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Socio-demographic characteristics of women sustaining injuries during pregnancy, A Study from the Danish National Birth Cohort

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TITLE PAGE

Socio-demographic characteristics of women sustaining injuries during pregnancy, A Study from the Danish National Birth Cohort

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Article summary

Article Focus

- We describe adverse birth outcomes associated with injuries that took place among pregnant women in the Danish National Birth Cohort and include in our assessment injury severity, cause, and mechanism.

Key Messages

- Pregnant women were slightly more likely to deliver stillbirth, preterm and have low birth weight, but not more likely to be SGA; and none of these differences reached statistical significance.
- Place of treatment was not adversely related to SGA, low birth weight, or preterm birth.
- Women sustaining head injuries were significantly more likely to have a stillbirth (HR:3.86, CL:1.23, 12.06).

Strengths and Limitations

- Many previous studies have selected pregnant trauma patients or emergency room patients, our study however presents injuries among pregnant women from a general population.
- We only have data on late spontaneous abortions, and if injured fetuses are aborted early we wouldn't detect an association.

Abstract

Objective: To describe adverse birth outcomes associated with hospital treated injuries that took place among women in the Danish National Birth Cohort (DNBC); and include in our assessment injury severity, cause, and mechanism.

Design, Setting & Participants: We utilized data from the DNBC, a longitudinal population based cohort of pregnant women and their offspring established during 1996–2002. Information was collected twice during pregnancy, at gestational age 12 and 30 weeks; and again when the children reached 6 and 18 months of age. To obtain information regarding birth outcomes, data for each woman were linked to the Danish National Birth Registry and the Danish National Patient Registry. Women were excluded for pre-eclampsia/eclampsia or diabetes (n=9,316) leaving 80,874 women for the analysis.

Primary and Secondary Outcome Measures: To determine if injured women were more likely to deliver preterm, low birth weight or stillbirth we estimated hazard ratios. Odds ratios were generated to assess Apgar scores <10. Models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, and maternal age at birth. Severity of injuries sustained was assessed by stratifying by place of treatment (admittance to emergency department versus other department).

Results: In our cohort of 80,874 pregnant women, 2,604 (3.2%) received medical treatment for an injury during their pregnancy. Injured pregnant women were slightly more likely to deliver stillbirth, preterm and have low birth weight, but not more likely to be SGA, and none of these differences reached statistical significance. However, women sustaining head injuries were significantly more likely to have a stillbirth (HR:3.86, CL:1.23, 12.06).

Conclusion: Our study shows that injuries occurring among moderately affluent women from an unselected population may cause no immediate adverse health effects to the unborn child, except for the case of stillbirth among women with head or neck injuries.

Introduction

During pregnancy, up to 7 percent of women sustain unintentional injuries [1]; and traumatic injuries are a major cause of maternal and neonatal morbidity and mortality [2,3] with widespread occurrences throughout the world. Less is known about less severe injuries occurring in an unselected population. We also know little about the context in which these injuries take place, and the socio demographic characteristics of women sustaining these injuries. We also have limited data on long term consequences of these injuries for the offspring. In this paper, we describe adverse birth outcomes associated with hospital treated injuries that took place among women in the Danish National Birth Cohort (DNBC); we include in our assessment injury severity, cause, and mechanism.

Methods

We utilized data collected from the Danish National Birth Cohort (DNBC), which is a longitudinal population based cohort of pregnant women and their offspring established during 1996–2002. Women were contacted to take part in the study by physicians providing their primary care during pregnancy. Approximately half of all general practitioners in Denmark participated in the study; and approximately 60% of women who were invited participated. Additional information on study design and data collection methods for the DNBC are described elsewhere [4]. Information was collected twice during pregnancy using computer assisted telephone interviews, at gestational age 12 and 30 weeks; and again when the children reached 6 and 18 months of age. All Regional Ethics Committee in Denmark approved the establishment of the cohort and this study was further approved by the Danish Data Protection Agency and UCLA Office for Protection of Research Subjects.

To obtain information regarding birth outcomes, data for each woman were linked through her personal civil registration number to the Danish National Birth Registry and the Danish National Patient Registry for the entire pregnancy period. The Danish National Birth Registry has collected data since 1968 for the primary purpose of monitoring the health of newborns and the quality of antenatal care, and has been

increasingly used for research [5]. The gestational age at birth and birth weight was obtained from the Birth Register. Small for gestational age (SGA) was defined as a weight below the 10th percentile for gestational age, grouped by week, among children born in the DNBC.

Information regarding injuries sustained during pregnancy was obtained from the Danish National Patient Registry, which contains data on all hospital stays and outpatient visits for the duration of each woman's pregnancy. For each admission or visit, the patient registry collects information on the primary discharge diagnosis (the discharge diagnosis that best describes the condition leading to the admission or outpatient visit and that is the primary reason for the prescribed and completed course of tests and treatments) and up to 20 subsidiary diagnoses. It also collects information on external cause of injury, including the mode, location, and mechanism causing the injury. Data were extracted with the use of *International Classification of Diseases, 10th Revision* (ICD Website, 2007) [6] and the second edition of the Nordic Medico-Statistical Committee's (NOMESCO) Classification of External Causes of Injuries (NCECI) [7].

We identified 90,190 women who were still pregnant at the time of the first interview. Since pre-eclampsia/eclampsia or diabetes of any type (n=9,316) may influence pregnancy outcomes we excluded these pregnancies from the analysis; leaving 80,874 women for the analysis. All injuries were classified by the body location and mechanism causing the injury; transportation injuries were further described by mode of transportation. Women were categorized as injured if they sustained an injury at any point during pregnancy, regardless of mode, body region, and mechanism causing the injury; and uninjured otherwise.

To determine if injured women were more likely to deliver preterm (<30 weeks, 30-37 weeks, > 37 weeks), low birth weight (<1500 grams, 1500-2500 grams, >2500 grams), or stillbirth we estimated hazard ratios (HRs) using PROC PHREG in SAS Statistical Software. These models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, and maternal age at birth. To determine if injured women were more likely to deliver SGA infants or infants with an APGAR

score <10, we generated odds ratios (ORs) using PROC GENMOD in SAS statistical software. To assess severity of injuries sustained, we stratified by place of treatment (admittance to emergency department versus other department).

