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## Childbirth, hospitalization, and sickness absence: a study of female twins

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BMJ Open - Childbirth, hospitalization, and sickness absence: a study of female twins

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

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b>
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 2</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 4</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 6</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 7</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 7-10</b>
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 7-10</b>
		(b) For matched studies, give matching criteria and number of exposed and unexposed N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 8-9</b>
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 <b>Page 7-10</b>
Bias	9	Describe any efforts to address potential sources of bias N/A
Study size	10	Explain how the study size was arrived at <b>Page 7</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Page 8-9</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 9-10</b>
		(b) Describe any methods used to examine subgroups and interactions <b>Page 9-10</b>
		(c) Explain how missing data were addressed N/A
		(d) If applicable, explain how loss to follow-up was addressed

		N/A
		(e) Describe any sensitivity analyses
<b>Results</b>		
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>Page 7, and page 22</b>
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram <b>Page 22</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 23</b>
		(b) Indicate number of participants with missing data for each variable of interest N/A
		(c) Summarise follow-up time (eg, average and total amount) N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time <b>Page 23</b>
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>Page 24-25</b>
		(b) Report category boundaries when continuous variables were categorized <b>Page 23</b>
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 24-25</b>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <b>Page 2 and page 13</b>
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 <b>Page 16</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 13 – 15</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 13-16</b>
<b>Other information</b>		
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 <b>Page 18</b>

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\*Give information separately for exposed and unexposed groups.

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4 2

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3 **Abstract**

4 **Objective:** To investigate associations of giving birth with morbidity in terms of  
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6 hospitalization and social consequences of morbidity in terms of sickness absence (SA), while  
7  
8 taking familial (genetics and shared environmental) factors into account.  
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10 **Design:** Prospective register-based cohort study. Estimates of risk of hospitalization and SA  
11  
12 were calculated as Hazard Ratios (HR) with 95% confidence intervals (CI).  
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15 **Setting:** All female twins, i.e. women with twin sister, born between 1959 and 1990 in  
16  
17 Sweden.  
18

19 **Participants:** 5118 Swedish female twins (women with twin sister), born 1959-1990, where  
20  
21 at least one in the twin pair had their first childbirth ( $T_0$ ) 1994-2009 and none gave birth  
22  
23 before 1994.  
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26 **Main outcome measures:** Hospitalization and SA during year 2-5 after first delivery or  
27  
28 equivalent.  
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30 **Results:** Preceding the first childbirth, the mean annual number of SA days increased for  
31  
32 mothers, and then decreased again. Hospitalization after  $T_0$  was associated with higher HRs of  
33  
34 short-term and long-term SA. Hospitalization both before and after first childbirth was  
35  
36 associated with a higher risk of future SA. Familial factors influenced the association between  
37  
38 hospitalization and long-term SA, regardless of childbirth status.  
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41 **Conclusion:** Women giving birth did not have a higher risk for SA than those not giving birth  
42  
43 and results indicate a positive health selection into giving birth. Mothers hospitalized before  
44  
45 and/or after giving birth had higher risks for future SA, that is, there was a strong association  
46  
47 between morbidity and future SA.  
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49 **Keywords:** sick leave, childbirth, inpatient care, hospitalization, cohort study, population  
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51 based, twins  
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3 51 **Article Summary**

4 52 **Article focus:**

- 5  
6 53 - To investigate the associations of giving birth with subsequent morbidity in terms of  
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8 54 hospitalization and sickness absence  
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10 55 - To study if hospitalization prior to (or after) childbirth increases the risk for future  
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12 56 hospitalization and sickness absence  
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15 57 **Key messages:**

- 16  
17 58 - Women giving birth did not have a higher future SA risk than those not giving birth  
18  
19 59 and results indicate a positive health selection into giving birth  
20  
21 60 - The high levels of inpatient care in women who did not give birth suggest that there is  
22  
23 61 a health selection in giving birth, where the women who give birth have a better health  
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25 62 initially  
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29 63 **Strengths and limitations:**

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31 64 - The strengths of the study include the population-based prospective design, using  
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33 65 national registers with high completeness and validity  
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35 66 - With a twin study design, we were able to take familial influences into account  
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37 67 - As inpatient care to a great extent has been replaced by outpatient treatment, some of  
38  
39 68 the decrease in hospitalization over the years is a result of a shift in the responsibility  
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41 69 for inpatient care from hospitals to outpatient care facilities  
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## 72 Introduction

73 In most countries with high labor force participation, women have higher levels of sickness  
74 absence (SA) than men<sup>1-4</sup>. Many theories and mechanism regarding this have been suggested,  
75 e.g., women having higher morbidity, higher workload (when combining paid and unpaid  
76 work), tougher situation on the labor market, men being the norm for how the labor market is  
77 organized, gender bias in healthcare and social insurance systems, discrimination and  
78 domestic violence, etcetera<sup>5-9</sup>. Another hypothesis behind this gender difference in SA  
79 focuses on SA during pregnancy and after childbirth<sup>6 10-13</sup>. Several studies show that women  
80 have higher SA during pregnancy<sup>10 14</sup> and that pregnancy-related SA explains half of the  
81 gender differences in SA in fertile ages<sup>15</sup>.

82 One of the changes in society that may affect health after childbirth is that the mean age for  
83 having the first child has increased over the last years and that women with higher level of  
84 morbidity now give birth. Further, nowadays, the proportion of caesarean sections has  
85 increased as well as vacuum extraction deliveries, leading to risk of later health problems<sup>16 17</sup>.

86 In this study, focus is on childbirth, morbidity, and SA among women, to get a better  
87 understanding of mechanisms behind SA among women in fertile ages. There are hardly any  
88 studies on the associations between giving birth and morbidity and SA, and those conducted  
89 have focused on a relatively short time period right after childbirth, most often within the first  
90 year following the child delivery<sup>18 19</sup>, while prospective studies with longer follow-up of  
91 mothers are rare<sup>6 12 20</sup>.

92 Pregnancy, delivery, and the postpartum period may imply large physical, mental, and  
93 social changes during a short period of time, increasing the risk for disease and injury<sup>21 22</sup>.  
94 Different types of physical and mental disorders are common during pregnancy and after  
95 childbirth – and can in some cases be longstanding or even permanent – however, this is  
96 hardly studied at all<sup>19</sup>. Giving birth may be associated with a higher risk of certain diseases  
97 demanding hospitalization, such as cardiovascular diseases, musculoskeletal diseases, mental



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3 98 disorders and different types of injuries<sup>23-26</sup>. For women with a disease present before the  
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5 99 childbirth, the disorder might deteriorate after childbirth<sup>23 24</sup>. Regarding symptoms related to  
6  
7 100 childbirth, high prevalence has been shown six months after childbirth for e.g., low back pain,  
8  
9 101 fatigue, headache, and sleep disorders<sup>19 27</sup>. Most of these symptoms seem to remain up to one  
10  
11 102 year after childbirth<sup>17</sup>. Besides physical health effects, also depression and other mental  
12  
13 103 disorders have been linked to childbirth<sup>26 28</sup>, but again, prospective studies with longer  
14  
15 104 follow-up are lacking<sup>27</sup>. Even though having children has been shown to contribute to an  
16  
17 105 overall wellbeing, this is not the case for everybody and especially not among single mothers  
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19 106 whose economic situation and thereby possibilities for good health care might be worse<sup>29-31</sup>.

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23 107 Morbidity can be measured in different ways, e.g., through self-reports and visits to  
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25 108 healthcare. Here we will use data on more severe morbidity and that involves assessments  
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27 109 from physicians, that is, morbidity that has led to hospitalization, a measure so far not used in  
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29 110 this type of studies. Sickness absence is not a good measure of morbidity— most people with  
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31 111 morbidity are not on SA<sup>4</sup>. Instead SA is considered a very good measure of social  
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33 112 consequences of morbidity, in terms of not being able to support yourself from work<sup>4</sup>. Yet,  
34  
35 113 there are surprisingly few studies on the association between morbidity and SA and in media  
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37 114 it sometimes even the level of morbidity among sickness absentees even is questioned.

