Young Researchers Seminar 2013

Lyon, France, June 5-7 2013

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Estimating road crashes in Denmark:

An application of the capture-recapture method

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Introduction

- A growing interest in estimating the exact number of road users in road crashes or just the number of road crashes

- The official road crash data from police records is thought to be underestimated, with under-reporting rates varying between 20%-60% across countries (Elvik and Mysen, 1999)

Introduction

- Under-reporting varies according to crash type and severity

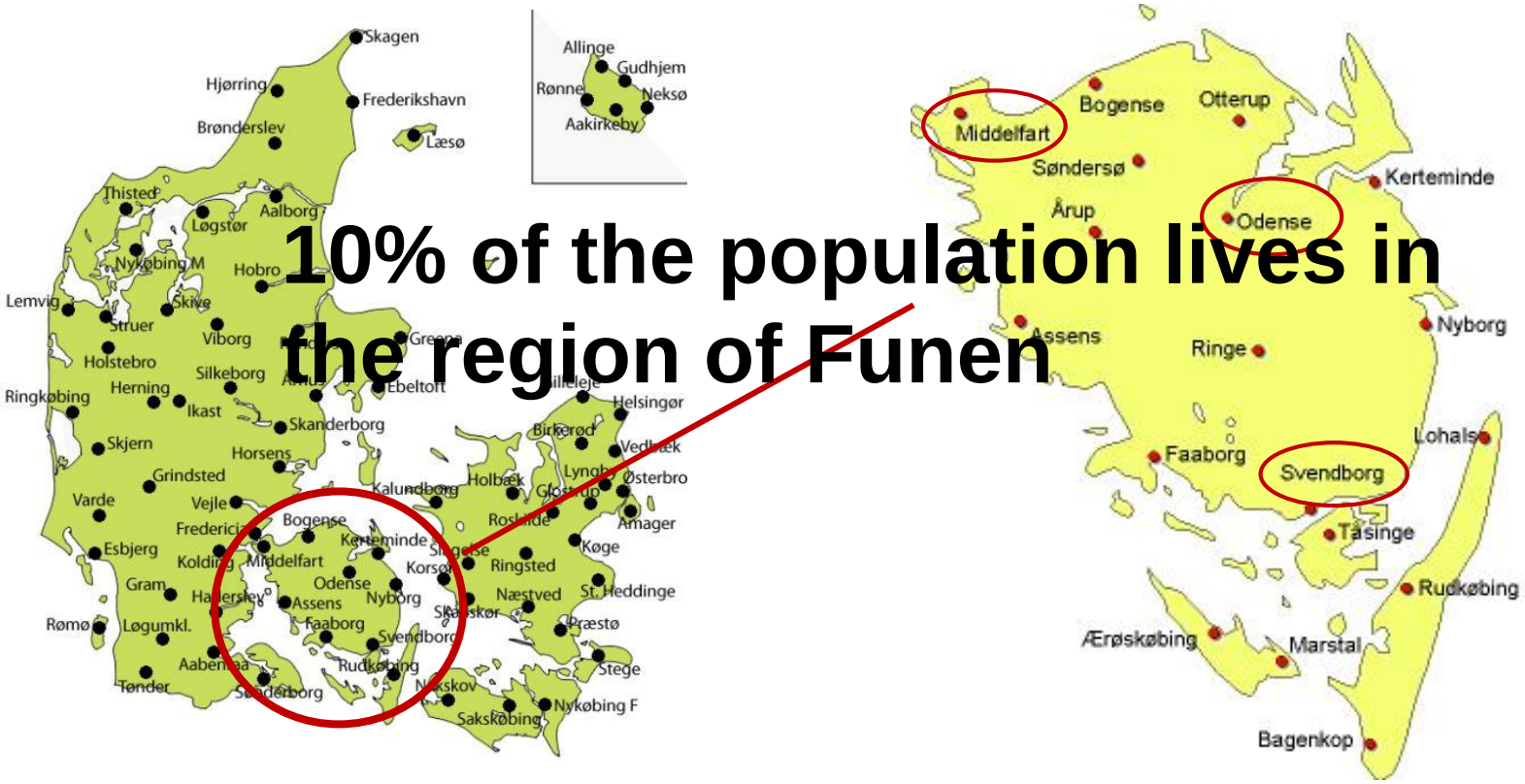
- Several studies focused on assessing the number of road users involved in road crashes, but none focused on Scandinavia and none explored the factors correlated with the under-reporting

