show no medical sequelae at the one-year examination (FIM<sub>DEFI</sub> = 0; Table VII). Conversely, only 58.3 percent of subjects predicted by M-IIS to show impairment (of whatever severity: M-IIS<sub>DEFI</sub> = 1) were actually assessed as showing sequelae by the examining physician (FIM<sub>DEFI</sub> = 1). This proportion was higher (72.1%) if the M-IIS threshold was set higher than 1 (M-IIS<sub>FUNC</sub> = 1).

When the FIM threshold was set in terms of detecting inability to perform certain everyday activities without outside help (FIM<sub>FUNC</sub>), the NPV was excellent (100% if M-IIS = 0; 91.5% if M-IIS ≤ 1). The PPV, on the other hand, was in that case very weak (13% for M-IIS > 0; 20% for M-IIS > 1).

Although posttraumatic complications were an explanatory factor for functional incapacity, the predictive values based on the complication-free subgroup were not very different from those for the study population as a whole (Table VII). Conversely, in subjects showing complications, the positive predictive value of M-IIS for functional impairment was much better.

**DISCUSSION**

There are few tools to predict one-year posttraumatic sequelae in road crash victims. The IIS is easy to use and in principle associates a predictable sequela to a given lesion. The present study used FIM assessment in one-year follow-up of severe road
injury to validate the ability of M-IIS to predict sequelae. A significant relation emerged between FIM and M-IIS: no subjects with functional disability on FIM requiring third-party intervention were scored M-IIS = 0. However, the results showed that M-IIS did not satisfactorily predict disability at one year as assessed on the FIM. Moreover, absence of posttraumatic complications emerged as a factor impairing the capacity of M-IIS to predict sequelae (whereas young age as a factor showed a smaller impact).

Evaluating M-IIS on a logistic regression model to which IIS application criteria variables (age 25–30 years, good baseline health, no posttraumatic complications) were added secondarily, rather than working from a population predefined by these criteria, enabled the study population to conserve statistical power. Yet another issue is the degree of sensitivity of the FIM, which is used in rehabilitation to monitor progress in severely affected patients but may not adequately assess sequelae in a road crash population, where very severely disabling consequences are rare. There would seem to be a ceiling effect with the FIM; the present population basically comprised patients affected patients but may not adequately assess sequelae in a road crash population, where very severely disabling consequences are rare. There would seem to be a ceiling effect with the FIM; the present population basically comprised patients affected patients but may not adequately assess sequelae in a road crash population, where very severely disabling consequences are rare.

The statistical analysis sought to assess the predictive capacity in terms of PPV and NPV of M-IIS rather than its sensitivity or specificity. What is of interest is M-IIS’s capacity to predict the presence or absence of sequelae at one year.

Another issue needs to be raised: What do the IIS and FIM actually measure? The IIS may sometimes be overestimated for certain lesions, such as in the head, when anatomic location is not taken into account: subdural hemorrhage of a given intensity, for example, may have very different consequences depending on location.

Yet another issue is the degree of sensitivity of the FIM, which is used in rehabilitation to monitor progress in severely affected patients but may not adequately assess sequelae in a road crash population, where very severely disabling consequences are rare. There would seem to be a ceiling effect with the FIM; the present population basically comprised patients with high FIM scores: 60.7 percent (108/178) had the maximum score, 71.4 percent (127/178) had the maximum mobility subscore, and 81.5 percent (145/178) had the maximum cognitive subscore. This issue in the FIM has already been raised in the literature (van der Putten et al. 1999).

<table>
<thead>
<tr>
<th>Variable explicative</th>
<th>Modality</th>
<th>FIMFUNC = 0</th>
<th>FIMFUNC = 1</th>
<th>OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-IISFUNC</td>
<td>M-IISFUNC = 0</td>
<td>107</td>
<td>10</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>M-IISFUNC = 1</td>
<td>49</td>
<td>12</td>
<td>2.6 (1.1–6.5)</td>
<td>1.7 (0.7–4.6)</td>
</tr>
<tr>
<td>Age</td>
<td>25–30</td>
<td>52</td>
<td>4</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16–24</td>
<td>13</td>
<td>3</td>
<td>0.2 (0.0–0.9)</td>
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</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>91</td>
<td>15</td>
<td>0.4 (0.1–1.7)</td>
<td></td>
</tr>
<tr>
<td>Complications</td>
<td>No</td>
<td>109</td>
<td>6</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>47</td>
<td>16</td>
<td>7.0 (2.3–21.3)</td>
<td></td>
</tr>
</tbody>
</table>

CI = confidence interval.