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40 115 Studies examining the role of familial factors (i.e. genetic and shared (mainly childhood)  
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42 116 environment) on morbidity have shown that genetics tends to explain a moderate to large  
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44 117 extent of the variability in most of the chronic diseases<sup>32 33</sup>. For example, heritability for  
45  
46 118 mental disorders varies between 30-90%<sup>34</sup>, whereas genetic factors have shown to explain  
47  
48 119 30-60% of the total variation in musculoskeletal disorders<sup>35 36</sup>. Taken together, familial  
49  
50 120 factors are important to account for when studying the association between morbidity (here in  
51  
52 121 terms of hospitalization) and SA as it could lead to erroneous conclusions otherwise. Twin  
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3 122 settings provide a powerful tool for studies of these aspects in research of SA, a research area  
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5 123 where selection, e.g., regarding type of work, otherwise might have a great impact on results.  
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9 125 The aims of the study were twofold. First we set out to investigate the associations of giving  
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11 126 birth with subsequent morbidity in terms of hospitalization and SA. Second, we aimed to  
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13 127 study if hospitalization prior to (or after) childbirth increases the risk for future hospitalization  
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15 128 and SA. Familiar factors (genetics and shared/early environmental) were taken into account in  
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17 129 order to assess if familial factors explain a potential association between childbirth and future  
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19 130 hospitalization and SA.  
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## 132 **Methods**

### 133 **Participants and data sources**

134 We performed a prospective population-based cohort study of female twins. All female twins,  
135 i.e., women with a twin sister, born in Sweden between 1959 and 1990 were selected from the  
136 Swedish Twin Registry (STR)<sup>37</sup>. After excluding women who delivered their first child  
137 before 1994 or whose twin sister had her first delivery before 1994, and twins where none in  
138 the pair had their first delivery between 1994 and 2009 (n=7 304), the final cohort comprised  
139 5 118 women. The Swedish Twin Registry (STR) is the largest population-based register of  
140 twin births in the world, with information such as birth date, sex, zygosity, and pair  
141 identification<sup>37 38</sup>. The selection of the study population is illustrated in Figure 1.  
142 The unique personal identity number assigned to each Swedish resident<sup>39</sup> was used to link  
143 information from several nationwide population-based registers at an individual level up  
144 through 2009, as follows. The Causes of Death Register was used to obtain information on  
145 date of death<sup>40</sup>. Information on all deliveries from the Medical Birth Register, which was  
146 established in 1973 and includes information on almost all births in Sweden<sup>41</sup>. In order to  
147 increase the coverage on delivery, we also used the National Patient Register (NPR) to obtain  
148 information on all deliveries. This register was founded in 1964 and includes all individuals  
149 admitted to any psychiatric or general hospital<sup>42</sup>. Information on hospitalization with a  
150 principal diagnosis for delivery (as defined by the International Classification of Disease  
151 (ICD): ICD-9: 650, 651.9, 652.2, 669.5-8; and ICD-10: O80-84) was obtained. The NPR was  
152 also used to obtain annual information on other hospitalizations. Annual information on  
153 educational level and on SA was obtained from Statistics Sweden.

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3 158 **Time in relation to childbirth**

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5 159 The studied women were followed in relation to year of first childbirth, referred to as  $T_0$ . In  
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7 160 order to compare those who gave birth to those who did not,  $T_0$  for the women who did not  
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9 161 give birth was defined as year of her twin sister's first childbirth.  
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14 163 **Hospitalization**

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16 164 Data on hospitalization covered the period six years prior to, and six years after year of first  
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18 165 childbirth ( $T_0$ ) or equivalent. For descriptive purposes, the total and the average number of  
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20 166 hospitalization days per year were calculated.

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23 167 In order to examine if hospitalization prior to (or after) childbirth increases the risk for future  
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25 168 hospitalization, the first part of the regression analyses considered hospitalization as both  
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27 169 exposure and outcome. We created one dichotomous variable for hospitalization before  $T_0$   
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29 170 (i.e., exposure), and two dichotomous outcome variables for hospitalization during year 2-5  
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31 171 after  $T_0$ : one for hospitalization with any diagnosis and one excluding hospitalization with  
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33 172 diagnoses related to pregnancy, childbirth, and the postpartum period.

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36 173 In order to answer the research question "Does hospitalization prior to (or after) childbirth  
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38 174 increase the risk for future SA?", we created two dichotomous hospitalization exposure  
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40 175 variables: one for hospitalization before  $T_0$ , and one variable: hospitalization year 1-2 after  $T_0$   
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42 176 (excluding diagnoses related to pregnancy, childbirth, and the postpartum period).  
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47 178 **Sickness absence**

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49 179 SA can be measured in several ways, related to duration and incidence<sup>43</sup>. Here we used the  
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51 180 following four measures: total and average number of SA days per year; number of women  
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53 181 with a new SA spell during year 2-5 after  $T_0$ ; and number of women with a new SA spell >90  
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55 182 sick-leave days during year 2-5 after  $T_0$ .  
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### 183 **Sickness insurance in Sweden**

184 In Sweden, all residents aged 16-65 years who have income from work or unemployment  
185 benefits are entitled to sickness benefits from the Swedish Social Insurance Agency, if unable  
186 to work due to disease or injury. Among employed individuals, sick pay was in most cases  
187 paid by the employer during the first 14 days of a sick-leave spell, which means that we do  
188 not have data on most of the short sick-leave spells. In most of the years studied, there was no  
189 limitation to duration of a sick-leave spell. Sickness benefits covered 80% of lost income, up  
190 to a certain level. All were covered by a health care insurance covering the right to hospital  
191 care when needed, at a much reduced cost, less than 10 Euros a day. Care during pregnancy  
192 and delivery was free.

193

### 194 **Potential confounding factor**

195 Educational level at  $T_0$  was classified into four categories; <9 years of compulsory school, 10-  
196 12 years of education (senior high school),  $\geq 13$  years of education (college/university),  
197 missing.

198

### 199 **Statistical analysis**

200 First, Cox proportional hazard models with constant time-at-risk<sup>44</sup> were applied to estimate  
201 hazard ratios (HR) with 95% confidence intervals (CI) for having at least one hospitalization  
202 after childbirth ( $T_0$ ). In a first model (model a), adjustments were made for age. Second  
203 (model b), additional adjustments were made for delivery year and educational level at time of  
204  $T_0$ . Thereafter, twin pairs who were discordant (Conditional Cox regression) with respect to  
205 outcomes, i.e., having at least one hospitalization after  $T_0$ , and were analyzed. In the next step,  
206 we analyzed the associations between childbirth, hospitalization, and SA by fitting three Cox  
207 regression models (table 3). The first (model a) was adjusted for birth year. In the second

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3 208 model (model b), additional adjustments were made for delivery year and educational level at  
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5 209 time of  $T_0$ . In the third model (model c), previous hospitalization was included. Thereafter,  
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7 210 twin pairs who were discordant (Conditional Cox regression) with respect to outcomes i.e.,  
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9 211 having had a SA spell or long-term SA (>90 days) were analyzed.

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11 212 Finally, in the step where we analyzed the association between hospitalization before and  
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13 213 after first childbirth, and subsequent SA (table 4), we adopted the first two models (model a-  
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15 214 b) from table 3. In a third model (model c), we fitted an additional model in which  
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17 215 adjustments were made for subsequent deliveries.

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20 216 Twins in a pair are optimally matched on genetic (100% for MZ pairs and on average 50%  
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22 217 for DZ pairs) and common environmental factors through childhood (100% for both MZ and  
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24 218 DZ twin pairs when reared together) in addition to age and sex (for the same-sexed pairs).  
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26 219 An experimental design, which can control for familial influences, is to examine discordant  
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28 220 twin sisters, that is, where one twin sister has given birth and the other has not. If discordant  
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30 221 twin sisters show similar associations as the analyses of the whole cohort, this would indicate  
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32 222 that the childbirth may actually be a contributing cause of the future SA. If instead the  
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34 223 association found among the whole cohort cannot be replicated within discordant twin sisters,  
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36 224 then familial factors are of importance. Influence of familial factors (genetic and common  
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38 225 environment) is indicated if the association found in the analyses of the whole cohort  
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40 226 disappear or change considerably in the analyses of discordant twin pairs<sup>45</sup>.

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43 227 All statistical analyses were performed with SAS 9.3 and STATA 12.1.  
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45 228 The project was approved by the Regional Ethical Review Board of Stockholm.

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**Results**

Of the 5 118 women included in the study, 77% had given birth at least once between 1994 and 2009 (Table 1). Of these women, nearly 70% also had given birth later, at least once. A majority of the women who gave birth had their first delivery before the age of 30 (61%). The educational level distribution was rather similar when comparing those who gave birth to those who did not. When hospitalizations with diagnoses for pregnancy and childbirth were excluded, 30% of the women who had given birth had at least one hospitalization during the period six years prior to and six years after their first delivery (the delivery year excluded). The corresponding rate for the women who had not given birth was 27%. Half of the women who gave birth had at least one SA spell during the period six years prior to or the six years after first delivery, when the year for childbirth was excluded. The majority of the women had no SA spell at all in the six years following childbirth.

The average annual number of days with inpatient care and SA, respectively, is presented in Figure 2. Up to year  $T_0$ , women who did not give birth had a higher average number of hospitalization days and SA days compared to those who gave birth. The average number of inpatient days increased rapidly during  $T_0$  for women who gave birth, especially because of hospitalization due to pregnancy and childbirth. After  $T_0$ , the number of SA days decreased quickly among these women. For women who gave birth, days with inpatient care and SA the years following  $T_0$  were to a large extent associated with subsequent childbirths.

