ELSEVIER

Estimating the Number of Serious Road Injuries in The Netherlands

MARTINE C.B. REURINGS, PhD, AND HENK L. STIPDONK, MSc

PURPOSE: This paper describes a new estimation method of the number of road injuries in The Netherlands.
METHODS: The bases for this method are the hospital inpatient registry and the police crash record database. Both databases contain errors and omissions. The police database in particular suffers from serious underreporting, and is also inaccurate in indicating injury severity. The hospital database is inaccurate in indicating that a patient was involved in a road crash. Nonetheless, in principle it contains all serious road injuries. After linking both databases an estimating method, inspired by capture–recapture, was used to estimate the number of road injuries. The differences in registration for transport mode, injury severity, and region of crash have been taken into account.
RESULTS: This leads to an estimation of the number of serious road injuries in the Netherlands in 1993–2008.
CONCLUSIONS: We found that 85% of the road injuries are recognizable as such in the hospital registry. The registration rate of the police registry is different for road injuries in crashes involving motorized vehicles (58% in 2008) and for road injuries in crashes not involving motorized vehicles (4% in 2008).
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KEY WORDS: Road Safety, Road Injuries, Record Linkage, Underreporting, The Netherlands.

INTRODUCTION

In The Netherlands, data on road crashes and injuries are collected by the police in cooperation with the Centre for Transport and Navigation. This police registry is almost complete for fatal crashes; about 90% of the road fatalities are recorded in the police database (1). The registration rate of serious road injuries (i.e., the fraction of casualties registered in the police database) is much lower. In fact, the less severe the injury, the lower the registration rate. Past research has shown that the number of hospitalized road casualties registered by the police is only about 40% of the actual number (2, 3). This registration problem occurs in other countries as well (4).

Despite the poor registration, it is important to know the number of serious road injuries accurately, because in The Netherlands the road safety target is expressed in terms of this number, next to the number of fatalities. The number of fatalities is determined by Statistics Netherlands (3). The number of road injuries cannot be determined exactly; only an estimation can be made. This is done by linking the police database with another database containing road injuries, namely, the hospital registry. The objective of this linking procedure is to identify pairs of records referring to the same casualty and the same crash. Once the number of road injuries recorded in both registries has been determined, as well as the number of road injuries recorded in only 1 of the 2 registries, it can be estimated how many road injuries were not recorded. Record linkage is widely used to determine which casualties are recorded in both registrations (5, 6).

Record linkage is not only used in road safety, but also in (other) epidemiologic studies that aim to determine the number of individuals in a certain population, such as the number of people diagnosed with AIDS (7) or the number of people with tuberculosis or other infectious diseases (8). Once the record linkage has been conducted, a capture–recapture method is often applied to estimate the number of unrecorded cases. This is the case in all publications that were mentioned previously (5–8). To apply a capture–recapture method, several conditions should be met. It is not always clear whether or not this is the case when determining the number of road casualties (9). Because of the nature of the police and hospital registries, it is not possible to apply the capture–recapture method in The Netherlands: In both registries, it is not possible to accurately identify road injuries. We explain why this is the case. The new estimation procedure, which is presented in this paper, was developed to solve this problem.

This paper does not discuss the linking procedure in detail; only a very limited description and the results will be given. More information on the linking procedure used, can be found in Brougthon et al. (10).