Results

In our cohort of 80,874 pregnant women, 2,604 (3.2%) received medical treatment for an injury during their pregnancy. Socio demographic characteristics of all women in the cohort are presented in table 1. Results have been stratified by presence/absence of injury. Injured women were younger, smoked cigarettes more often and had lower household socioeconomic status. Injury characteristics such as mode of injury, activity engaged in while sustaining injury, mechanism causing injury and body region of injury are presented in table 2. Approximately one third of the injuries were due to falls and look place during a leisure activity. Less than one fifth of the injuries were related to transportation. We found that injured pregnant women were slightly more likely to deliver stillbirth, preterm and have low birth weight, but not more likely to be SGA; and none of these differences reached statistical significance. To assess severity of injury we stratified injuries by admittance to the emergency department, and women who sustained head or neck injuries. Place of treatment was not adversely related to SGA, low birth weight, or preterm birth. However, women sustaining head injuries were significantly more likely to have a stillbirth (HR:3.86, CL:1.23, 12.06).

Discussion

Our study shows that most injuries occurring in an unselected affluent Danish population cause no immediate adverse health effects to the unborn child except for stillbirth, which may be increased among women with head or neck injuries. Adverse pregnancy outcomes resulting from maternal injury have been documented in other studies [8-23]. Severely injured pregnant women are more likely to have preterm labor, placental abruption, cesarean-section, uterine rupture, low birth-weight, and their infants are more

likely to result in pre-term delivery and suffer from fetal distress, asphyxia, respiratory distress syndrome and circum to fetal, neonatal and infant death compared to their uninjured counterparts [13].

Unlike many previous studies that have selected pregnant trauma patients or emergency room patients, our study presents injuries among pregnant women from a general population. Our data shows that injured women were slightly younger than their non-injured counterparts. Trends in household socio-economic status also seemed to differ slightly; there were fewer injured women with higher-grade professional household status and more injured women with unskilled work status, compared to their non-injured counterparts. Injured women were also slightly more likely to smoke cigarettes and consume three or more alcoholic drinks per week. The high prevalence of binge drinking in the DNBC occurred often at very early stage of pregnancy, when pregnancy status may be uncertain or unknown to the mother. Nine out of ten traumatic injuries during pregnancy are minor; however, 60-70% of fetal losses during pregnancy have been reported as a result of minor injuries [16]. In this study we only have data on late spontaneous abortions, and if injured fetuses are aborted early it may explain why we detect limited associations among newborns. Other authors have found adverse maternal, neonatal, and infant outcomes associated with maternal injury [2,3].

While previous studies on pregnant injured women have focused on maternal, neonatal and infant outcomes, this study addresses socio-demographic characteristics. Future studies need to focus on long term infant outcomes, that extend beyond the perinatal period, and consider maternal characteristics that may influence susceptibility to injury severity and injury proneness. At present these results are reassuring; even women who are hospitalized for an injury will in only a few cases have an excess risk of having an abnormal pregnancy outcome.

Author Contributions

JV, JO, and PH contributed to conception and design of the paper. JO contributed to acquisition of data. JV and PH contributed to analysis of the data. JV, JO and PH contributed to interpretation of data. JV wrote the original paper draft; JO and PH contributed to revisions of the paper. JV, JO and PH approved the final version of the paper to be published.

Data Sharing Statement

There is no additional data available.

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Competing Interests Statement

The authors of this paper declare no competing interests.

Table 1: Demographic statistics on study population stratified by injury status and department of hospital admittance

	Total cohort						Place of treatment			
	All N=80874		Non-Injured n=78270		Injured n=2604		Other n=78297		Emergency n=2577	
Characteristics	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Maternal age at delivery										
<25 yr	7641	9.5	7243	9.3	398	15.3	7250	9.3	391	15.2
25-29 yr	31011	38.3	29971	38.3	1040	39.9	29980	38.3	1031	40.0
30-34 yr	30279	37.4	29454	37.6	825	31.7	29462	37.6	817	31.7
35-39 yr	10691	13.2	10390	13.3	301	11.6	10393	13.3	298	11.6
≥40 yr	1252	1.6	1212	1.6	40	1.5	1212	1.6	40	1.6
Gestational age at delivery (weeks)										
< 30	399	0.6	385	0.3	14	0.5	385	0.6	14	0.5
31-36	2891	3.7	2779	3.7	112	4.4	2782	3.7	109	4.4
37-40	32953	42.2	31831	42.1	1122	44.3	31840	42.1	1113	44.4
41-42	36966	47.3	35819	47.4	1147	45.3	35832	47.4	1134	45.3
>42	4883	6.3	4746	6.3	137	5.4	4747	6.3	136	5.4
Birth weight (grams)										
< 1500	679	0.9	661	0.9	18	0.7	661	0.9	18	0.7
1500-2500	1703	2.2	1636	2.2	67	2.7	1636	2.2	67	2.7
>2500	75710	97.0	73263	97.0	2447	96.6	73289	97.0	2421	96.6
Sex of child										
Female	38130	48.8	36934	48.8	1196	47.2	36938	48.9	1192	47.6
Male	39953	51.2	38617	51.2	1336	52.8	38639	51.1	1314	52.4
Parity										
1	35265	46.4	34012	46.2	1253	51.4	34027	46.2	1238	51.3
2	28471	37.4	27626	37.5	845	34.7	27631	37.5	840	34.8
3+	12313	16.2	11972	16.3	341	14.0	11977	16.3	336	13.9
Smoking status										
None	59271	73.3	57534	73.5	1737	66.7	57553	73.5	1718	66.7
Stopped during pregnancy	11788	14.6	11332	14.5	456	17.5	11336	14.5	452	17.5
1-10	9707	12.0	9297	11.9	410	15.8	9301	11.9	406	15.8
≥10	108	0.1	107	0.1	1	0.0	107	0.1	1	0.0
Average alcohol consumption (drinks/week)										
None	35459	43.8	34289	43.8	1170	44.9	34303	43.8	1156	44.9
1	9636	11.9	9370	12.0	266	10.2	9372	12.0	264	10.2
2	6393	7.9	6219	8.0	174	6.7	6219	7.9	174	6.8