Table 2 presents HR for the association between childbirth and hospitalization, for all diagnoses and for diagnoses where those related to pregnancy, childbirth, and the postpartum period were excluded. When these diagnoses were removed, women who did not give birth and who had been hospitalized at least once before  $T_0$  had twice the risk of future hospitalization compared to those not hospitalized prior to  $T_0$  (HR: 2.3; 95% CI 1.6-3.3) after adjustments for birth year, delivery year, and educational level. The association was explained by familial factors in the analysis of discordant twin pairs (HR: 1.2; 0.8-1.9).

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3 256 When restricting the analyses to women who gave birth, a total of 2 792 women were  
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5 257 studied, i.e., 1 396 complete pairs in which both twins had given birth. The reference group  
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7 258 constituted of mothers who had not been hospitalized prior to their first childbirth. Mothers  
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9 259 who had been hospitalized before their first childbirth had a slightly higher HR for future  
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11 260 hospitalization when diagnoses related to pregnancy and childbirth were excluded (HR 1.5;  
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13 261 1.2-2.0). This association disappeared in the analyses of discordant twin pairs, suggesting an  
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15 262 influence of familial factors (HR: 1.0; 0.8-1.3).

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18 263 Regardless of childbirth status, hospitalization year 1-2 after T<sub>0</sub> was a predictor of having a  
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20 264 new SA spell (  
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3 266 Table 3). Compared to women who did not give birth and who were not hospitalized the  
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5 267 first two years after T<sub>0</sub>, mothers hospitalized after first childbirth had an HR of 2.4 (2.0-2.9)  
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7 268 after adjustments for birth year, delivery year, and educational level. Hospitalization after T<sub>0</sub>  
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9 269 also was associated with long-term SA (  
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3 271 Table 3). Women who did not give birth had a nearly three-fold risk of long-term SA (HR  
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5 272 2.8; 1.5-5.1), whereas women who gave birth had an HR of 1.8 (1.3-2.5). The analyses of  
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7 273 twin pairs discordant for having a new long-term SA spell year 2-5 after  $T_0$ , show attenuated  
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9 274 point estimates, hence suggesting that familial effects may play a role.

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11 275 The analyses, in which we considered hospitalization before and after first childbirth as  
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13 276 exposure, and outcome was future SA (Table 4) show that mothers who had been hospitalized  
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15 277 at least once both before and after their first child birth had a higher risk of future SA (HR  
16  
17 278 1.8; 1.4-2.2). These women also had a higher risk of long-term SA; however, these risk  
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19 279 estimates were not statistically significant. After controlling for familial confounding, the  
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21 280 estimated risk for long-term SA (>90 days) for those who had been hospitalized before  $T_0$  was  
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23 281 in the same direction but the HR was reduced, which suggest that also familial factors may  
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25 282 have an influence on the studied association.  
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3 283 **Discussion**

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5 284 In this register study of a population-based Swedish cohort of female twins born between  
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7 285 1959 and 1990, the associations of delivery with hospitalization and SA were examined as  
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9 286 well as whether familial (i.e. genetic and shared, mainly childhood, environmental) factors  
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11 287 were contributing to these associations. Just before the first childbirth, the SA days increased  
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13 288 much for mothers, an increase that gradually decreased during the years after the delivery. We  
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15 289 found hospitalization prior to T<sub>0</sub> to be a risk factor for future hospitalization, regardless of  
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17 290 childbirth status, also when excluding hospitalization due to childbirth. Furthermore,  
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19 291 hospitalization after the first childbirth was associated with a higher HR of both short-term  
20  
21 292 and long-term future SA. An additional analysis focusing solely on the women who gave birth  
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23 293 showed that hospitalization both before and after the first childbirth was associated with a  
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25 294 higher risk of future SA. Familial factors seemed to have an influence on the association  
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27 295 between hospitalization and long-term SA, regardless of childbirth status.

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31 296 In line with some previous studies<sup>10 20 46 47</sup>, we found that SA increased in women during  
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33 297 the time before the first childbirth. Giving birth was also associated with a future somewhat  
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35 298 higher risk for SA, in line with that of those not giving birth. However, this higher risk could  
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37 299 be due to subsequent pregnancies. A recent Norwegian study found that the increased SA risk  
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39 300 in women in the years after pregnancy disappeared when SA during subsequent pregnancies  
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41 301 were accounted for<sup>20</sup>. Several explanations have been suggested for such higher levels of SA,  
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43 302 among others the double burden hypothesis<sup>20 48-50</sup>. This hypothesis has been questioned, as  
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45 303 research has indeed shown that women who occupy multiple roles tend to be healthier than  
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47 304 those who enact fewer roles<sup>51-53</sup>. Thus, the combination of employment and parenthood does  
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49 305 not seem to imply worse health, on the contrary. In our study, the annual rates of SA  
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51 306 decreased steadily after the first childbirth, speaking in favor of this hypothesis. Further  
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53 307 studies of this are warranted.  
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3 308 To our best knowledge, this is the first study to examine long-term associations between  
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5 309 childbirth, hospitalization and both short- and long-term SA. Women who gave birth did not  
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7 310 have a higher risk for long-term SA nor for hospitalization (besides hospitalization due to  
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9 311 subsequent pregnancy and childbirth) when compared to women who did not give birth.

11 312 Those who did not give birth had a more stable pattern of SA during the studied period,  
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14 313 however, with a slight increase in annual SA days over the years. This is in line with a  
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16 314 Swedish study examining whether family obligations influence the risk of SA in publicly  
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18 315 employed women and found a slight risk increase for SA among women without children<sup>54</sup>.  
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20 316 Further, a broad systematic literature review published in 2004 provided no evidence of an  
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22 317 association between having children in the household and an increased risk of SA<sup>55</sup>. It is  
23  
24 318 important to consider family situation when examining the association between having  
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26 319 children and morbidity, as single women with children have been shown to have worse health  
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28 320<sup>30 31 56</sup> and higher levels of SA<sup>6 54</sup>.

31 321 Even though pregnancy, delivery, and the postpartum period may increase the risk for  
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33 322 disease and injury<sup>25 27</sup>, our findings do not suggest that women who gave birth are more  
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35 323 likely to be hospitalized after their first childbirth, except for hospitalizations related to  
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37 324 subsequent deliveries. We found no differences in risk for future hospitalization when  
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39 325 comparing those who gave birth to those who did not. Thus, giving birth does not have to be  
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41 326 associated with subsequent health problems. The fact that we found no differences in future  
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43 327 hospitalization between those who gave birth and not, may have different explanations. As  
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45 328 mentioned above, one could expect that there is a health selection, where women who do not  
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47 329 give birth may have worse health and choose not to have or cannot have a child. Also, giving  
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49 330 birth is in itself a risk factor for future morbidity. Further, we know that, during the last  
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51 331 decades, the number of women who voluntarily do not want to become parents has increased  
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53 332 worldwide<sup>57</sup>.

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3 333 Hospitalization prior to the first childbirth or equivalent ( $T_0$ ) was a risk factor for future SA  
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5 334 for all women, regardless of childbirth status. In particular, women who had been hospitalized  
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7 335 both before and after  $T_0$  were at risk for future SA. Furthermore, we found an association  
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9 336 between hospitalization and future longer SA spells.  
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11 337 When comparing women who gave birth to those who did not, with respect to exposure to  
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13 338 hospitalization and risk of SA, mothers hospitalized at least once after the first childbirth had  
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15 339 slightly higher risk for future SA regardless of duration, whereas those who did not give birth  
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17 340 hospitalized after  $T_0$  had higher risk for long-term SA.  
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20 341 Hospitalization both before and after the year  $T_0$  seems to be the strongest indicator, i.e.,  
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22 342 these individuals had the highest risk for future SA. Consequently, the women who had been  
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24 343 hospitalized both before and after  $T_0$  had the highest risk for future SA. Our analyses of  
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26 344 women who gave birth revealed a graded association between hospitalization and SA, where  
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28 345 those who only were hospitalized before *or* after their first childbirth had a higher risk of SA,  
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30 346 whereas those who were hospitalized both before and after the first childbirth had even higher  
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32 347 risks. Thus, we found a strong association between morbidity, here measured as  
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34 348 hospitalization, and future SA among women who have given birth— an association that often  
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36 349 has been question regarding women with children<sup>12</sup>.  
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40 350 Familial factors seemed to contribute to the association between hospitalization before and  
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42 351 after  $T_0$  among those who did not give birth. The influence of familial factors may relate to  
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44 352 morbidity among women not giving birth – morbidity that might be more severe and  
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46 353 potentially also being relatively strongly influenced by genetics. Familial factors also played a  
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48 354 role in the associations between hospitalization and future long-term SA. This could be  
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50 355 related to the fact that the hospitalization usually is required for severe conditions that may  
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52 356 have a strong genetic component. However, since genetics have been shown to influence the  
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54 357 risk of DP<sup>58</sup>, and some indications exist that genetics also play a role in long-term SA and  
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3 358 mortality, it can be suspected that the effects of familial factors on SA can be either direct or  
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5 359 through other influential factors.  
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10 361 **Strengths and limitations**

