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A case study on agreement between self-reported bicycle accidents and hospital and police records

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Abstract

A self-report questionnaire on bicycle accidents was distributed to 6,793 respondents every month for one year (2012/2013). This paper evaluates the agreement between hospital data, police data, and self-reports concerning the number of accidents, as well as the information recorded regarding each accident.

Six hundred and ninety-four accidents were self-reported by 6,793 respondents. In 99 cases, the respondents reported getting medical care at a hospital. Of these self-reported contacts, 74 could be matched to a hospital record, but only 53 of the 74 were registered in the hospital records as traffic accidents. Information on the primary opposite party in the 53 accidents was compared, and moderate agreement was found between self-reports and hospital records (κ=0.63).

In 23 of the self-reported accidents, it was stated that a police report had been recorded, but only 6 accidents could be located in the police records. The sample size was too small to calculate statistical agreement between police records and self-reports.

These findings are relevant to discuss of the level of underreporting of bicycle accidents in Denmark because they indicate that there could be substantially more accidents than noted in official records. Furthermore, this paper provides insight into methodological issues associated with self-reporting of traffic accidents.

1. Introduction

"Underreporting" of road accidents is defined as incompleteness in road accident records. If the level of underreporting is biased (e.g., affected by injury severity, mode of transportation, or age of the road user involved) or not constant over time (i.e., time of year, over the years), the number of accidents reported will

be systematically skewed and thus incorrect. The traffic safety initiatives based on these numbers will then be misdirected and inefficient.

Many studies have been conducted in the field of underreporting of traffic accidents (e.g., Elvik, Mysen, 1999; Derriks, Mak, 2007). In order to estimate underreporting, one must compare two or more data sources. But no matter which data sources are compared, we are faced with the same challenge: The rather hypothetical "true" number of accidents is unknown, and so is the completeness and correctness of any given data source. Data from hospital records are usually compared or matched to data from police records to estimate either the degree of underreporting in police records or the total number of accidents (Bull, Roberts, 1973; Broughton, Keigan et al., 2010; Boufous, Ivers et al., 2010; Janstrup, Kaplan et al., 2016). Fewer studies compare police records with other data sources, such as insurance records or self-reports of accidents (Isaksson-Hellman, 2012; Finestone, Guo et al., 2011).

In Denmark, it is estimated that only about 14% of severe bicycle accidents registered at hospitals are also registered by the police. Moreover, the police records have been shown to be systematically skewed (, Janstrup, Kaplan et al., 2016). On the contrary, the completeness and correctness of two other data sources—hospital records and self-reports of accidents—have not yet been evaluated in the scientific literature.

The aim of this research was to identify the discrepancies between three data sources: self-reported accidents, hospital records, and police records. Two questions were asked:

1) What is the probability of the existence of a police/hospital record given that a respondent claims its existence?
2) If the record exits, how consistent is the data provided by the respondent with the data in the police/hospital record?

The main aim of this research was to reveal the differences in information given on the same accident among different data sources, thus contributing to the knowledge of possible conclusional flaws that can arise when basing decisions and calculations on data from these sources.

2. Method

2.1 Participants and questionnaire design

A study based on self-reports of accidents was conducted as part of a project on the traffic safety effects of wearing a brightly-colored jacket while bicycling (Lahrmann, Madsen et al., 2018), in which 6,793 participants were divided into a test group (N=3,402) and a control group (N=3,391) and asked to answer a questionnaire each month for the duration of a year, beginning in November 2012 and ending in October 2013. In the online questionnaire, the respondents were asked whether they had had a bicycle accident in the previous month. If they answered in the affirmative, they were then given more questions about the nature of their accident.