Introduction

1st research objective: to estimate the number of road users involved in road crashes in the Funen region in Denmark

2nd research objective: to reveal the underlying factors in reporting to the police or emergency room in Funen

Data



10% of the population lives in the region of Funen

Data

The three emergency rooms in Funen





Demographic data from Statistics Denmark

Road crashes from the Road Directorate





Linking of the hospital, police and demographic data sources is conducted through the use of the civil registration number

Data

Year	Number of matched records	Unmatched records in police data	Unmatched records in emergency room data	Number of registered records (road users in total)
2003	930	1,812	3,096	5,838
2004	809	1,633	3,202	5,644
2005	753	1,503	3,085	5,341
2006	879	1,566	2,940	5,385
2007	917	1,802	3,409	6,128
2008	880	1,386	3,668	5,934
Total	5,168	9,702	19,400	34,270

Methodology

Capture-recapture (Chapman)

The total number of road users involved in a road crash in Funen region

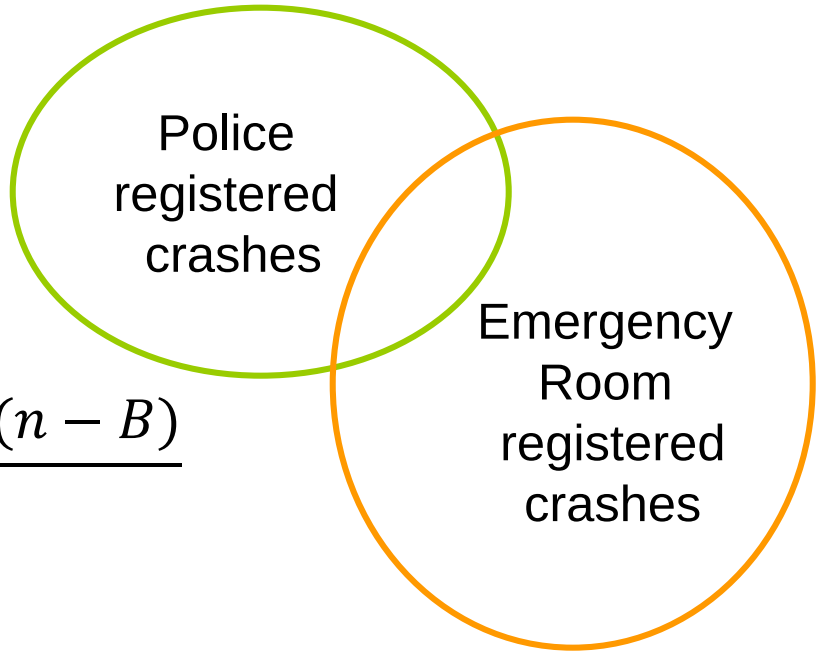
$$N = \frac{(m+1)(n+1)}{B+1} - 1$$

The variance

$$Var(N) = \frac{(m+1)(n+1)(m-B)(n-B)}{(B+1)^2(B+2)}$$

The 95% confidence interval

$$95\%CI = N \pm 1.96\sqrt{Var(N)}$$



Methodology



The probability that a crash would be reported in both sources

$$P_{nmatc\ h} = 1 - \Phi(\theta - \beta' z_n)$$

z_n is a vector of individual and crash characteristics, β and θ are the parameters to be estimated.

The log-likelihood over N registered injured road users:

$$LL = \sum_{n=1}^{N} \log[1 - \Phi(\theta - \beta' z_n)]^{d_n}$$

d_n equals one if a road user n registered the crash to the emergency room and the police, zero otherwise.



Results

Estimated number of **road users with slight injuries** involved in road crashes in Funen

Year	Unmatched records in police data	Unmatched records in emergency room data	Number of matched records	Estimated number (95% CI)
2003	112	2,370	457	3,519 (3,388-3,649)
2004	94	2,411	408	3,467 (3,333-3,601)
2005	70	2,320	395	3,195 (3,082-3,308)
2006	83	2,270	439	3,229 (3,119-3,338)
2007	96	2,698	457	3,817 (3,682-3,951)
2008	71	2,826	472	3,793 (3,679-3,907)



Results

Estimated number of **severely injured road users** involved in road crashes in Funen

Year	Unmatched records in police data	Unmatched records in emergency room data	Number of matched records	Estimated number (95% CI)
2003	108	723	454	1,457 (1,411-1,503)
2004	66	789	381	1,372 (1,329-1,416)
2005	67	761	341	1,318 (1,271-1,365)
2006	62	661	412	1,234 (1,201-1,268)
2007	87	705	433	1,366 (1,325-1,408)
2008	44	838	384	1,362 (1,326-1,398)