11 362 The strengths of this study are the population-based prospective cohort study design,  
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13 363 including all in the study population, not a sample, using nationwide registers with high  
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15 364 completeness and validity<sup>40-42</sup>. Further, we used a large study cohort without loss to follow  
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17 365 up. With a twin study design, we were able to take familial influences into account. When  
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19 366 measuring both exposure and outcome with register-based data, we avoid problem with recall  
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21 367 bias.  
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25 368 This study has, however, some limitations. First of all, we do not know whether the women  
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27 369 who did not give birth were childless voluntarily or not. Differences in health between  
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29 370 voluntary and involuntary childlessness have been shown, where voluntarily childless women  
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31 371 showed higher levels of overall well-being<sup>57,59</sup> which might be related to hospitalization  
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33 372 and/or SA. Another limitation is that the terms for inpatient care have changed during the  
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35 373 studied period. In Sweden, inpatient care has to a great extent been replaced by outpatient  
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37 374 treatment. Therefore, some of the decrease in hospitalization over the years is a result of a  
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39 375 shift in the responsibility for inpatient care from hospitals to outpatient care facilities<sup>60</sup>,  
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41 376 however, this affected all women equally, and is to some extent handled by adjusting for birth  
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43 377 year. The CIs are wider in the years far from T<sub>0</sub>, e.g., T<sub>6</sub>, due to fewer follow up year for some  
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45 378 – e.g., for those who gave birth late during the studied period.  
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48  
49 379 It is important to be aware of that giving birth is in focus here, irrespective of whether the  
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51 380 child survived or not. Some of the women who did not give birth might be mothers, e.g., due  
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53 381 to adoption. Other studies in this area has ‘being mother’ or ‘living with child’ as exposure  
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55 382 term, rather than ‘giving birth’.  
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5 384 **Conclusion**

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7 385 Women giving birth did not have a higher future SA risk than those not giving birth and  
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9 386 results indicate a positive health selection into giving birth. Mothers with different types of  
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11 387 morbidity, in terms of hospitalization before and/or after giving birth had higher risks for  
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13 388 future SA. Most women had no SA in the six years following childbirth and those who had  
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15 389 SA generally had that for shorter periods. Among the few women who had severe morbidity,  
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17 390 in terms of hospitalization, the future risk for SA was, as expected, higher. Hospitalization  
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19 391 prior to  $T_0$  was strongly associated with later hospitalization and later SA. The high levels of  
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21 392 inpatient care in women who did not give birth suggest that there is a health selection in  
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23 393 giving birth, where the women who give birth have a better health initially. However, most  
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25 394 women had no hospitalization and no SA.  
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5 396 **Ethical approval**  
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7 397 The study was approved by the Regional Ethical Review Board, Stockholm, Sweden

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10 398 (2007/524-31).

11 399

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3031 407 **Competing interest statement**

32 408 We declare that no competing interests exist.

33 409  
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3536 410 **Author's contributions**

37 411 KA and PS originated the idea. EB analysed the data in consultation with KA, LK, JN, AR

38  
39 412 and PS. EB wrote the first and subsequent drafts of the manuscript, with important intellectual40  
41 413 input from all the co-authors. All authors contributed in designing the study and to the42  
43 414 interpretation of the results and to the writing and approval of the final article.  
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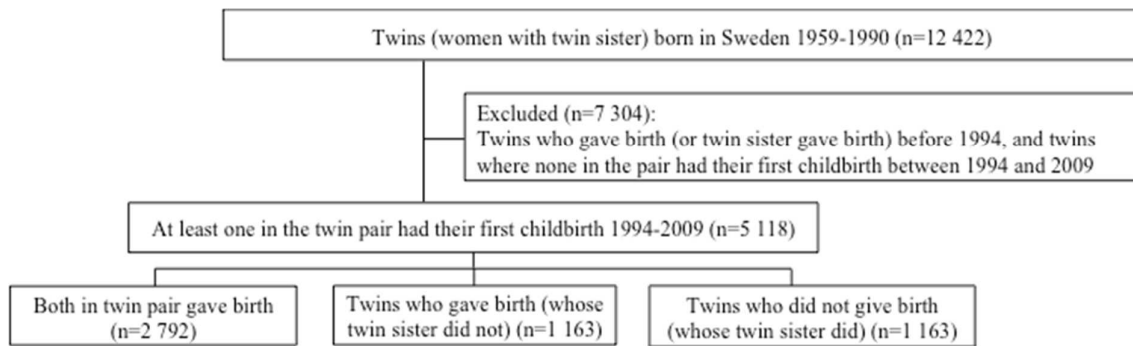
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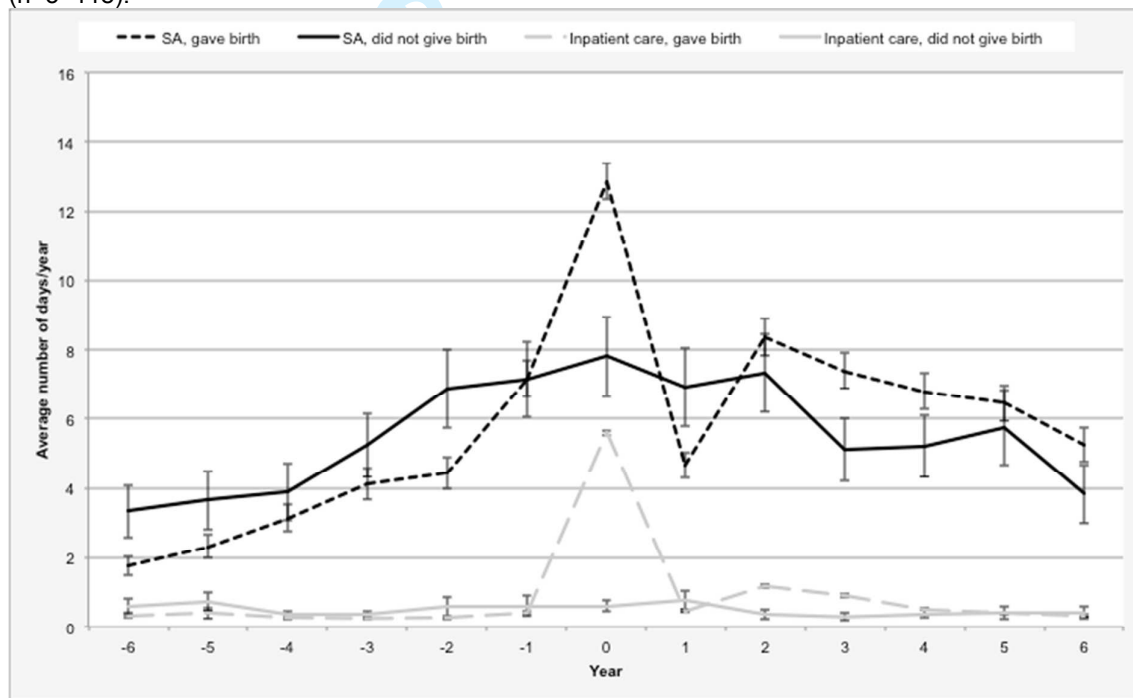
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565 **Suggested figures and tables**  
 566 Figure 1. Flow chart for the study population



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Figure 2. Average annual number of days on sickness absence (SA) and hospitalization, respectively, (with 95% CI), six years prior through six year after T<sub>0</sub> for women who gave birth/did not give birth (n=5 118).



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Table 1. Cohort characteristics for twins (women with twin sister) born in Sweden 1959-1990 (excluding those who gave birth before age 16 and those who died before age 16), where at least one in the pair had their first childbirth 1994-2009 and none before 1994.  $T_0$  is defined as year for first childbirth for women who gave birth, and year of twin sister's childbirth for those who did not give birth.