The data used in this paper stem from the 6,793 participants' monthly questionnaires. More information about the project and the questionnaire design can be found in existing publications (Thedchanamoorthy, Madsen et al., 2014; Hansen, Thedchanamoorthy et al., 2014; Lahrmann, Madsen, 2014; Lahrmann, Madsen et al., 2018). It is important to note that the participants were all volunteers; therefore, this sample is not necessarily representative of neither the Danish population in general or the part of the population that cycle regularly. Men made up a small majority of this group (57%), and 76% of the participants were between 35 and 65 years of age. The Danish population consists of 50% men, and 41% of the population is between the ages of 35 and 65 years (Statistics Denmark, 2017). The bicycle is most frequently used by people aged 21-29 and the amount of kilometers per day is quite evenly distributed between men and women

(Transportministeriet 2013). It is unknown whether the participants' views on relevant themes (e.g., attitude towards accident registration and faith in authority) deviated from the general population norm. However, the fact that the participants answered 97.5% of the monthly questionnaires about accidents (Lahrmann, Madsen et al., 2014) indicates that they were extraordinarily dedicated. In comparison, a study from Sweden on accidents with a questionnaire comparable to that used in this study had a return rate of 35% (Tivesten, Jonsson et al., 2012).

2.2 Data sources and definitions

A traffic accident is reportable by the Danish police if one of the following circumstances is present (Hemdorff, Lund et al., 2003):

- A person was injured (bruises and abrasions do not count as injuries)
- Material damage of more than 50,000 DKK per vehicle or 5,000 DKK per other equipment occurred
- Foreigners were involved, and a compensation claim is made against them
- A person employed by the police was involved in the accident
- There was a violation of the Road Traffic Act that should lead to preliminary charges.

In contrast to this, the hospital personnel keep records of all people who seek medical care, no matter the severity of their injuries or the extent of material damages.

In the self-report questionnaire, respondents could list all accidents that they had encountered, thus also accounting for minor accidents with little or no personal injury or material damage.

Thus, there are differences among the three types of data sources in terms of the severity of accidents one could expect to find recorded. Hospital data cover accidents resulting in personal injuries only, police data cover a combination of accidents resulting in personal injuries and accidents resulting in material damage, and finally, self-reported accidents are expected to cover all accidents regardless of severity.

Different definitions of what constitutes an accident are also applied among the three data sources.
The police define a traffic accident as an accident occurring on a public road/square/area in which at least one of the involved parties was driving (Hemdorff, Lund et al., 2003). The hospital defines a traffic accident as an accident involving a means of transport or an animal being used to transport persons or goods from one place to another (Sundhedsstyrelsen, 2009). The self-report survey defines an accident as an event occurring on a public road in Denmark in which the self-reporter was traveling by bike and at least one of the following instances occurred (Lahrmann, Madsen et al., 2014):

- The bicyclist made physical contact with an opposite party
- The bicyclist fell over, was hurt, or experienced material damage because of an opposite party's behavior; this also includes events in which no physical contact occurred
- The bicyclist fell over or was hurt while biking, even though there were no other parties involved

The information recorded in the three data sources varies as well. Table 1 illustrates a simplified form of the information requested via the questionnaire, as well as information recorded by the police and the hospital.

Police records contain various categories of accident information, both as multiple choice data and descriptive fields, and police personnel are required to fill out all fields (cf. Table 1). Hospital records contain, as a standard, very little mandatory accident-related information (cf. Table 1). The self-reported records contain information on the same themes as police records, with some additions (cf. Table 1).

Table 1: The design of the monthly questionnaire in comparison with police and hospital records. Only data from police and hospital records comparable with the self-reports are shown in the table; police and hospital records contain more information than shown below (e.g., alcohol consumption in police records). [M]=Multiple choice, [D]=Descriptive, [Opt]=Optional, not mandatory to record, [A]=Only recorded if activity is filed as a traffic accident. The emergency room in Odense on the Danish island of Funen carries out extended recording (Ulykkes Analyse Gruppen, 2014), which is not shown here.