SERIOUSLY INJURED ROAD CASUALTIES

Definition

In The Netherlands, a seriously injured road casualty has long been defined as a casualty who had been hospitalized

From the SWOV Institute for Road Safety Research, Leidschendam, The Netherlands.
Address correspondence to: Martine C.B. Reurings, PhD, SWOV Institute for Road Safety Research, PO Box 1090, 2260 BB Leidschendam, The Netherlands. Tel.: (+31) 70 3173353; Fax: (+31) 70 3201261. E-mail: martine.reurings@swov.nl.
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Selected Abbreviations and Acronyms

AIS = Abbreviated Injury Scale
MAIS = Maximum Abbreviated Injury Scale

for at least 1 night. However, in 2007 research showed that 10%–15% of those casualties were not actually seriously injured, but had been hospitalized for observation only (11). Thus, the Minister of Transport introduced a different definition of seriously injured road casualties. In addition to hospitalization, this new definition takes the actual injury severity of casualties into account. The injury severity is determined on the basis of the internationally used Abbreviated Injury Scale (AIS), 1990 revision. Each injury is assigned a severity code, ranging from 1 (minor) to 6 (currently untreatable). For each casualty the maximum AIS (MAIS) is determined by taking the highest AIS code over the different injuries. It was decided to consider only hospitalized road casualties with an injury severity, expressed in MAIS, greater than or equal to 2 as seriously injured road casualties. They will be called serious road injuries, although a 2 on the MAIS stands for "moderate injury" and not for "seriously injured" (which is a 3 on the MAIS).

Road Injuries in the Police Registry

The police registry contains variables indicating whether or not a victim died (and if so, when) and was transported and admitted to a hospital. If this information in the police registry were reliable, it would be possible to identify road accident victim who were hospitalized after the crash in the police registry. It is, however, not possible to identify serious road injuries in the police registry, because the MAIS severity is not recorded.

Seriously Injured in the Hospital Registry

The Dutch hospital registry uses codes for the injuries of each patient, following the *International Classification of Diseases, 9th revision, Clinical Modification*. This enables the application of software to determine the AIS per body region, as well as the MAIS, 1990 revision. The software used was ICDmap90 (12). This means that in the hospital database it is possible to identify the patients with a MAIS greater than or equal to 2. It is, however, not possible to identify the patients among them who were injured in a road crash. The reasons for this will be explained.

When an injury is from an external cause, this is indicated in the hospital registry with an "E-code." Each external cause has its own E-code; this is also the case for various types of road crashes. One might, therefore, expect it to be possible to identify serious road injuries in the hospital database on basis of the MAIS and the E-codes. There is, however, a problem. It is possible that a road casualty is assigned an E-code not indicating a road crash. For example, if someone crashes with the bicycle, he may have been given an E-code indicating a fall. Therefore, like the police registry, the hospital registry does not allow identification of serious road injuries either.

In Both Registries

Although it is not possible to identify road injuries in the separate police and hospital registries, it is possible to identify those present in both registries. This is done by record linkage. Indeed, each corresponding pair of a police and a hospital record is known to refer to a road casualty (because it is registered in the police registry). Furthermore, if the hospital record identifies an injury with a severity of at least 2 on the MAIS, it is known that the pair of records corresponds to a serious road injury. This is sufficient information to make an estimate of the total number of serious road injuries.

METHODS

The Linking Procedure

Because neither registry has a unique personal identifier, the linking procedure has to use other variables. These variables, the so-called key variables, are date and time of crash and hospital admittance, gender, date of birth, province of crash, and province of hospital. Also hospital admittance according to the police registration and the E-code in the hospital registry are key variables. The linking procedure used for this study is a distance-based linkage. This means that the variables do not have to be identical in order to match records relating to the same casualty and the same crash, but that small differences are allowed (3, 10).

The police registry used in the linking procedure not only includes casualties injured according to the police, but also uninjured drivers involved in the crashes. The reason for including the latter category in the linking procedure is that persons may have been confused in the police registration process, so that the uninjured driver in the police registry could in reality be injured. The hospital registry used in the linking procedure is also extended with records not directly corresponding to road casualties, because there can be road casualties among records with other E-codes than the E-codes indicating a road crash, as explained.

The linking procedure has been applied to the police and hospital registries for the 1993–2008. The number of records in the police registry decreased from around 85,000 records in 1993 to just under 50,000 records in 2008. This decrease does not mean that there are fewer road casualties, but that