Variables	Both gave birth		Twin pairs where only one in the pair gave birth		Total
	birth	Twin 1 (gave birth)	Twin 2 (did not give birth)		
N	2 792	1 163	1 163	5 118	
<b>Number of deliveries</b>					
One delivery	711 (25%)	501 (43%)			
Two or more deliveries	2 081 (75%)	662 (57%)			
<b>Age at <math>T_0</math></b>					
16-19 years	47 (2%)	33 (21%)			
20-24 years	511 (18%)	239 (21%)			
25-29 years	1 150 (41%)	444 (38%)			
30-34 years	847 (30%)	323 (28%)			
35-39 years	207 (7%)	109 (9%)			
<40 years	30 (1%)	15 (1%)			
<b>Zygoty</b>					
Monozygotic	1 726 (62%)	608 (52%)	608 (52%)	2 942 (57%)	
Dizygotic	1 066 (38%)	555 (48%)	555 (48%)	2 176 (43%)	
<b>Highest attained education<sup>1</sup></b>					
≤ 9 year	179 (6%)	74 (6%)	55 (5%)	308 (6%)	
10-12 year	1 434 (51%)	608 (52%)	621 (53%)	2 663 (52%)	
≥ 13 year	1 173 (42%)	474 (41%)	422 (36%)	2 069 (40%)	
Information on education missing	6 (0%)	7 (1%)	65 (6%)	78 (2%)	
<b>Hospitalization<sup>2</sup></b>					
- At least one hospitalization during the period six years prior through six years after $T_0$	2 161 (77%)	703 (60%)	325 (28%)	3 189 (62%)	
-At least one hospitalization during the period six years prior through six years after $T_0$ (excluding hospitalizations with a diagnosis for pregnancy, childbirth, and the puerperium)	865 (31%)	315 (27%)	314 (27%)	1 494 (29%)	
- At least one hospitalization during the period six years prior through six years after $T_0$ (excluding hospitalizations with a diagnosis for pregnancy, and childbirth)	1 183 (42%)	407 (35%)	325 (28%)	1 915 (37%)	
- At least one hospitalization during the period six years prior to $T_0$	679 (24%)	251 (22%)	217 (19%)	1 147 (22%)	
- At least one hospitalization during the period six years after $T_0$	1 965 (70%)	585 (50%)	168 (14%)	2 718 (53%)	
- At least one hospitalization both before and after $T_0$	483 (17%)	133 (11%)	60 (5%)	676 (13%)	
<b>Sickness Absence (SA)<sup>3</sup></b>					
At least one SA spell during the period six years prior through six years after $T_0$	1 526 (55%)	530 (46%)	365 (31%)	2 420 (47%)	
At least one SA spell during the period six years prior to $T_0$	690 (25%)	274 (24%)	224 (19%)	1 188 (23%)	
At least one SA spell during the period six years after $T_0$	1 245 (45%)	382 (33%)	221 (19%)	1 848 (36%)	

<sup>1</sup> At time of  $T_0$

<sup>2</sup> Excluding hospitalizations occurring during  $T_0$

<sup>3</sup> Excluding SA spells occurring during  $T_0$

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Table 2. Cox proportional hazard ratios (HR) with 95% CI for the association between childbirth and hospitalization in twins where at least one in the pair had her first childbirth 1994-2009 and none before 1994.

Status childbirth and hospitalization	All diagnoses			Diagnoses related to pregnancy, childbirth and the puerperium excluded <sup>1</sup>		
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>3,7</sup>
<b>All women (n=5 118)</b>						
No childbirth, no hospitalization before T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization before T <sub>0</sub> <sup>8</sup>	2.5 (1.7-3.6)	2.3 (1.6-3.3)	2.4 (1.3-4.5)	2.7 (1.8-3.9)	2.3 (1.6-3.4)	1.2 (0.8-1.9)
Childbirth, no hospitalization before T <sub>0</sub> <sup>8</sup>	6.1(5.0-7.5)	5.5 (4.5-6.8)	8.3 (5.8-11.8)	1.1 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.7-1.1)
Childbirth, hospitalization before T <sub>0</sub> <sup>8</sup>	6.5 (5.2-8.1)	5.6 (4.4-7.1)	7.9 (5.4-11.5)	1.9 (1.4-2.5)	1.4 (1.1-1.9)	0.9 (0.7-1.2)
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>4,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>5,7</sup>
<b>Women who had at least one childbirth (n=2 792)</b>						
No hospitalization before T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before T <sub>0</sub> <sup>8</sup>	1.0 (0.9-1.2)	1.0 (0.9-1.1)	1.0 (0.8-1.2)	1.7 (1.3-2.3)	1.5 (1.2-2.0)	1.0 (0.8-1.3)

<sup>1</sup> Diagnoses O00-O99

<sup>2</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=1 016 pairs)

<sup>3</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=456 pairs)

<sup>4</sup> Twin pairs (both giving birth) where one having had a hospitalization during the follow-up and the other not (n=508 pairs)

<sup>5</sup> Twin pairs (both giving birth) with one had a hospitalization during the follow-up and the other not (n=271 pairs)

<sup>6</sup> Adjusted for birth year

<sup>7</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>8</sup> During the period 1-5 years prior to T<sub>0</sub>

Table 3. Cox proportional HR with 95% CI for the association between childbirth, hospitalization and sickness absence (SA), in twins where at least one in the pair had their first childbirth 1994-2009.

Status childbirth and hospitalization	SA (at least one day)				Long-term SA (>90 days)			
	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>1,7</sup>	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>
<b>All women (n=5 118)</b>								
No childbirth, no hospitalization year 1-2 after T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization year 1-2 after T <sub>0</sub> <sup>8</sup>	2.7 (1.8-4.1)	2.2 (1.5-3.4)	2.1 (1.4-3.2)	1.5 (0.8-2.9)	4.5 (2.5-8.2)	3.5 (1.9-6.2)	2.8 (1.5-5.1)	1.1 (0.5-2.3)
Childbirth, no hospitalization year 1-2 after T <sub>0</sub> <sup>8</sup>	2.1 (1.8-2.5)	1.8 (1.5-2.2)	1.8 (1.5-2.2)	1.7 (1.3-2.2)	1.1 (0.8-1.6)	1.0 (0.7-1.4)	1.0 (0.7-1.3)	0.8 (0.6-1.2)
Childbirth, hospitalization year 1-2 after T <sub>0</sub> <sup>8</sup>	3.0 (2.5-3.6)	2.4 (2.0-2.9)	2.4 (2.0-2.9)	2.0 (1.5-2.6)	2.3 (1.6-3.2)	1.8 (1.3-2.5)	1.8 (1.3-2.5)	1.0 (0.7-1.5)
<b>Women who had at least one childbirth (n=2 792)</b>								
No hospitalization year 1-2 after T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization year 1-2 after T <sub>0</sub> <sup>8</sup>	1.3 (1.2-1.5)	1.3 (1.1-1.4)	1.2 (1.1-1.4)	1.2 (1.0-1.5)	2.0 (1.5-2.6)	1.9 (1.4-2.5)	1.8 (1.4-2.4)	1.4 (1.0-1.9)

<sup>1</sup> Twin pairs where one had a SA spell during the follow-up and the other not (n=835 pairs)

<sup>2</sup> Twin pairs where one had a long-term SA spell during the follow-up and the other not (n=277 pairs)

<sup>3</sup> Twin pairs where one had a SA spell during the follow-up and the other not (n=542 pairs)

<sup>4</sup> Twin pairs where one had a long-term SA spell during the follow-up and the other not (n=184 pairs)

<sup>5</sup> Adjusted for birth year

<sup>6</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>7</sup> Model b, and additional adjustments for earlier hospitalization

<sup>8</sup> Diagnoses O00-O99 excluded

Table 4. Cox proportional HR with 95% CI for the association between hospitalization before and after first childbirth, and sickness absence (SA), in twins who had their first childbirth 1994-2009 (n=2 792).

Status hospitalization before and after childbirth	SA (at least one day)				Long-term SA (>90 days)			
	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>1,4</sup>	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>2,4</sup>
No hospitalization either before T <sub>0</sub> <sup>6</sup> or during year 1-2 after T <sub>0</sub> <sup>7</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before T <sub>0</sub> <sup>6</sup> but not during year 1-2 after T <sub>0</sub> <sup>7</sup>	1.2 (1.0-1.5)	1.2 (1.0-1.4)	1.2 (1.0-1.4)	1.0 (0.8-1.3)	2.3 (1.6-3.4)	2.1 (1.5-3.1)	2.2 (1.5-3.1)	1.2 (0.8-1.7)
No hospitalization before T <sub>0</sub> <sup>6</sup> but during year 1-2 after T <sub>0</sub> <sup>7</sup>	1.2 (1.1-1.4)	1.2 (1.0-1.4)	1.1 (0.9-1.2)	1.1 (0.9-1.4)	2.0 (1.5-2.8)	1.9 (1.4-2.7)	1.9 (1.4-2.7)	1.4 (1.0-2.1)
Hospitalization before T <sub>0</sub> <sup>6</sup> and during year 1-2 after T <sub>0</sub> <sup>7</sup>	2.0 (1.6-2.5)	1.8 (1.4-2.2)	1.6 (1.3-2.1)	1.6 (1.1-2.2)	4.2 (2.7-6.4)	3.5 (2.3-5.3)	3.5 (2.3-5.4)	1.5 (0.9-2.4)

<sup>1</sup> Twin pairs where one had an SA spell during the follow-up and the other not (n=542)