Topic	Self-reported information	Police records	Hospital records
Time and date of accident	Date[M] Month[M] Year[M] Time (hourly interval)[M]	Date[M] Month[M] Year[M] Time (exact)[M]	
Place	Location – Coordinates from maps.google.dk Place[D]	Location – Distance from a selected point	Place [M]
Circumstances	Road surface[M] Visibility[M] Day/night[M] Weather[M] Street light[M]	Road surface[M] Visibility[M] Day/night[M] Weather[M] Street light[M]	Road surface[Opt] Activity [M]
Safety measures	Use of lights on bike[M] Use of fluorescent bike jacket[M] Use of helmet[M]	Use of lights on bike[M] Use of helmet[M]	Use of helmet[Opt]
Accident	Other parties or solo accident[M] How many parties[M] Primary opposite party [M] Accident description[D]	Other parties or solo accident[M] How many parties[M] Primary opposite party [M] Accident description[M]	Other parties or solo accident[M, A] Primary opposite party [M, A]
Severity	Most severe injury[M] Injuries[D] Medical treatment[M] Absenteeism[M] Police report[M] Insurance report[M]	Most severe injury[M] Medical treatment[M]	Injuries[M] Medical treatment[M]

2.3 Matching records

All participants had to provide their CPR number (*Central Person Register*; a Danish civil registration system that provides each citizen with a unique identifier) in their participant registration. A match was based on matching CPR numbers across different datasets. Time constraints must also be taken into account; a respondent could have had several different accidents during the one-year study period, with no guarantee that every experienced accident was either self-reported or recorded by the police or the hospital. We considered the records to match if the date of the contact to the hospital was between one month prior to

the self-reported accident date and two months after. Because respondents were asked to self-report every month, it would be highly unlikely for them to forget their accident date and state the accident date as more than one month off. To ensure that respondents who did not seek medical attention immediately after their accident were not excluded from the match, we considered accidents that were recorded by the hospital up to two months after the self-reported accident date to be a match.

If it was clear from the data in the LPR (*Landspatientregisteret;* the National Patient Registry, which is the source of the hospital data) that an entry could not describe a traffic accident, we excluded the match from the study. When we could not exclude the possibility that the injuries were sustained from a traffic accident, the records were considered a match.

Whereas police records are based on accidents, hospital records are based on injuries and contact with the hospital. Thus, one person can have multiple records in the hospital database due to one accident. To avoid counting duplicates of accidents in hospital records, we manually handled all the matching hospital records and discarded duplicates.

The same time constraints were applied to the matching of self-reports and police records, along with the criteria that the respondent was riding a bicycle during the accident.

A schematic overview of the matching procedure is shown in Figure 1.