3	2437	3.0	2366	3.0	71	2.7	2366	3.0	71	2.8
4+	2302	2.9	2239	2.9	65	2.5	2238	2.9	64	2.5
≥5 at one time	24647	30.5	23789	30.4	858	33.0	23799	30.4	848	32.9
Household socio-economic status										
Higher-grade professionals	19484	24.1	18926	24.2	558	21.4	18931	24.2	553	21.5
Middle-grade professionals	25220	31.2	24468	31.3	752	28.9	24473	31.3	747	29.0
Skilled work	22321	27.6	21575	27.6	746	28.7	21584	27.6	737	28.6
Unskilled work	11109	13.7	10662	13.6	447	17.2	10667	13.6	442	17.2
Student	1933	2.4	1868	2.4	65	2.5	1868	2.4	65	2.5
Unemployed > 1 yr	617	0.8	587	0.8	30	1.2	590	0.8	27	1.1
Unclassified	190	0.2	184	0.2	6	0.2	184	0.2	6	0.2
Partner cohabitation status										
Cohabits	59831	99.0	57967	99.0	1864	98.2	57986	99.0	1845	98.2
Does not cohabit	618	1.0	584	1.0	34	1.8	584	1.0	34	1.8
Place of delivery										
Urban*	42252	52.2	40912	52.3	1340	51.5	40933	52.3	1319	51.2
Rural	38622	47.8	37358	47.8	1264	48.5	37364	47.7	1258	48.8
Outcome										
Low birth weight (<2500 grams)	2029	2.6	1952	2.6	77	3.1	1952	2.6	77	3.1
Preterm birth (<37 weeks)	3031	3.9	2915	3.9	116	4.6	2917	3.9	114	4.6
Small for gestational age (SGA)	7368	9.5	7118	9.4	250	9.9	7120	9.4	248	9.9
Spontaneous abortion	784	1.0	770	98.2	14	1.8	770	98.2	14	1.8
Stillbirth	236	0.3	225	95.3	11	4.7	226	95.8	10	4.2

*Urban residence include Aarhus, Gentolle, Frederisksberg, Odense, Aalborg

**Missing values: gestational age=2782, birthweight=2782, sex of child=2791, parity=4816, cohabit=20417, low birthweight=3279, pre-term birth=3189, SGA=2923

Table 2: Description of Injuries

Mode of Injury	
Knock, blow caused by fall on the same level	415
Knock, blow caused by fall on stairway/lower level	301
Knock, blow due to bodily contact with object/animal/person	834
Crushing/cut/sting	537
Foreign object	99
Chemical influence	26
Thermal/electrical impact or radiation	49
Acute overload of the whole or part of the body	276
Other/unspecified cause of injury	66
Activity during injury	
Sport, exercise	149
Play, hobby and other leisure activity	751
Work	458
Vital activity	243
Unpaid work	123
Other activity/Unspecified	880
Description of transportation injuries	
On foot	11
Bicycle	119
Moped/Motorbike/scooter	20
Car	313
Delivery van/truck/bus or other	5
Other/Unspecified transportation	10

Table 3: Odds and Hazard Ratios for abnormal birth outcomes following maternal exposure to injuries

Outcome		Non-Injured Women N=80874	Injured Women N=2604	Injured women admitted to Emergency Department N=2577	Women with head and neck injuries N=462	Women with head injuries N=312
Small for gestational age		reference	0.98 (0.86, 1.12)	0.98 (0.85, 1.12)	1.15 (0.85, 1.54)	1.30 (0.92, 1.84)
APGAR Score <10		reference	1.08 (0.93, 1.25)	1.09 (0.94, 1.26)	1.01 (0.70, 1.44)	1.04 (0.68, 1.60)
Stillbirth		reference	1.71 (0.93, 3.13)	1.57 (0.83, 3.00)	2.61 (0.83,8.15)	3.86 (1.23, 12.06)
Low birth weight (grams)	<1500	-	0.90 (0.49, 1.63)	0.91 (0.50, 1.66)	0.90 (0.22, 3.62)	0.67 (0.09, 4.76)
	1500-2500	-	1.17 (0.91, 1.51)	1.19 (0.92, 1.52)	1.26 (0.72, 2.19)	1.30 (0.67, 2.54)
	>2500	-	reference	reference	reference	reference
Preterm birth	<30 weeks	-	0.92 (0.41, 2.07)	0.93 (0.41, 2.09)	0.87 (0.41, 2.09)	1.29 (0.18, 9.22)
	30-37 weeks	-	1.18 (0.98, 1.43)	1.18 (0.98, 1.43)	1.45 (0.97, 2.17)	1.53 (0.95, 2.47)
	>37 weeks	-	reference	reference	reference	reference

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

TITLE PAGE

Socio-demographic characteristics of women sustaining injuries during pregnancy, A Study from the Danish National Birth Cohort

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Key words: Cohort study, Descriptive study, Pregnancy, Birth outcomes

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Article summary

Article Focus

- We describe adverse birth outcomes associated with injuries that took place among pregnant women in the Danish National Birth Cohort and include in our assessment injury severity, cause, and mechanism.

Key Messages

- Injured pregnant women were more likely to deliver infants that were stillborn or have pregnancies that were terminated by spontaneous abortion. We did not detect an adverse effect between injuries sustained during pregnancy and delivery of preterm, low birth weight or small for gestational age infants, or infants with an APGAR score of less than 7.
- Women sustaining head or neck injuries were more likely to deliver an infant SGA and have a stillbirth, though these results were not statistically significant.

Strengths and Limitations

- Previous studies have selected pregnant trauma patients or emergency room patients, our study however presents injuries among pregnant women from a general population.
- We only have data on late spontaneous abortions, and if injured fetuses are aborted early we would not detect an association.

Abstract

Objective: To describe adverse birth outcomes associated with hospital treated injuries that took place among women in the Danish National Birth Cohort (DNBC).

Design, Setting & Participants: We utilized data from the DNBC, a longitudinal cohort of pregnant women and their offspring established during 1996–2002. Information was collected twice during pregnancy, at 12 and 30 weeks of gestation; and again when the children reached 6 and 18 months of age. To obtain information regarding birth outcomes, data for each woman were linked to the Danish National Birth Registry and the Danish National Patient Registry.

Primary and Secondary Outcome Measures: To determine if injured women were more likely to deliver an infant preterm, with low birth weight, stillborn or have a spontaneous abortion we estimated hazard ratios. Odds ratios were generated to assess APGAR scores and infants born small for gestational age. Models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, eclampsia/pre-eclampsia or gestational diabetes status during pregnancy and maternal age at birth; estimates for preterm birth were also adjusted for prior history of preterm birth.

Results: In our cohort of 90,452 pregnant women, 3,561 (3.9%) received medical treatment for an injury during pregnancy. Injured pregnant women were more likely to deliver infants that were stillborn or have pregnancies terminated by spontaneous abortion. We did not detect an adverse effect between injuries sustained during pregnancy and delivery of preterm, low birth weight or small for gestational age infants, or infants with an APGAR score of less than 7.

Conclusion: Our study shows that injuries occurring among women from an unselected population may not have an adverse effect on birth weight, gestational age, APGAR score, or small for gestational age status but may adversely affect the risk of stillbirth and spontaneous abortions in some situations.