*FIMFUNC = 0 if no FIM subscore ≤ 5.

*FIMFUNC = 1 if ≥ 1 FIM subscore ≤ 5.

*M-IISFUNC = 0 if M-IIS ≤ 1.

*M-IISFUNC = 1 if M-IIS > 1.

<table>
<thead>
<tr>
<th>Frequency FIMFUNC</th>
<th>Univariate model</th>
<th>Multivariate model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Table VII Positive and negative predictive values of functional impairment by M-IIS in ESPARR cohort adults aged ≥16 years (according to the 2 thresholds chosen per indicator; with or without taking into account the presence of complications)

<table>
<thead>
<tr>
<th></th>
<th>FIMDEFI</th>
<th>FIMFUNC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPV</td>
<td>NPV</td>
</tr>
<tr>
<td>178 Subjects of study population as a whole with or without complications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-IISDEFI</td>
<td>95/163  = 58.3%</td>
<td>11/15 = 73.3%</td>
</tr>
<tr>
<td>M-IISFUNC</td>
<td>44/61 = 72.1%</td>
<td>62/117 = 53.0%</td>
</tr>
<tr>
<td>115 Subjects without complications one year postcrash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-IISDEFI</td>
<td>52/104 = 50.0%</td>
<td>7/11 = 63.6%</td>
</tr>
<tr>
<td>M-IISFUNC</td>
<td>16/29 = 55.2%</td>
<td>46/86 = 53.5%</td>
</tr>
<tr>
<td>63 Subjects with complications one year postcrash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-IISDEFI</td>
<td>43/59 = 72.9%</td>
<td>4/4 = 100%</td>
</tr>
<tr>
<td>M-IISFUNC</td>
<td>28/32 = 87.5%</td>
<td>16/31 = 51.6%</td>
</tr>
</tbody>
</table>

M-IIS PPV = probability of ≥1 sequelae on FIM when M-IISDEFI or M-IISFUNC = 1.

M-IIS NPV = probability of no sequelae on FIM when M-IISDEFI or M-IISFUNC = 0.
It may also be that the FIM and IIS do not measure the same thing, despite their broadly similar presentations; thus, pain was taken into account in designing the IIS, although it does not necessarily induce the kind of functional impairment assessed on the FIM. Otherwise, the lack of correlation between M-IIS and outcomes measured by the FIM could be due to an association between the 2 most frequent injury regions (MIIS\textsubscript{HEAD} and MIIS\textsubscript{LOWER\ LIMBS}). However, this correlation is not significant.

Finally, one other hypothesis is that the interval to FIM observation, which was a median 449 days in the present study, could account for the better scores on the FIM (due to improved health status over time), given that the M-IIS is a prediction at one year.

The present findings are similar to those of previous reports (Bradford et al. 1994; Campbell et al. 1994; Koch et al. 1994; Yates et al. 1994): regardless of the size of the study population or the method used to evaluate it, the IIS was not found to be a satisfactory predictor of the functional consequences of road trauma as assessed on the FIM. There may be several reasons for this.

- One primary reason lies in the choice of clinical validation tools and in time to follow-up, which in some cases did not correspond to the criteria used by the authors of the IIS. Previous studies have used a variety of tools: self-assessment of impairment 12 months after injury (Barnes and Morris 2009; Yates et al. 1994); physician’s assessment of medical impairment in terms of loss of function, pain, and mental dysfunction at one year (Koch et al. 1994); physician’s 5-level assessment (good recovery, temporary impairment, permanent impairment, persistent vegetative state, death), conducted in hospital or 3 months postcrash (Campbell et al. 1994); or the Glasgow Outcome Scale, implemented at a mean of 10 months (range, 6–52 months) after head injury (Ross 1995). These tools were not measuring the same consequences at the same time point as predicted by the IIS; the present study therefore used a standard tool, the FIM, based on a clinical examiner’s assessment of one-year functional impairment. Moreover, this tool exists in a French-language version and covers several types of body function, making it better adapted to the present population of road crash victims, most of whom showed multiple trauma.