Results

Estimated number of **fatally injured road users** involved in road crashes in Funen

Year	Unmatched records in police data	Unmatched records in emergency room data	Number of matched records	Estimated number (95% CI)
2003	9	2	19	31 (29-33)
2004	8	1	20	29 (28-31)
2005	7	4	17	30 (26-33)
2006	3	2	28	33 (32-34)
2007	8	5	27	41 (39-44)
2008	8	3	24	36 (34-38)

Results – binary probit

Mckelvey & Zavonia
$R^2 = 0.588$

Variable	Categories	Coefficient	t-statistic
Age group	0-9 years old	-	-
	10-14 years old	0.109	1.06
	15-17 years old	0.418	4.49
	18-24 years old	0.410	4.58
	25-34 years old	0.492	5.45
	35-44 years old	0.584	6.47
	45-54 years old	0.532	5.81
	55-64 years old	0.594	6.32
	65-74 years old	0.575	5.68
	75 years old and above	0.427	3.99
Gender	Female	-	-
	Male	0.187	6.91
Living status	Other	-	-
	Partner	0.027	0.41
	Single	0.123	1.82
Education background	Other	-	-
	High	-0.051	-1.55

Results – binary probit

Mckelvey & Zavonia
$R^2 = 0.588$

Variable	Categories	Coefficient	t-statistic
Transport type	Car	-	-
	Van	-0.143	-1.89
	Truck and tractor	0.050	0.29
	Bus	-1.014	-5.46
	Motor cyclist	1.049	13.42
	Moped	1.367	22.15
	Cyclist	0.832	17.12
	Pedestrian	1.700	23.41
Seatbelt	No	-	-
	Yes	2.105	49.64
Helmet	No	-	-
	Yes	0.043	0.98
Number of motor vehicle involved in the crash	None	-	-
	One	1.456	43.73
	Two or more	1.548	34.58

Results – binary probit

Mckelvey & Zavonia
$R^2 = 0.588$

Variable	Categories	Coefficient	t-statistic
Time of the day	7 am - 5 pm	0.055	2.08
	6 pm – 6 am	-	-
Year	2003	-	-
	2004	-0.098	-2.26
	2005	-0.084	-1.93
	2006	-0.038	-0.88
	2007	-0.072	-1.63
	2008	0.107	1.40
Type of severity	Slight injury	-	-
	Serious injury	0.540	17.76
	Fatal injury	1.735	10.46
Type of injury	Other damage	-	-
	Head and spine	0.882	8.46
	Neck damage only	-0.445	-7.47
	Lower and upper extremity	0.185	2.67
	Lower extremity and spine	1.128	7.09
	Upper extremity damage only	-0.397	-8.22
	Spine damage only	0.681	10.04

Conclusions

The total number of road users involved in a road crash on Funen island is higher that the listed in official crash statistics:

- **Fatal injuries: the police removes crashes from the database upon evidence of suicide or death prior to the crash. The hospital does not have records of crash scene fatalities**

- **Severe and slight injuries: the injured people transport to the emergency room by themselves without calling the police**

Conclusions

Records of children under 10 years old have a higher probability of appearing in both sources

- **They are passengers who needs help to be taken out of the car and they are always taken to a health check**

Conclusions

Police records of male injured are less likely to appear in the emergency room data. Male hospital records are more likely to appear in the police records.

- **Gender differences in reporting patterns between males and females, possibly males prefer to report to the police as their default while females prefer to report to the hospital**

Conclusions

Records of vulnerable road users and seatbelt users have a higher probability to appear in both sources

- **Vulnerable road users sustain more severe injuries**
- **Seatbelt users are possibly more risk aware, and possibly need professional aid to get out of the car**

Conclusions

The reporting rate to both sources increased with severity degree and number of vehicles involved

- **Help from the police to remove vehicles and guide traffic around the crash site, crash witnesses report to the police, and reporting due to damage/liability claims**

Conclusions

Head, spine and lower extremity have a higher probability of appearing in both sources, while neck and upper-extremity injuries only are reported to the emergency room

- **Road users with head, spine and lower-extremity injuries are more visible, may result in immediate effects, and may results in difficulties to get out of the vehicle without the aid of the emergency forces**

- **Neck injuries (e.g., whiplash) may not show until several days after the crash happens**

Thank you for your attention!

Questions and comments?