<sup>2</sup> Twin pairs where one had a long-term SA spell during the follow-up and the other not (n=184)

<sup>3</sup> Adjusted for birth year

<sup>4</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>5</sup> Model b, and additional adjustments for subsequent deliveries

<sup>6</sup> During the period 1-5 years prior to T<sub>0</sub>

<sup>7</sup> Diagnoses O00-O99 excluded

# BMJ Open

## Childbirth, hospitalization, and sickness absence: a study of female twins

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2  
3 **Abstract**

4 **Objective:** To investigate associations of giving birth with morbidity in terms of  
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6 hospitalization and social consequences of morbidity in terms of sickness absence (SA), while  
7  
8 taking familial (genetics and shared environmental) factors into account.  
9

10 **Design:** Prospective register-based cohort study. Estimates of risk of hospitalization and SA  
11  
12 were calculated as hazard ratios (HR) with 95% confidence intervals (CI).  
13

14 **Setting:** All female twins, i.e., women with twin sister, born in Sweden.  
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16 **Participants:** 5118 Swedish female twins (women with twin sister), born 1959-1990, where  
17  
18 at least one in the twin pair had their first childbirth ( $T_0$ ) 1994-2009 and none gave birth  
19  
20 before 1994.  
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23 **Main outcome measures:** Hospitalization and SA during year 3-5 after first delivery or  
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25 equivalent.  
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28 **Results:** Preceding the first childbirth, the mean annual number of SA days increased for  
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30 mothers, and then decreased again. Hospitalization after  $T_0$  was associated with higher HRs of  
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32 short-term and long-term SA (HR for short-term SA: 3.0; 95% CI 2.5-3.6 and for long-term  
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34 SA: 2.3; 95% CI 1.6-3.2). Hospitalization both before and after first childbirth was associated  
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36 with a higher risk of future SA (HR for long-term SA: 4.2; 95% CI 2.7-6.4). Familial factors  
37  
38 influenced the association between hospitalization and long-term SA, regardless of childbirth  
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40 status.  
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43 **Conclusion:** Women giving birth did not have a higher risk for SA than those not giving birth  
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45 and results indicate a positive health selection into giving birth. Mothers hospitalized before  
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47 and/or after giving birth had higher risks for future SA, that is, there was a strong association  
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49 between morbidity and future SA.  
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52 **Keywords:** sick leave, childbirth, inpatient care, hospitalization, cohort study, population  
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54 based, twins  
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3 51 **Article Summary**

4 52 **Article focus:**

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6 53 To investigate associations of giving birth with morbidity in terms of hospitalization and  
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8 54 social consequences of morbidity in terms of sickness absence (SA), while taking familial  
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10 55 (genetics and shared environmental) factors into account.

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12  
13 56 **Key messages:**

- 14  
15 57 - Women giving birth did not have a higher future SA risk than those not giving birth  
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17 58 and results indicate a positive health selection into giving birth  
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19 59 - The high levels of inpatient care in women who did not give birth suggest that there is  
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21 60 a health selection in giving birth, where the women who give birth have a better health  
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23 61 initially

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26 62 **Strengths and limitations:**

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28 63 - The strengths of the study include the population-based prospective design, using  
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30 64 national registers with high completeness and validity  
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32 65 - With a twin study design, we were able to take familial influences into account  
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34 66 - As inpatient care to a great extent has been replaced by outpatient treatment, some of  
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36 67 the decrease in hospitalization over the years is a result of a shift in the responsibility  
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38 68 for inpatient care from hospitals to outpatient care facilities  
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## 71 Introduction

72 In most countries with high labor force participation, women have higher levels of sickness  
73 absence (SA) than men<sup>1-4</sup>. Many theories and mechanism regarding this have been suggested,  
74 e.g., women having higher morbidity, higher workload (when combining paid and unpaid  
75 work), tougher situation on the labor market, men being the norm for how the labor market is  
76 organized, gender bias in healthcare and social insurance systems, discrimination, and  
77 domestic violence, etcetera<sup>5-9</sup>. Another hypothesis behind this gender difference in SA  
78 focuses on SA during pregnancy and after childbirth<sup>6 10-13</sup>. Several studies show that women  
79 have higher SA during pregnancy<sup>10 14</sup> and that pregnancy-related SA explains half of the  
80 gender differences in SA in fertile ages<sup>15</sup>.

81 One of the changes in society that may affect health after childbirth is that the mean age for  
82 having the first child has increased over the last years and that women with higher level of  
83 morbidity now give birth. Further, nowadays, the proportion of caesarean sections has  
84 increased as well as vacuum extraction deliveries, leading to risk of later health problems<sup>16 17</sup>.

85 In this study, focus is on childbirth, morbidity, and SA among women, to get a better  
86 understanding of mechanisms behind SA among women in fertile ages. There are hardly any  
87 studies on the associations between giving birth and morbidity and SA, and those conducted  
88 have focused on a relatively short time period right after childbirth, most often within the first  
89 year following the child delivery<sup>18 19</sup>, while prospective studies with longer follow-up of  
90 mothers are rare<sup>6 12 20</sup>.

91 Pregnancy, delivery, and the postpartum period may imply large physical, mental, and  
92 social changes during a short period of time, increasing the risk for disease and injury<sup>21 22</sup>.  
93 Different types of physical and mental disorders are common during pregnancy and after  
94 childbirth – and can in some cases be longstanding or even permanent – however, this is  
95 hardly studied at all<sup>19</sup>. Giving birth may be associated with a higher risk of certain diseases  
96 demanding hospitalization, such as cardiovascular diseases, musculoskeletal diseases, mental

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3 97 disorders, and different types of injuries<sup>23-26</sup>. For women with a disease present before the  
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5 98 childbirth, the disorder might deteriorate after childbirth<sup>23 24</sup>. Regarding symptoms related to  
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7 99 childbirth, high prevalence has been shown six months after childbirth for e.g., low back pain,  
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9 100 fatigue, headache, and sleep disorders<sup>19 27</sup>. Most of these symptoms seem to remain up to one  
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11 101 year after childbirth<sup>17</sup>. Besides physical health effects, also depression and other mental  
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13 102 disorders have been linked to childbirth<sup>26 28</sup>, but again, prospective studies with longer  
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15 103 follow-up are lacking<sup>27</sup>. Even though having children has been shown to contribute to an  
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17 104 overall wellbeing, this is not the case for everybody and especially not among single mothers  
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19 105 whose economic situation and thereby possibilities for good health care might be worse<sup>29-31</sup>.

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23 106 Morbidity can be measured in different ways, e.g., through self-reports and visits to  
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25 107 healthcare. Here we will use data on more severe morbidity that involves assessments from  
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27 108 physicians, that is, morbidity that has led to hospitalization, a measure so far not used in this  
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29 109 type of studies. Sickness absence is not a good measure of morbidity—most people with  
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31 110 morbidity are not on SA<sup>4</sup>. Instead SA is considered a very good measure of social  
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33 111 consequences of morbidity, in terms of not being able to support yourself from work<sup>4</sup>. Yet,  
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35 112 there are surprisingly few studies on the association between morbidity and SA and in media  
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37 113 sometimes even the level of morbidity among sickness absentees even is questioned.

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40 114 Studies examining the role of familial factors (i.e. genetic and shared (mainly childhood)  
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42 115 environment) on morbidity have shown that genetics tends to explain a moderate to large  
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44 116 extent of the variability in most of the chronic diseases<sup>32 33</sup>. For example, heritability for  
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46 117 mental disorders varies between 30-90%<sup>34</sup>, whereas genetic factors have been shown to  
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48 118 explain 30-60% of the total variation in musculoskeletal disorders<sup>35 36</sup>. Taken together,  
49  
50 119 familial factors are important to account for when studying the association between morbidity  
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52 120 (here in terms of hospitalization) and SA as studies otherwise could lead to erroneous  
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54 121 conclusions. Twin settings provide a powerful tool for studies of these aspects in research of  
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3 122 SA, a research area where different selection biases otherwise might have an impact on  
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5 123 results. Twins in a pair are optimally matched on genetic (100% for MZ pairs and on average  
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7 124 50% for DZ pairs) and common environmental factors through childhood (100% for both MZ  
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9 125 and DZ twin pairs when reared together) in addition to age and sex (for the same-sexed pairs).  
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11 126 An experimental design, which can control for these familial influences, is to examine  
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13 127 discordant twin sisters, that is, where one twin sister has given birth and the other has not. If  
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15 128 discordant twin sisters show similar associations as the analyses of the whole cohort, this  
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17 129 would indicate that the childbirth may actually be a contributing cause of the future SA. If  
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19 130 instead the association found among the whole cohort cannot be replicated within discordant  
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21 131 twin sisters, then familial factors are of importance. Influence of familial factors (genetic and  
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23 132 common environment) is indicated if the association found in the analyses of the whole cohort  
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25 133 disappear or change considerably in the analyses of discordant twin pairs<sup>37</sup>.  
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31 135 The aim of the study was to investigate the associations of giving birth with subsequent  
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33 136 morbidity in terms of hospitalization and SA. Familial factors (genetics and shared/early  
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35 137 environmental) were taken into account in order to assess if familial factors explain a  
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37 138 potential association between childbirth and future hospitalization and SA.  
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## 140 **Methods**