Introduction

During pregnancy, up to 7 percent of women sustain unintentional injuries [1]; and traumatic injuries are a major cause of maternal and neonatal morbidity and mortality [2,3]. The association of complications arising from blunt trauma in the presence of bleeding and contractions are evident but less is known about adverse birth outcomes linked to minor injuries. It is possible, that minor trauma during pregnancy may lead to sub-clinical chronic placental disruption that persists during pregnancy which may cause an increase in the risk for acute placental abruption, preterm labor, preterm premature rupture of the membranes, and placental insufficiency that restricts fetal growth [4]. But we know less about the occurrence of minor injuries as they are not captured the same way as severe injuries, and the impact they have on the fetus is expected to be small or not harmful. Not much is known about the context in which these injuries take place, and the socio demographic characteristics of women sustaining these injuries; and furthermore there is limited data on long term consequences of these injuries for the offspring. In this paper, we describe adverse birth outcomes associated with hospital treated injuries that took place among women in the Danish National Birth Cohort (DNBC); we include in our assessment injury severity, cause, and mechanism.

Methods

We utilized data collected from the Danish National Birth Cohort (DNBC), which is a longitudinal population based cohort of pregnant women and their offspring established during 1996–2002. Women were contacted to take part in the study by physicians providing their primary care during pregnancy. Approximately half of all general practitioners in Denmark participated in the study; and approximately 60% of women who were invited participated. Additional information on study design and data collection methods for the DNBC are described elsewhere [5]. Information was collected twice during pregnancy using computer assisted telephone interviews, at gestational age 12 and 30 weeks; and again when the children reached 6 and 18 months of age. All Regional Ethics Committee in Denmark approved the

establishment of the cohort and this study was further approved by the Danish Data Protection Agency and UCLA Office for Protection of Research Subjects.

To obtain information regarding birth outcomes, data for each woman were linked through her personal civil registration number to the Danish National Birth Registry and the Danish National Patient Registry for the entire pregnancy period. The Danish National Birth Registry has collected data since 1968 for the primary purpose of monitoring the health of newborns and the quality of antenatal care, and has been increasingly used for research [6]. The gestational age at birth and birth weight was obtained from the Birth Register. Small for gestational age (SGA) was defined as a weight below the 10th percentile for gestational age, grouped by week, among children born in the DNBC.

Information regarding injuries sustained during pregnancy was obtained from the Danish National Patient Registry, which contains data on all hospital stays and outpatient visits for the duration of each woman's pregnancy. For each admission or visit, the patient registry collects information on the primary discharge diagnosis (the discharge diagnosis that best describes the condition leading to the admission or outpatient visit and that is the primary reason for the prescribed and completed course of tests and treatments) and up to 20 subsidiary diagnoses. It also collects information on external cause of injury, including the mode, location, and mechanism causing the injury. Data were extracted with the use of *International Classification of Diseases, 10th Revision* (ICD Website, 2007) [6] and the second edition of the Nordic Medico-Statistical Committee's (NOMESCO) Classification of External Causes of Injuries (NCECI) [8].

We identified 90,452 women who completed the first interview. All injuries were classified by the body location and mechanism causing the injury; transportation injuries were further described by mode of transportation. Women were categorized as injured if they sustained an injury at any point during pregnancy, regardless of mode, body region, and mechanism causing the injury; and uninjured otherwise.

To determine if injured women were more likely to deliver preterm (<34 weeks, 34-36 weeks, ≥ 37 weeks), low birth weight (<1500 grams, 1500-2499 grams, ≥2500 grams), stillbirth or have a spontaneous abortion, we estimated Cox proportional hazard ratios (HRs) using PROC PHREG in SAS Statistical Software, to allow for a time-to-event analysis. These models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, eclampsia/pre-eclampsia or gestational diabetes status during pregnancy and maternal age at birth; estimates for preterm birth were also adjusted for prior history of preterm birth. To determine if injured women were more likely to deliver SGA infants or infants with an APGAR score of <3 or between 4-6 using ≥ 7 as a baseline, we generated odds ratios (ORs) using PROC GENMOD in SAS statistical software. To assess severity of injuries sustained we compared women who sustained head, and head and neck injuries to uninjured women.

Results

In our cohort of 90,452 pregnant women, 3,561 (3.9%) received medical treatment for an injury during their pregnancy. Socio demographic characteristics of all women in the cohort are presented in table 1. Results have been stratified by presence/absence of injury. Injured women were younger, smoked cigarettes more often and had lower household socioeconomic status. Injury characteristics such as mode of injury, activity engaged in while sustaining injury, mechanism causing injury and body region of injury are presented in table 2. Approximately one third of the injuries were due to falls and took place during a leisure activity. Less than one fifth of the injuries were related to transportation. Hazard and odds ratios are presented in table 3. We found that injured pregnant women were slightly more likely to deliver infants that were stillborn or have pregnancies were terminated by spontaneous abortion. We did not detect an adverse effect between injuries sustained during pregnancy and delivery of preterm, low birth weight or small for gestational age infants, or infants with an APGAR score of less than 7.

Discussion

Our study shows that injuries occurring in an unselected Danish population of pregnant women do not adversely affect birth weight, gestational age, APGAR scores, or SGA status but are adversely associated with stillbirth and spontaneous abortion. Adverse pregnancy outcomes resulting from maternal injury have been documented in other studies [9-24]. Severely injured pregnant women are more likely to have preterm labor, placental abruption, cesarean-section, uterine rupture, low birth-weight, and their infants are more likely to result in pre-term delivery and suffer from fetal distress, asphyxia, respiratory distress syndrome and circum to fetal, neonatal and infant death compared to their uninjured counterparts [14]. Minor trauma has also been recognized as contributor to poor fetal outcomes. Fischer et al. found minor injuries were associated with fetal demise, preterm birth and low birth weight [25]. We were not able to corroborate these findings, possibly due to the nature of the health care system in Denmark, where the first point of medical intervention is often with a primary care physician. It is possible that we missed detection of injuries seen by midwives or the primary care physician, which restrict our effect estimates to more severe outcomes.

Our results may not apply to other healthcare settings. This study is based on a Danish population which has low fertility and where most women take part in the work force. Furthermore, duration of pregnancy leave is generous, compensated, and accesses to health care services are covered at no cost to patients. In this study we were able to assess socio-demographic characteristics of this population and our data shows that injured women were slightly younger than their non-injured counterparts. Trends in household socio-economic status also seemed to differ slightly; there were fewer injured women with higher-grade professional household status and more injured women with unskilled work status, compared to their non-injured counterparts. Injured women were also slightly more likely to smoke cigarettes and consume three or more alcoholic drinks per week. The high prevalence of binge drinking in the DNBC occurred often at very early stage of pregnancy, when pregnancy status may be uncertain or unknown to the mother. Nine out of ten traumatic injuries during pregnancy are minor; however, 60-70% of fetal losses during pregnancy have been reported as a result of minor injuries [17]. In this study we only have data on

late spontaneous abortions, and if injured fetuses are aborted early it may explain why we detect limited associations among newborns.