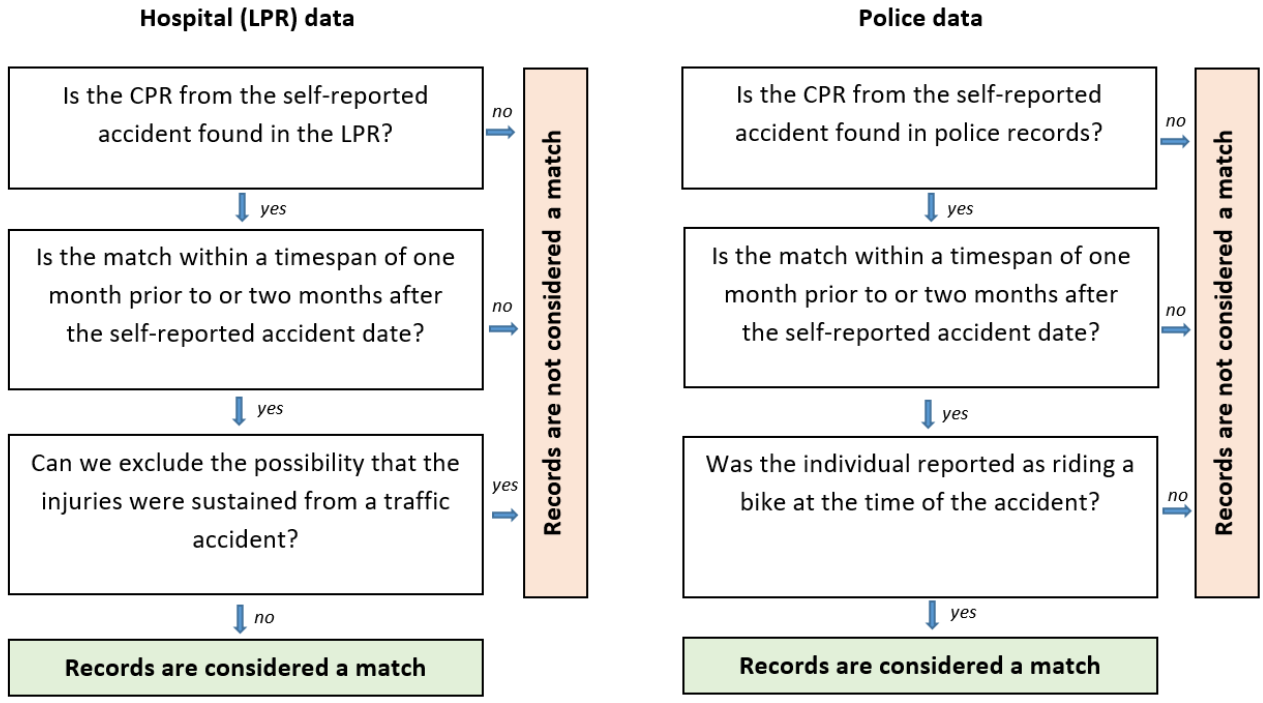

Figure 1: Schematic overview of the matching procedure of self-reported accidents with LPR data and police data.

3. Results

The participants reported 833 accidents during the project period, but some were discarded by the project team (139) because they did not meet the definition of an accident set within the study. Hence, the study is based on 694 self-reported bicycle accidents.

3.1 Self-reported contacts to hospital, police, and insurance companies

As can be seen from Table 2, the hospital was the most frequently contacted, closely followed by insurance companies. Police contact and visits to a general practitioner (GP) were much more uncommon. The overlap of records can be seen in Figure 2 in Appendix 1.

Table 2: Entities with which self-reporters claim to have made contact due to their accident; N=694. (*)The self-reporters did not specifically answer "no" to this because the question about seeking medical attention had a different phrasing.

	Yes	No	Do not know
Police	23	667	4
Insurance	96	585	13
Hospital / Emergency room	99	595*	0
Only GP and not hospital	21	673*	0

The rules for matching, as described in the *Method* section, yielded 74 matches between respondents' self-reported accidents and accidents registered in the LPR.

Twenty-one out of the 74 matching records were not registered in the LPR as traffic accidents (cf. Table 3 in Appendix 1) but with other activities leading to the accident.

Eleven of the 74 respondents who were matched to a record in the hospital database stated that they did not receive medical care (cf. Table 4 in Appendix 1).

The rules for matching, as described in the *Method* section, yielded 6 recorded accidents in the police records.

3.2 Consistency between LPR data and self-reports

The 53 matches in the LPR registered as traffic accidents provide information about the primary opposite party that can be compared with the self-reported information. Table 5 shows the primary opposite parties listed in the hospital traffic accident records and the primary opposite parties listed in the self-reported questionnaires. More solo accidents and fewer bicyclists as opposite parties were registered in the hospital records.

Table 5: The consistency between primary opposite parties listed in self-reports and opposite parties entered in the hospital database, N=53. [*]=The opposite party could not be registered by EUM-code (EUM-codes are part of the classification system used in the LPR; for a thorough introduction to the coding system, the reader is referred to Sundhedsstyrelsen (2009)).

Primary opposite party	LPR [number of cases]	Self-registered [number of cases]
Solo accident – no opposite party (EUM0 or EUU0)	32	24
Pedestrian (EUM1)	3	2
Bicyclist (EUM2)	4	10
Moped (EUM3)	1	1
Motorcycle (EUM4)	2	1
Car (EUM5)	10	13
Not specified (EUM9), or other (Truck/bus, animal)[*]	1	2

Cohen's Kappa was calculated to obtain the degree of agreement between the primary opposite party registered in LPR and that registered in self-reports, resulting in $\kappa=0.63$ ($p<0.001$), 95% CI (0.7946, 0.4654), which is in the lower region of the moderate interpretation (weak: $\kappa=0.40–0.59$, moderate: $\kappa=0.60–0.79$), (McHugh, 2012).