### 141 **Participants and data sources**

142 We performed a prospective population-based cohort study of female twins. All female twins,  
143 i.e., women with a twin sister, born in Sweden between 1959 and 1990 were selected from the  
144 Swedish Twin Registry (STR)<sup>38</sup>. After excluding women who delivered their first child  
145 before 1994 or whose twin sister had her first delivery before 1994, and twins where none in  
146 the pair had their first delivery between 1994 and 2009 (n=7 304), the final cohort comprised  
147 5 118 women of which 95% had income from work, the others had income from parental  
148 benefits, unemployment benefits, student benefits, different types of sickness benefits, or a  
149 mixture of those (in the year prior to the birth year, i.e., T(-1). All had some of those types of  
150 income, all granting rights to SA benefits. The Swedish Twin Registry (STR) is the largest  
151 population-based register of twin births in the world, with information such as birth date, sex,  
152 zygosity, and pair identification<sup>38 39</sup>. The selection of the study population is illustrated in  
153 Figure 1.

154 The unique personal identity number assigned to each Swedish resident<sup>40</sup> was used to link  
155 information from several nationwide population-based registers at an individual level up  
156 through 2009, as follows. The Causes of Death Register was used to obtain information on  
157 date of death<sup>41</sup>. This register contains information on all deceased Swedish residents since  
158 1952. Information on all deliveries (including still births) was derived from the Medical Birth  
159 Register, which was established in 1973 and includes information on almost all births in  
160 Sweden<sup>42</sup>. In order to increase the coverage on delivery, we also used the National Patient  
161 Register (NPR) to obtain information on all deliveries. This register was founded in 1964 and  
162 includes all individuals admitted to any psychiatric or general hospital<sup>43</sup>. Information on  
163 hospitalization with a principal diagnosis for delivery (as defined by the International  
164 Classification of Disease (ICD): ICD-9: 650, 651.9, 652.2, 669.5-8; and ICD-10: O80-84) was  
165 obtained. The NPR was also used to obtain annual information on other hospitalizations, i.e.,



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3 166 inpatient care. Annual information on educational level and on SA days was obtained from  
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5 167 Statistics Sweden.

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10 169 **Time in relation to childbirth**

11 170 The studied women were followed in relation to year of first childbirth, referred to as  $T_0$ . In  
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14 171 order to compare those who gave birth to those who did not,  $T_0$  for the women who did not  
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16 172 give birth was defined as year of her twin sister's first childbirth.

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21 174 **Hospitalization**

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23 175 Data on hospitalization covered the period six years prior to, and six years after year of first  
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25 176 childbirth ( $T_0$ ) or equivalent. For descriptive purposes, the total and the average number of  
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27 177 hospitalization days per year were calculated.

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29 178 In order to examine if hospitalization prior to (or after) childbirth increases the risk for future  
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31 179 hospitalization, the first part of the regression analyses considered hospitalization as both  
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33 180 exposure and outcome. We created one dichotomous variable for hospitalization before  $T_0$   
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35 181 (i.e., exposure), and two dichotomous outcome variables for hospitalization during year 3-5  
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37 182 after  $T_0$ : one for hospitalization with any diagnosis and one excluding hospitalization with  
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39 183 diagnoses related to pregnancy, childbirth, and the postpartum period.

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42 184 In order to answer the research question "Does hospitalization prior to (or after) childbirth  
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44 185 increase the risk for future SA?", we created two dichotomous hospitalization exposure  
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46 186 variables: one for hospitalization before  $T_0$  and one variable: hospitalization year 1-2 after  $T_0$   
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48 187 (excluding diagnoses related to pregnancy, childbirth, and the postpartum period).

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54 189 **Sickness absence**

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3 190 SA can be measured in several ways, related to duration and incidence<sup>44</sup>. Here we used the  
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5 191 following four measures: total and average number of SA days per year; number of SA days  
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7 192 during year 3-5 after T<sub>0</sub>; and number of SA days >90 sick-leave days during year 3-5 after  
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9 193 T<sub>0</sub>.

### 194 **Sickness insurance in Sweden**

195 In Sweden, all residents aged 16-65 years who have income from work, unemployment  
196 benefits, parental benefits, or student benefits are entitled to sickness benefits from the  
197 Swedish Social Insurance Agency, if unable to work due to disease or injury. Among  
198 employed individuals, sick pay was in most cases paid by the employer during the first 14  
199 days of a sick-leave spell, which means that we do not have data on most of the short sick-  
200 leave spells. In most of the years studied, there was no limitation to duration of a sick-leave  
201 spell. Sickness benefits covered 80% of lost income, up to a certain level. All were covered by  
202 a health care insurance covering the right to hospital care when needed, at a much reduced  
203 cost, less than 10 Euros a day. Care during pregnancy and delivery was free.

### 205 **Potential confounding factor**

206 As research has shown socioeconomic disparities in age at first birth (e.g., the higher the  
207 education, the later the first birth)<sup>45 46</sup>, we adjusted for educational level at T<sub>0</sub>. Years of  
208 education was classified into four categories; <9 years of compulsory school, 10-12 years of  
209 education (senior high school), ≥13 years of education (college/university), missing.

### 211 **Statistical analysis**

212 First, Cox proportional hazard models with constant time-at-risk<sup>47</sup> were applied to estimate  
213 hazard ratios (HR) with 95% confidence intervals (CI) for having at least one hospitalization  
214 after childbirth (T<sub>0</sub>). In a first model (model a), adjustments were made for age. Second

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3 215 (model b), additional adjustments were made for delivery year and educational level at time of  
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5 216  $T_0$ . Thereafter, twin pairs who were discordant with respect to outcomes, i.e., having at least  
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7 217 one hospitalization after  $T_0$ , were analyzed using Conditional Cox regression. In the next step,  
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9 218 we analyzed the associations between childbirth, hospitalization, and SA by fitting three Cox  
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11 219 regression models (table 3). The first (model a) was adjusted for birth year. In the second  
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13 220 model (model b), additional adjustments were made for delivery year and educational level at  
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15 221 time of  $T_0$ . In the third model (model c), previous hospitalization was included. Thereafter,  
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17 222 twin pairs who were discordant (Conditional Cox regression) with respect to outcomes i.e.,  
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19 223 having had SA or long-term SA (>90 days) were analyzed.  
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23 224 Finally, in the step where we analyzed the association between hospitalization before and  
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25 225 after first childbirth, and subsequent SA (table 4), we adopted the first two models (model a-  
26  
27 226 b) from table 3. In a third model (model c), we fitted an additional model in which  
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29 227 adjustments were made for subsequent deliveries.  
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32 228 The proportional hazards assumption was checked by including time-dependent versions of  
33  
34 229 all the covariates in the models. This did not indicate a violation of the proportionality  
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36 230 assumption.  
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39 231 All statistical analyses were performed with SAS 9.3 and STATA 12.1.

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41 232 The STROBE checklist was used in designing and reporting the study.

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43 233 The project was approved by the Regional Ethical Review Board of Stockholm.  
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**Results**

Of the 5 118 women included in the study, 77% had given birth at least once between 1994 and 2009 (Table 1). Of these women, nearly 70% also had given birth later, at least once. A majority of the women who gave birth had their first delivery before the age of 30 (61%). The educational level distribution was rather similar when comparing those who gave birth to those who did not. When hospitalizations with diagnoses for pregnancy and childbirth were excluded, 30% of the women, i.e., the 1 183 where both in a pair gave birth and the 407 twins where only one in the pair gave birth had at least one hospitalization during the period six years prior to and six years after their first delivery (the delivery year excluded). The corresponding rate for the women who had not given birth was 27%. Half of the women who gave birth had at least one day of SA during the period six years prior to or the six years after first delivery, when the year for childbirth was excluded. The majority of the women had no SA at all in the six years following childbirth.

The average annual number of days with inpatient care and SA, respectively, is presented in Figure 2. Up to year  $T_0$ , women who did not give birth had a higher average number of hospitalization days and SA days compared to those who gave birth. Women who gave birth had approximately 0.3 hospitalization days per year whereas those who did not give birth had around 0.5 hospitalization days per year. The average number of SA days for women giving birth was 3.8 days/year and for those not giving birth 5.0 days/year. SA differences between those giving birth and women not giving birth were statistically significant with the exception of year (-4) and (-3). For inpatient care, the differences between those giving birth and women not giving birth were not statistically significant. The average number of inpatient days increased rapidly during  $T_0$  for women who gave birth, especially because of hospitalization due to pregnancy and childbirth. After  $T_0$ , the number of SA days decreased quickly among these women. For women who gave birth, days with inpatient care and SA the years following  $T_0$  were to a large extent associated with subsequent childbirths.