Future studies should focus on long term infant outcomes that extend beyond the perinatal period, to fully assess the effects of maternal injury. Additional research evaluating maternal characteristics that may influence injury severity and proneness may aid in maternal injury prevention. At present it is reassuring that even women hospitalized for an injury during pregnancy will in only a few cases have an excess risk of having an adverse pregnancy outcome.

Author Contributions

JV, JO, and PH contributed to conception and design of the paper. JO contributed to acquisition of data. JV and PH contributed to analysis of the data. JV, JO and PH contributed to interpretation of data. JV wrote the original paper draft; JO and PH contributed to revisions of the paper. JV, JO and PH approved the final version of the paper to be published.

Data Sharing Statement

There is no additional data available.

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Competing Interests Statement

The authors of this paper declare no competing interests.

Table 1: Demographic statistics on study population stratified by injury status and department of hospital admittance

	Total cohort							
	All N=90452		Non-Injured n=86891		Injured± n=3561		Head or Neck Injuries n=534	
Characteristics	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Maternal age at delivery								
<25 yr	8695	9.6	8142	9.4	553	15.5	86	16.1
25-29 yr	34726	38.4	33341	38.4	1385	38.9	194	36.3
30-34 yr	33537	37.1	32392	37.3	1145	32.2	180	33.7
35-39 yr	12006	13.3	11594	13.3	412	11.6	63	11.8
≥40 yr	1488	1.6	1422	1.6	66	1.9	11	2.1
Gestational age at delivery (weeks)								
< 34	1227	1.5	1177	1.4	50	1.5	9	1.8
34-36	2756	3.2	2629	3.2	127	3.8	20	4.0
≥37	82642	95.3	79454	95.4	3188	94.7	475	94.2
Birth weight (grams)								
< 1500	538	0.6	538	0.6	18	0.5	4	0.8
1500-2499	2074	2.5	2074	2.5	101	3.0	15	3.0
≥2500	80451	96.9	80451	96.9	3238	96.5	484	96.2
Sex of child								
Female	42284	48.8	40696	48.8	1588	47.2	236	46.8
Male	44435	51.2	42656	51.2	1779	52.8	268	53.2
Parity								
1	39224	46.3	37569	47.2	1655	50.7	238	48.1
2	31604	37.3	30463	38.3	1141	35.0	192	38.8
3+	13859	16.4	11593	14.6	466	14.3	65	13.1
Smoking status								
None	64589	73.4	62299	73.7	2290	66.7	344	67.3
Stopped during pregnancy	12530	14.2	11923	14.1	607	17.7	91	17.8
1-10	10725	12.2	10193	12.1	532	15.5	76	14.9
≥10	120	0.1	117	0.1	3	0.1	0	0
Average alcohol consumption (drinks/week)								
None	41325	64.9	39642	64.7	1683	68.8	270	34.3
1	10480	16.5	10124	16.5	356	14.5	466	59.2
2	6872	10.8	6649	10.9	223	9.1	29	3.7
3	2554	4.0	2462	4.0	92	3.8	7	0.9
4+	2442	3.8	2351	3.8	91	3.7	15	1.977
≥5 at one time	26779	30.8	25663	29.5	1116	31.3	167	31.2

Household socio-economic status								
Higher-grade professionals	20713	23.5	19989	23.6	724	21.1	126	24.7
Middle-grade professionals	27304	31.0	26326	31.1	978	28.5	135	26.4
Skilled work	24577	27.9	23587	27.9	990	28.8	143	28.0
Unskilled work	12408	14.1	11804	14.0	604	17.6	83	16.2
Student	2075	2.4	1991	2.4	84	2.4	11	2.2
Unemployed > 1 yr	683	0.8	641	0.8	42	1.2	9	1.8
Unclassified	204	0.2	194	0.2	10	0.3	4	0.8
Partner cohabitation status								
Cohabits	66859	99.0	64359	98.1	2500	98.1	353	98.1
Does not cohabit	687	1.0	639	1.9	48	1.95	7	1.95
Place of delivery								
Urban*	48570	53.7	46681	53.0	1889	53.0	274	51.3
Rural	41882	46.3	40210	47.0	1672	47.0	260	48.7
Outcome								
Low birth weight (<2500 grams)	2731	3.0	2612	3.0	119	3.8	19	3.6
Preterm birth (<37 weeks)	3886	4.3	3715	4.3	171	4.8	29	5.4
Small for gestational age (SGA)	8528	9.4	8162	9.4	336	9.4	59	11.0
Spontaneous abortion	3355	3.7	3181	3.7	174	4.9	27	5.1
Stillbirth	288	0.3	271	0.3	17	0.5	3	0.6
Apgar Score <7	605	0.7	586	0.7	19	0.5	1	0.2

*Urban residence include Aarhus, Gentolle, Frederisksberg, Odense, Aalborg

**Missing values: gestational age=184, birth weight=389, sex of child=90, parity=5765, smoking=1155, cohabitation status=22,920

[±] P-values less than 0.05 stratified by injury status and calculated by chi-square test: maternal age, parity, maternal smoking, alcohol consumption, household socio-economic status and partner cohabitation status

Table 2: Description of Injuries

Mode of Injury	
Knock, blow caused by fall on the same level	519
Knock, blow caused by fall on stairway/lower level	381
Knock, blow due to bodily contact with object/animal/person	975
Crushing/cut/sting	621
Foreign object	115
Chemical influence	28
Thermal/electrical impact or radiation	55
Acute overload of the whole or part of the body	331
Other/unspecified cause of injury	74
Activity during injury	
Sport, exercise	185
Play, hobby and other leisure activity	913
Work	545
Vital activity*	300
Unpaid work	161
Other activity/Unspecified	765
Description of transportation injuries	
On foot	12
Bicycle	131
Moped/Motorbike/scooter	21
Car	351
Delivery van/truck/bus or other	10
Other/Unspecified transportation	7

*includes sleep, rest, taking meals and personal hygiene

Table 3: Odds and Hazard Ratios, and 95% Confidence Limits for adverse birth outcomes following maternal exposure to injuries during pregnancy*