3.3 Consistency of information between police records and self-reports

The rules for matching only yielded 6 recorded accidents in the police records. The small sample size means that calculation of Cohen's kappa is discouraged; normally, a sample size of at least 30 comparisons is necessary (McHugh, 2012). Although no statistical testing could be conducted, the comparison of information present in the two datasets is given in Table 6; it indicates that most of the information matches.

Table 6: A comparison of information given in self-report questionnaires and registered in police records of the same accident. The number indicates how many of the 6 records contain the given information.

	Self-reports	Police records
Weather	6: No rain	6: No rain
Road surface	6: Dry	5: Dry 1: Wet
Daylight	4: Daylight 1: Night 1: Does not remember	5: Daylight 1: Night
Lighting	1: No street lights present	1: No street lights present

	1: Street lights lit 3: Street lights unlit 1: Does not remember	1: Street lights lit 4: Street lights unlit
Visibility	5: Good visibility 1: Does not remember	6: Good visibility
Helmet	5: Using helmet 1: Not using helmet	5: Using helmet 1: Not using helmet
Injuries	1: Femoral fracture 1: Concussion 1: Bruises and similar 3: Other	2: Fracture or ligament injury in hip/leg/foot 2: Slight injuries or admitted for observation (concussion) 1: Lesion on spine/neck/pelvis 1: Fracture or ligament injury in shoulder/arm/hand

4. Discussion

The rather low probability of a self-reported contact with the hospital resulting in a matching record could be affected by several factors. Measurement error (i.e., participants providing inaccurate answers to the questions asked [Dillman, Christian et al., 2014]) due to the questionnaire design seems highly relevant in a discussion of this because the Danish medical service enables people to call a doctor outside office hours[1] and to come in for a physical examination. This emergency service doctor is often, although not always, located at the hospital. Thus, it is quite possible that some respondents contacted the emergency service doctor and regarded this as having contacted the hospital due to the location of the doctor's office at the hospital. However, the emergency service doctor is in fact not a ward in the hospital and does not report his or her patients to the LPR; thus, the emergency doctor service records are not included in this study.

The low probability of the existence of a police record when a respondent claims to have been in contact with the police could be influenced by sampling error (i.e., error that occurs when only some of the members of a sample frame are selected to be surveyed [Dillman, Christian et al., 2014]). Because the sample list consists of volunteers, the individuals surveyed might be more interested in traffic safety than cyclists or the public in general and very keen to contribute to information on bicycle accidents. This could result in the respondents being more likely to contact the police than the average bicyclist, even with accidents that do not meet the police criteria for classification of traffic accidents, thus biasing the results. That self-reports can be subject to statistical bias due to possible overreporting by some subgroups has previously been argued (Tivesten, Wiberg, 2013; Wåhlberg 2009). But even if the sample is viewed as an overreporting subgroup, this does not explain the 12 respondents who claimed they had been in contact with the police while also claiming injuries worse than bruises and abrasions. It is not possible to determine whether the discrepancies can be attributed to measurement errors or erroneous recording practices by the police; this would require further study.

The overall trend of respondents reporting more accidents than can be found in the official datasets coincides with the results of other research comparing self-reports with police-recorded accidents (Arthur, Tubre et

[1] In Danish terms: "Vagtlægen"

al., 2001), (Boufous, Ivers et al., 2010). However, there are no studies comparing self-reported medical attention and official hospital records with which to compare these findings.