- A second reason concerns the choice of validation population. Most of the previous studies evaluated the IIS in a population defined by a single lesion type. Thus, Yates et al. (1994) studied a population of 163 patients with lower-limb lesions; Campbell et al. (1994) studied 7502 patients with a single type of lesion, to either the head, abdomen, or lower limbs; Ross (1995) studied 2099 patients, aged 20 to 54 years, with head lesions; and Barnes and Morris (2009), in a recent UK study, reported on 31 road crash victims with lower-limb or whiplash injury. Methodologically, these choices were reasonable but failed to show any relation between the IIS and the sequelae in question. Such restrictive choices in terms of type of injury represent a limitation in the validation of the IIS for road trauma, where multiple traumas are frequent. The present study therefore focused on a typical road crash victim population, including patients with multiple injury locations, each of whom could be given several IIS scores. Another point of discussion concerns the choice of the M-IIS; by analogy to the M-AIS, the present study was based on the subject’s maximal IIS score (M-IIS), on the hypothesis that sequelae at one year are basically due to the most severe injuries. This approach was previously recommended (Bradford et al. 1994; Campbell et al. 1994; Ross 1995) in populations including victims of multiple injuries: The hypothesis may not be correct, but in that case the M-IIS would show a high rate of false negatives, which was not in fact found to be the case. It may be that M-IIS is not the optimal means of assessing the IIS in multiple trauma: a new index should be built for these populations, perhaps in the same way as the NISS was developed.

- Finally, following a literature review, it was hypothesized that the negative results in previous studies were related to the fact that the predictive capacity of the IIS is better in severe injury. The previously published IIS validation studies always included all levels of severity; the present study therefore focused on severe injury to test this hypothesis.

Because the IIS is intended to predict sequelae at one year, disabilities prior to the crash have to be excluded in this approach to evaluation. Previous studies have not reported this information, which may have biased the results. The present study population included no subjects with disability prior to their crash, so the road crash was definitely the cause of the sequelae at one year.

One limitation of the present study lies in the size of the study population, which was also an issue in some of the previous studies (Barnes and Morris 2009; Yates et al. 1994). Because we sought to evaluate use of the IIS for real clinical observations, assessment was restricted to serious injury clinically assessed on the FIM, whereas less severely injured subjects were asked merely to fill out a questionnaire (Hours et al. 2010); this considerably reduced the study population. This limitation probably explains why the univariate models testing other thresholds proved nonsignificant, due to small sample size in one category or another. Another consequence of lack of power concerns the choice of test thresholds for the FIM and M-IIS, of which there were only 2 for each because the thresholds were always at low sequelae levels. The proportion of subjects with IIS > 1 is systematically low in the literature: 1.4 to 12.9 percent (Barnes and Morris 2009; Bradford et al. 1994; Campbell et al. 1994; Koch et al. 1994; O’Connor 2004; Yates et al. 1994); the IIS is therefore often divided into fewer classes to increase power in analyses that are not merely descriptive (Barnes and Morris 2009; Bradford et al. 1994; Waller et al. 1995). The present study, like Steven Ross’s (1995), focused on severe injury, so the proportion of subjects with IIS > 1 was higher but still too low to test the greatest degrees of impairment. Likewise, FIM scores in the present population were generally good, with a mean of 122.8 and
more than half of the population reaching the maximum score of 126, so the inadequate prediction capacity can be explained by a lack of subjects with high M-IIS and low FIM scores.

In conclusion, in the present population of severely injured victims, the IIS failed to predict satisfactorily one-year sequelae as measured on the FIM. There was, however, a good correlation between FIM and M-IIS scores. Evaluation should be pursued, in larger series or testing other indicators (such as return to work) or other measures of one-year sequelae, to obtain a robust tool for predicting sequelae one year after road trauma. Such tools would be of great use for road safety and public health policy. Awaiting further evaluation, IIS results should be interpreted taking these limitations into account.

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**REFERENCES**