Outcome		Non-Injured Women N=87252	Injured Women N=2938	Women with head or neck injuries N=462	Women with head injuries N=312
Small for gestational age[†]		reference	1.05 (0.94, 1.18)	1.15 (0.87, 1.51)	1.18 (0.84, 1.64)
Spontaneous abortion[ǂ]		reference	1.18 (0.99, 1.40)	1.02 (0.68, 1.53)	0.93 (0.55, 1.58)
Stillbirth[ǂ]		reference	1.67 (1.01, 2.77)	2.14 (0.69, 6.70)	3.24 (1.04, 10.10)
Low birth weight (grams)[ǂ]	<1500	-	0.76 90.39, 1.48)	0.89 (0.22, 3.57)	0.83 (0.12, 5.95)
	1500-2499	-	1.05 (0.90, 1.23)	0.99 (0.68, 1.45)	1.09 (0.70, 1.71)
	≥2500	-	Reference	Reference	Reference
Preterm birth[ǂ]	<34 weeks	-	0.76 (0.39, 1.48)	0.89 (0.22, 3.57)	0.83 (0.12, 5.95)
	34-36 weeks	-	1.05 (0.90, 1.23)	0.99 (0.68, 1.45)	1.09 (0.70, 1.71)
	≥37 weeks	-	reference	reference	Reference
APGAR Score[†]	≤3	-	1.15 (0.83, 1.60)	not enough data	not enough data
	4-6	-	0.78 (0.47, 1.31)	not enough data	not enough data
	7-10	-	Reference	reference	Reference

*All models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, and maternal age at birth, preterm birth model includes all aforementioned variables and history of preterm birth; Non-Injured women were used as the comparison group.
[†] Odds Ratios, [ǂ] Hazard Ratios

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Secondary Subject Heading:	Public health
Keywords:	EPIDEMIOLOGY, Prenatal diagnosis < OBSTETRICS, PUBLIC HEALTH

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
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Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

TITLE PAGE

Socio-demographic characteristics of women sustaining injuries during pregnancy, A Study from the Danish National Birth Cohort

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Article summary

Article Focus

- We describe adverse birth outcomes associated with injuries that took place among pregnant women in the Danish National Birth Cohort and include in our assessment injury severity, cause, and mechanism.

Key Messages

- Injured pregnant women were more likely to deliver infants that were stillborn or have pregnancies that were terminated by spontaneous abortion. We did not detect an adverse effect between injuries sustained during pregnancy and delivery of preterm, low birth weight or small for gestational age infants, or infants with an APGAR score of less than 7.
- Women sustaining head or neck injuries were more likely to deliver an infant SGA and have a stillbirth, though these results were not statistically significant.

Strengths and Limitations

- Previous studies have selected pregnant trauma patients or emergency room patients, our study however presents injuries among pregnant women from a general population.
- We only have data on late spontaneous abortions, and if injured fetuses are aborted early we would not detect an association.

Abstract

Objective: To describe adverse birth outcomes associated with hospital treated injuries that took place among women in the Danish National Birth Cohort (DNBC).

Design, Setting & Participants: We utilized data from the DNBC, a longitudinal cohort of pregnant women and their offspring established during 1996–2002. Information was collected twice during pregnancy, at 12 and 30 weeks of gestation; and again when the children reached 6 and 18 months of age. To obtain information regarding birth outcomes, data for each woman were linked to the Danish National Birth Registry and the Danish National Patient Registry.

Primary and Secondary Outcome Measures: To determine if injured women were more likely to deliver an infant preterm, with low birth weight, stillborn or have a spontaneous abortion we estimated hazard ratios. Odds ratios were generated to assess APGAR scores and infants born small for gestational age. Models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, eclampsia/pre-eclampsia or gestational diabetes status during pregnancy and maternal age at birth; estimates for preterm birth were also adjusted for prior history of preterm birth.

Results: In our cohort of 90,452 pregnant women, 3,561 (3.9%) received medical treatment for an injury during pregnancy. Injured pregnant women were more likely to deliver infants that were stillborn or have pregnancies terminated by spontaneous abortion. We did not detect an adverse effect between injuries sustained during pregnancy and delivery of preterm, low birth weight or small for gestational age infants, or infants with an APGAR score of less than 7.

Conclusion: Our study shows that injuries occurring among women from an unselected population may not have an adverse effect on birth weight, gestational age, APGAR score, or small for gestational age status but may adversely affect the risk of stillbirth and spontaneous abortions in some situations.

Introduction

During pregnancy, up to 7 percent of women sustain unintentional injuries [1]; and traumatic injuries are a major cause of maternal and neonatal morbidity and mortality [2,3]. The association of complications arising from blunt trauma in the presence of bleeding and contractions are evident but less is known about adverse birth outcomes linked to minor injuries. It is possible, that minor trauma during pregnancy may lead to sub-clinical chronic placental disruption that persists during pregnancy which may cause an increase in the risk for acute placental abruption, preterm labor, preterm premature rupture of the membranes, and placental insufficiency that restricts fetal growth [4]. But we know less about the occurrence of minor injuries as they are not captured the same way as severe injuries, and the impact they have on the fetus is expected to be small or not harmful. Not much is known about the context in which these injuries take place, and the socio demographic characteristics of women sustaining these injuries; and furthermore there is limited data on long term consequences of these injuries for the offspring. In this paper, we describe adverse birth outcomes associated with hospital treated injuries that took place among women in the Danish National Birth Cohort (DNBC); we include in our assessment injury severity, cause, and mechanism.

Methods

We utilized data collected from the Danish National Birth Cohort (DNBC), which is a longitudinal population based cohort of pregnant women and their offspring established during 1996–2002. During these years women were contacted to take part in the study by physicians providing their primary care during pregnancy. Approximately half of all general practitioners in Denmark participated in the study; and approximately 60% of women who were invited participated. Additional information on study design and data collection methods for the DNBC are described elsewhere [5]. Information was collected twice during pregnancy using computer assisted telephone interviews, at gestational age 12 and 30 weeks; and again when the children reached 6 and 18 months of age. All Regional Ethics Committee in Denmark

approved the establishment of the cohort and this study was further approved by the Danish Data Protection Agency and UCLA Office for Protection of Research Subjects.

To obtain information regarding birth outcomes, data for each woman were linked through her personal civil registration number to the Danish National Birth Registry and the Danish National Patient Registry for the entire pregnancy period. The Danish National Birth Registry has collected data since 1968 for the primary purpose of monitoring the health of newborns and the quality of antenatal care, and has been increasingly used for research [6]. The gestational age at birth and birth weight was obtained from the Birth Register. Small for gestational age (SGA) was defined as a weight below the 10th percentile for gestational age, grouped by week, among children born in the DNBC.