The accidents recorded as traffic accidents in the LPR are usually used to calculate the level of underreporting of accidents Denmark (Statistics Denmark, 2014). Our findings indicate that the level of underreporting by the police could actually be much higher than previously thought due to the mislabeled reports in the hospital database, as well as the high proportion of injured individuals seeking medical care at their GP instead of the hospital. There is a possibility that the number of injuries not labeled in the LPR as traffic injuries could be counterbalanced to some degree by people seeking medical care for injuries sustained due to something other than a traffic accident and being mislabeled as victims of traffic accidents. This is mentioned as a source of error by Roberts, Vingilis et al. (2008), but because it is much more time consuming for hospital personnel to register someone as injured in traffic than as otherwise injured (due to the fact that more information must be included in records of traffic accidents than in any other type of accident), it seems more likely that the bias in a busy emergency room would lean towards registering fewer traffic accidents. This speculation is consistent with the results shown in Table 3, in which 10 of the 21 mislabels are somewhat vague (EUA79, EUA8, EUA9). Table 3 also shows that 8 of the mislabels are found in the category EUA5: *Sport and exercise*. This indicates that further studies of the records in that category could yield knowledge about accidents that are mislabeled as traffic accidents. These findings are limited to bicycle accidents. It is not known how the rate or distribution of mislabels is affected by the mode of transportation.

5. Conclusion

What is the probability of the existence of a police/hospital record given that a respondent claims its existence?

Of the respondents, 99 reported receiving medical care at the hospital or the emergency room due to their accidents, 74 could be matched by their CPR number with an accident that happened between one month prior to the self-reported accident date and two months after, and of these 74 entries, 21 were not labeled as traffic accidents in the hospital records. Thus, the reporting level of bicycle accidents in hospital records was 53/99 * 100 = 53.54%.

Twenty-four respondents reported contact with the police due to their accidents. Only 6 respondents could be matched to police records. Thus, there was a police record for 25% of the respondents who claimed to have been in contact with the police. Of the 24 respondents, 12 stated that their most serious injury was bruises, abrasions (7), or no physical injury at all; thus, half of the accidents reported to the police did not meet the injury criteria for police reportable accidents in Denmark (cf. section 2.3, *Data sources and definitions*). The self-reported injuries of the remaining 12 respondents who contacted the police were so severe that they met the criteria for accidents reportable by the police.

If the record exists, how consistent is the data provided by the respondent with the data in the police or hospital record?

Cohen's kappa was calculated to obtain the degree of agreement between information in hospital records and in self-reports of accidents, yielding $\kappa=0.63$, which is a moderate degree of agreement between the two data sources. The main contributory factor to the discrepancies seems to be that the hospital wrongfully recorded bicycle accidents with another bicyclist as counterpart as single accidents.

The 6 matching police records and the self-reported accident information seemed fairly consistent with each other, but due to the low number of matching records, it was not possible to calculate Cohen's kappa.

Self-reports have not previously been applied to explore underreporting and consistency in hospital data, but the fact that hospital data suffers from underreporting is in line with the findings of Janstrup, Kaplan et al. (2016). The finding that 28% of the matches in hospital data are not recorded as traffic accidents and that there is only moderate agreement between the information provided by self-reporters and the information in the matching hospital records calls for awareness. Thus, researchers should take care when utilizing hospital data for traffic research purposes if steps are not taken to heighten the focus of hospital personnel to improve their recording practices.

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Appendix 1

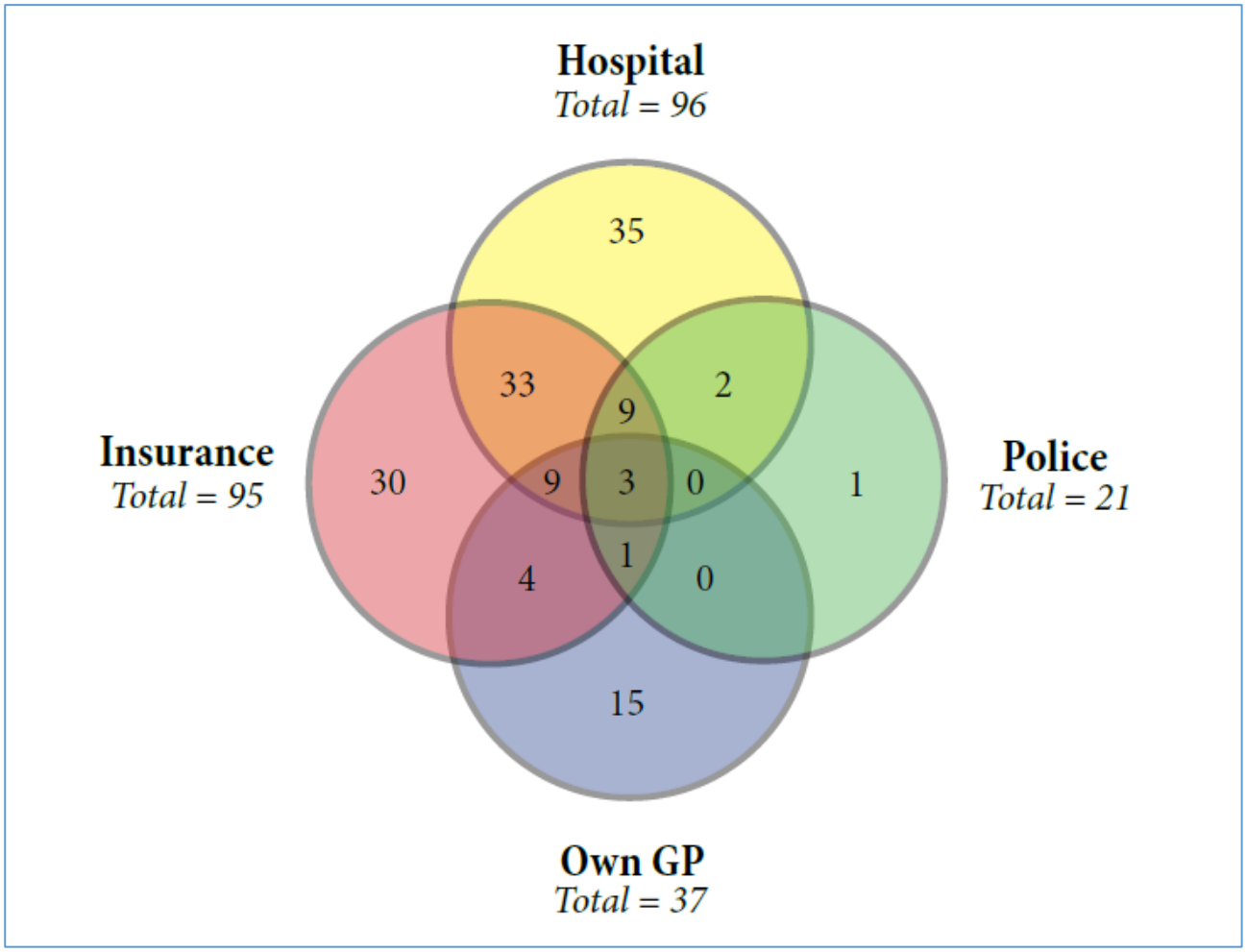

Figure 2: An Euler diagram of the self-reported data. Overlap between contact with police and contact with insurance company only=6, overlap between contact with own GP and contact with hospital only=5. Answers of "do not know" were excluded from the diagram; this is the reason for the inconsistency between the total numbers and the total numbers shown in the Euler diagram.

Table 3: The recorded activities leading to injuries registered in the LPR for all respondents for which there was a match between hospital records and self-reported accidents.

Activity	Code	Number of accidents	Considered a traffic accident in the LPR?
Paid transportation work	EUA0	1	Yes
Transport between workplaces	EUA02	2	
Paid work	EUA1	1	No
Paid work, unspecified	EUA19	1	
Transportation in spare time	EUA2	39	Yes
Transport to/from work	EUA21	1	
Other unspecified transportation	EUA28	1	
Transportation, unspecified	EUA29	9	
House activities and unpaid work	EUA3	1	No
Sports during school/education	EUA42	2	No
Sport and exercise	EUA5	8	No
Vital activity, unspecified	EUA79	1	No
Other activity	EUA8	5	No
Activity not specified	EUA9	4	No
Total		74	*Yes= 53* *No=21*

Table 4: The self-reported information regarding receipt of medical care.

		All matched [N=74]	Matched and registered in LPR with a traffic accident [N=53]
Did you receive medical treatment?	Yes	63	49
	No	11	4