Information regarding injuries sustained during pregnancy was obtained from the Danish National Patient Registry, which contains data on all hospital stays and outpatient visits for the duration of each woman's pregnancy. For each admission or visit, the patient registry collects information on the primary discharge diagnosis (the discharge diagnosis that best describes the condition leading to the admission or outpatient visit and that is the primary reason for the prescribed and completed course of tests and treatments) and up to 20 subsidiary diagnoses. It also collects information on external cause of injury, including the mode, location, and mechanism causing the injury. Data were extracted for the entire study period (1996-2002) with the use of *International Classification of Diseases, 10th Revision* (ICD Website, 2007) [6] and the second edition of the Nordic Medico-Statistical Committee's (NOMESCO) Classification of External Causes of Injuries (NCECI) [8].

We identified 90,452 women who completed the first interview. All injuries were classified by the body location and mechanism causing the injury; transportation injuries were further described by mode of transportation. Women were categorized as injured if they sustained an injury at any point during pregnancy, regardless of mode, body region, and mechanism causing the injury; and uninjured otherwise.

To determine if injured women were more likely to deliver preterm (<34 weeks, 34-36 weeks, ≥ 37 weeks), low birth weight (<1500 grams, 1500-2499 grams, ≥2500 grams), stillbirth or have a spontaneous abortion, we estimated Cox proportional hazard ratios (HRs) using PROC PHREG in SAS Statistical Software, to allow for a time-to-event analysis. These models were adjusted for maternal smoking and drinking during pregnancy, household socioeconomic status, eclampsia/pre-eclampsia or gestational diabetes status during pregnancy and maternal age at birth; estimates for preterm birth were also adjusted for prior history of preterm birth. To determine if injured women were more likely to deliver SGA infants or infants with an APGAR score of <3 or between 4-6 using ≥ 7 as a baseline, we generated odds ratios (ORs) using PROC GENMOD in SAS statistical software. Approximately 8 percent of women in the study participated more than once. Repeated subject statement was entered into each statistical model. To assess severity of injuries sustained we compared women who sustained head, and head and neck injuries to uninjured women.

Results

In our cohort of 90,452 pregnant women, 3,561 (3.9%) received medical treatment for an injury during their pregnancy. Socio demographic characteristics of all women in the cohort are presented in table 1. Results have been stratified by presence/absence of injury. Injured women were younger, smoked cigarettes more often and had lower household socioeconomic status. Maternal age, parity, smoking status, alcohol consumption, household socio-economic status and partner cohabitation status were statistically different in the injured versus non-injured groups (p-values less than 0.05 were calculated by chi-square test). Injury characteristics such as mode of injury, activity engaged in while sustaining injury, mechanism causing injury and body region of injury are presented in table 2. Approximately one third of the injuries were due to falls and took place during a leisure activity. Less than one fifth of the injuries were related to transportation. Hazard and odds ratios are presented in table 3. We found that injured pregnant women were slightly more likely to deliver infants that were stillborn or have pregnancies that were terminated by spontaneous abortion. We did not detect an adverse effect between injuries sustained

during pregnancy and delivery of preterm, low birth weight or small for gestational age infants, or infants with an APGAR score of less than 7.

Discussion

Our study shows that injuries occurring in an unselected Danish population of pregnant women do not adversely affect birth weight, gestational age, APGAR scores, or SGA status but are adversely associated with stillbirth and spontaneous abortion. Adverse pregnancy outcomes resulting from maternal injury have been documented in other studies [9-25]. Severely injured pregnant women are more likely to have preterm labor, placental abruption, cesarean-section, uterine rupture, low birth-weight, and their infants are more likely to result in pre-term delivery and suffer from fetal distress, asphyxia, respiratory distress syndrome and circum to fetal, neonatal and infant death compared to their uninjured counterparts [14]. Minor trauma has also been recognized as contributor to poor fetal outcomes. Fischer et al. found minor injuries were associated with fetal demise, preterm birth and low birth weight [26]. We were not able to corroborate these findings, possibly due to the nature of the health care system in Denmark, where the first point of medical intervention is often with a primary care physician. It is possible that we missed detection of injuries seen by midwives or the primary care physician, which restrict our effect estimates to more severe outcomes.

Our results may not apply to other healthcare settings. This study is based on a Danish population which has low fertility and where most women take part in the work force. Furthermore, duration of pregnancy leave is generous, compensated, and accesses to health care services are covered at no cost to patients. In this study we were able to assess socio-demographic characteristics of this population and our data shows that injured women were slightly younger than their non-injured counterparts. Trends in household socio-economic status also seemed to differ slightly; there were fewer injured women with higher-grade professional household status and more injured women with unskilled work status, compared to their non-injured counterparts. Injured women were also slightly more likely to smoke cigarettes and consume

three or more alcoholic drinks per week. The high prevalence of binge drinking in the DNBC occurred often at very early stage of pregnancy, when pregnancy status may be uncertain or unknown to the mother. Nine out of ten traumatic injuries during pregnancy are minor; however, 60-70% of fetal losses during pregnancy have been reported as a result of minor injuries [17]. In this study we only have data on late spontaneous abortions, and if injured fetuses are aborted early it may explain why we detect limited associations among newborns.

Future studies should focus on long term infant outcomes that extend beyond the perinatal period, to fully assess the effects of maternal injury. Additional research evaluating maternal characteristics that may influence injury severity and proneness may aid in maternal injury prevention. At present it is reassuring that even women hospitalized for an injury during pregnancy will in only a few cases have an excess risk of having an adverse pregnancy outcome.

Author Contributions

JV, JO, and PH contributed to conception and design of the paper. JO contributed to acquisition of data. JV and PH contributed to analysis of the data. JV, JO and PH contributed to interpretation of data. JV wrote the original paper draft; JO and PH contributed to revisions of the paper. JV, JO and PH approved the final version of the paper to be published.

Data Sharing Statement

There is no additional data available.

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Competing Interests Statement

The authors of this paper declare no competing interests.

Table 1: Demographic statistics on study population stratified by injury status and department of hospital admittance

	Total cohort							
	All N=90452		Non-Injured n=86891		Injured± n=3561		Head or Neck Injuries n=534	
Characteristics	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Maternal age at delivery								
<25 yr	8695	9.6	8142	9.4	553	15.5	86	16.1
25-29 yr	34726	38.4	33341	38.4	1385	38.9	194	36.3
30-34 yr	33537	37.1	32392	37.3	1145	32.2	180	33.7
35-39 yr	12006	13.3	11594	13.3	412	11.6	63	11.8
≥40 yr	1488	1.6	1422	1.6	66	1.9	11	2.1
Gestational age at delivery (weeks)								
< 34	1227	1.5	1177	1.4	50	1.5	9	1.8
34-36	2756	3.2	2629	3.2	127	3.8	20	4.0
≥37	82642	95.3	79454	95.4	3188	94.7	475	94.2
Birth weight (grams)								
< 1500	538	0.6	538	0.6	18	0.5	4	0.8
1500-2499	2074	2.5	2074	2.5	101	3.0	15	3.0
≥2500	80451	96.9	80451	96.9	3238	96.5	484	96.2
Sex of child								
Female	42284	48.8	40696	48.8	1588	47.2	236	46.8
Male	44435	51.2	42656	51.2	1779	52.8	268	53.2
Parity								
1	39224	46.3	37569	47.2	1655	50.7	238	48.1
2	31604	37.3	30463	38.3	1141	35.0	192	38.8
3+	13859	16.4	11593	14.6	466	14.3	65	13.1
Smoking status								
None	64589	73.4	62299	73.7	2290	66.7	344	67.3
Stopped during pregnancy	12530	14.2	11923	14.1	607	17.7	91	17.8
1-10	10725	12.2	10193	12.1	532	15.5	76	14.9
≥10	120	0.1	117	0.1	3	0.1	0	0
Average alcohol consumption (drinks/week)								
None	41325	64.9	39642	64.7	1683	68.8	270	34.3
1	10480	16.5	10124	16.5	356	14.5	466	59.2
2	6872	10.8	6649	10.9	223	9.1	29	3.7
3	2554	4.0	2462	4.0	92	3.8	7	0.9
4+	2442	3.8	2351	3.8	91	3.7	15	1.977
≥5 at one time	26779	30.8	25663	29.5	1116	31.3	167	31.2

Household socio-economic status								
Higher-grade professionals	20713	23.5	19989	23.6	724	21.1	126	24.7
Middle-grade professionals	27304	31.0	26326	31.1	978	28.5	135	26.4
Skilled work	24577	27.9	23587	27.9	990	28.8	143	28.0
Unskilled work	12408	14.1	11804	14.0	604	17.6	83	16.2
Student	2075	2.4	1991	2.4	84	2.4	11	2.2
Unemployed > 1 yr	683	0.8	641	0.8	42	1.2	9	1.8
Unclassified	204	0.2	194	0.2	10	0.3	4	0.8
Partner cohabitation status								
Cohabits	66859	99.0	64359	98.1	2500	98.1	353	98.1
Does not cohabit	687	1.0	639	1.9	48	1.95	7	1.95
Place of delivery								
Urban*	48570	53.7	46681	53.0	1889	53.0	274	51.3
Rural	41882	46.3	40210	47.0	1672	47.0	260	48.7
Outcome								
Low birth weight (<2500 grams)	2731	3.0	2612	3.0	119	3.8	19	3.6
Preterm birth (<37 weeks)	3886	4.3	3715	4.3	171	4.8	29	5.4
Small for gestational age (SGA)	8528	9.4	8162	9.4	336	9.4	59	11.0
Spontaneous abortion	3355	3.7	3181	3.7	174	4.9	27	5.1
Stillbirth	288	0.3	271	0.3	17	0.5	3	0.6
Apgar Score <7	605	0.7	586	0.7	19	0.5	1	0.2

*Urban residence include Aarhus, Gentolle, Frederisksberg, Odense, Aalborg
**Missing values: gestational age=184, birth weight=389, sex of child=90, parity=5765, smoking=1155, cohabitation status=22,920
± P-values less than 0.05 stratified by injury status and calculated by chi-square test: maternal age, parity, maternal smoking, alcohol consumption, household socio-economic status and partner cohabitation status

Table 2: Description of Injuries

Mode of Injury	N	%
Knock, blow due to bodily contact with object/animal/person	975	27
Crushing/cut/sting	621	17
Knock, blow caused by fall on the same level	519	15
Knock, blow caused by fall on stairway/lower level	381	11
Acute overload of the whole or part of the body	331	9
Foreign object	115	3
Thermal/electrical impact or radiation	55	2
Chemical influence	28	1
Other/unspecified cause of injury	74	2
Activity during injury		
Play, hobby and other leisure activity	913	26
Work	545	15
Vital activity*	300	8
Sport, exercise	185	5
Unpaid work	161	5
Other activity/Unspecified	765	21
Description of transportation injuries		
Car	351	66
Bicycle	131	25
Moped/Motorbike/scooter	21	4
On foot	12	2
Delivery van/truck/bus or other	10	2
Other/Unspecified transportation	7	1

*includes sleep, rest, taking meals and personal hygiene

Table 3: Odds and Hazard Ratios, and 95% Confidence Limits for adverse birth outcomes following maternal exposure to injuries during pregnancy*

Outcome		Non-Injured Women N=86891	Injured Women N=3561	Women with head or neck injuries N=534	Women with head injuries N=312
Small for gestational age†		reference	1.06 (0.95, 1.18)	1.15 (0.88, 1.52)	1.18 (0.84, 1.64)
Spontaneous abortion‡		reference	1.18 (0.99, 1.40)	1.02 (0.68, 1.53)	0.93 (0.60, 1.44)
Stillbirth‡		reference	1.67 (1.01, 2.77)	2.08 (0.67, 6.50)	3.17 (1.02, 9.88)
Low birth weight (grams)†	<1500	-	0.76 (0.48, 1.24)	0.89 (0.22, 3.57)	0.83 (0.12, 5.95)
	1500-2499	-	1.05 (0.90, 1.23)	1.12 (0.67, 1.89)	1.09 (0.70, 1.71)
	≥2500	-	reference	reference	reference
Preterm birth‡	<34 weeks	-	0.77 (0.39, 1.48)	0.89 (0.22, 3.57)	0.92 (0.13, 6.60)
	34-36 weeks	-	1.05 (0.90, 1.23)	0.99 (0.68, 1.45)	1.35 (0.86, 2.12)
	≥37 weeks	-	reference	reference	reference
APGAR Score†	≤3	-	1.15 (0.93, 1.40)	not enough data	not enough data
	4-6	-	0.78 (0.47, 1.31)	not enough data	not enough data
	7-10	-	reference	reference	reference

*All models were adjusted for eclampsia/pre-eclampsia and gestational diabetes status during pregnancy, maternal smoking and drinking during pregnancy, household socioeconomic status, and maternal age at birth, preterm birth model includes all aforementioned variables and history of preterm birth; Non-Injured women were used as the comparison group. † Odds Ratios, ‡ Hazard Ratios

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