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3 260 Table 2 presents HR for the association between childbirth and hospitalization, for all  
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5 261 diagnoses and for diagnoses where those related to pregnancy, childbirth, and the postpartum  
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7 262 period were excluded. When these diagnoses were removed, women who did not give birth  
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9 263 and who had been hospitalized at least once before  $T_0$  had twice the risk of future  
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11 264 hospitalization compared to those not hospitalized prior to  $T_0$  (HR: 2.3; 95% CI 1.6-3.3) after  
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13 265 adjustments for birth year, delivery year, and educational level. The association was explained  
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15 266 by familial factors in the analysis of discordant twin pairs (HR: 1.2; 0.8-1.9).

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17 267 When restricting the analyses to women who gave birth, a total of 2 792 women were  
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19 268 studied, i.e., 1 396 complete pairs in which both twins had given birth. The reference group  
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21 269 constituted of mothers who had not been hospitalized prior to their first childbirth. Mothers  
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23 270 who had been hospitalized before their first childbirth had a slightly higher HR for future  
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25 271 hospitalization when diagnoses related to pregnancy and childbirth were excluded (HR 1.5;  
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27 272 1.2-2.0). This association disappeared in the analyses of discordant twin pairs, suggesting an  
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29 273 influence of familial factors (HR: 1.0; 0.8-1.3).

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31 274 Regardless of childbirth status, hospitalization year 1-2 after  $T_0$  was a predictor of having a  
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33 275 new SA in year 3-5 after  $T_0$  (Table 3). Compared to women who did not give birth and who  
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35 276 were not hospitalized the first two years after  $T_0$ , mothers hospitalized after first childbirth  
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37 277 had an HR of 2.4 (2.0-2.9) for a new SA after adjustments for birth year, delivery year, and  
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39 278 educational level. Hospitalization after  $T_0$  was also associated with a new long-term SA (>90  
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41 279 days) in year 3-5 after  $T_0$  (Table 3). Women who did not give birth had a nearly three-fold  
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43 280 risk of a new long-term SA year 3-5 after  $T_0$  (HR 2.8; 1.5-5.1), whereas women who gave  
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45 281 birth had an HR of 1.8 (1.3-2.5). The analyses of twin pairs discordant for having a new long-  
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47 282 term SA year 3-5 after  $T_0$ , showed attenuated point estimates, hence suggesting that familial  
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49 283 effects may play a role.  
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3 284 The analyses, in which we considered hospitalization before and after first childbirth as  
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5 285 exposure, and outcome was a new SA year 3-5 after  $T_0$  (Table 4) show that mothers who had  
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7 286 been hospitalized at least once both before and after their first child birth had a higher risk of  
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9 287 future SA (HR 1.8; 1.4-2.2). These women also had a higher risk of long-term SA; however,  
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11 288 these risk estimates were not statistically significant. After controlling for familial  
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13 289 confounding, the estimated risk for long-term SA for those who had been hospitalized before  
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15 290  $T_0$  was in the same direction but the HR was reduced, which suggest that also familial factors  
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17 291 may have an influence on the studied association.  
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3 292 **Discussion**

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5 293 In this register study of a population-based Swedish cohort of female twins born between  
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7 294 1959 and 1990, the associations of delivery with hospitalization and SA were examined as  
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9 295 well as whether familial (i.e., genetic and shared, mainly childhood, environmental) factors  
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11 296 were contributing to these associations. Just before the first childbirth, the SA days increased  
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13 297 much for mothers, an increase that gradually decreased during the years after the delivery. We  
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15 298 found hospitalization prior to T<sub>0</sub> to be a risk factor for future hospitalization, regardless of  
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17 299 childbirth status, also when excluding hospitalization due to childbirth. Furthermore,  
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19 300 hospitalization after the first childbirth was associated with a higher HR of both short-term  
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21 301 and long-term future SA. An additional analysis focusing solely on the women who gave birth  
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23 302 showed that hospitalization both before and after the first childbirth was associated with a  
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25 303 higher risk of future SA. Familial factors seemed to have an influence on the association  
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27 304 between hospitalization and long-term SA, regardless of childbirth status.  
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32 305 In line with some previous studies<sup>10 20 48 49</sup>, we found that SA increased in women during  
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34 306 the time before the first childbirth. Giving birth was also associated with a future somewhat  
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36 307 higher risk for SA, in line with that of those not giving birth. However, this higher risk could  
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38 308 be due to subsequent pregnancies. A recent Norwegian study found that the increased SA risk  
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40 309 in women in the years after pregnancy disappeared when SA during subsequent pregnancies  
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42 310 were accounted for<sup>20</sup>. Several explanations have been suggested for such higher levels of SA,  
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44 311 among others the double burden hypothesis<sup>20 50-52</sup>. This hypothesis has been questioned, as  
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46 312 research has indeed shown that women who occupy multiple roles tend to be healthier than  
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48 313 those who enact fewer roles<sup>53-55</sup>. Thus, the combination of employment and parenthood does  
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50 314 not seem to imply worse health, on the contrary. In our study, the annual rates of SA  
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52 315 decreased steadily after the first childbirth, speaking in favor of this hypothesis. Further  
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54 316 studies of this are warranted.  
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3 317 To our best knowledge, this is the first study to examine long-term associations between  
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5 318 childbirth, hospitalization and both short- and long-term SA. Women who gave birth did not  
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7 319 have a higher risk for long-term SA nor for hospitalization (besides hospitalization due to  
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9 320 subsequent pregnancy and childbirth) when compared to women who did not give birth.

11 321 Those who did not give birth had a more stable pattern of SA during the studied period,  
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13 322 however, with a slight increase in annual SA days over the years. This is in line with a  
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15 323 Swedish study examining whether family obligations influence the risk of SA in publicly  
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17 324 employed women and found a slight risk increase for SA among women without children<sup>56</sup>.  
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19 325 Further, a broad systematic literature review published in 2004 provided no evidence of an  
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21 326 association between having children in the household and an increased risk of SA<sup>57</sup>. It is  
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23 327 important to consider family situation when examining the association between having  
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25 328 children and morbidity, as single women with children have been shown to have worse health  
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27 329<sup>30 31 58</sup> and higher levels of SA<sup>6 56</sup>.

31 330 Even though pregnancy, delivery, and the postpartum period may increase the risk for  
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33 331 disease and injury<sup>25 27</sup>, our findings do not suggest that women who gave birth are more  
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35 332 likely to be hospitalized after their first childbirth, except for hospitalizations related to  
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37 333 subsequent deliveries. We found no differences in risk for future hospitalization when  
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39 334 comparing those who gave birth to those who did not. Thus, giving birth does not have to be  
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41 335 associated with subsequent health problems. The fact that we found no differences in future  
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43 336 hospitalization between those who gave birth and those who did not, may have different  
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45 337 explanations. As mentioned above, one could expect that there is a health selection, where  
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47 338 women who do not give birth may have worse health and choose not to have or cannot have a  
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49 339 child. Also, giving birth is in itself a risk factor for future morbidity<sup>16 19 22</sup>. Further, during the  
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51 340 last decades, the number of women who voluntarily do not want to become parents has  
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53 341 increased worldwide<sup>59</sup>.



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3 342 Hospitalization prior to the first childbirth or equivalent ( $T_0$ ) was a risk factor for future SA  
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5 343 for all women, regardless of childbirth status. In particular, women who had been hospitalized  
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7 344 both before and after  $T_0$  were at risk for future SA. Furthermore, we found an association  
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9 345 between hospitalization and future long-term SA.

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11 346 When comparing women who gave birth to those who did not, with respect to exposure to  
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13 347 hospitalization and risk of SA, mothers hospitalized at least once after the first childbirth had  
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15 348 slightly higher risk for future SA regardless of duration, whereas those who did not give birth  
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17 349 hospitalized after  $T_0$  had higher risk for long-term SA.

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20 350 Hospitalization both before and after the year  $T_0$  seems to be the strongest indicator, i.e.,  
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22 351 these individuals had the highest risk for future SA. Consequently, the women who had been  
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24 352 hospitalized both before and after  $T_0$  had the highest risk for future SA. Our analyses of  
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26 353 women who gave birth revealed a graded association between hospitalization and SA, where  
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28 354 those who only were hospitalized before *or* after their first childbirth had a higher risk of SA,  
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30 355 whereas those who were hospitalized both before and after the first childbirth had even higher  
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32 356 risks. Thus, we found a strong association between morbidity, here measured as  
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34 357 hospitalization, and future SA among women who have given birth – an association that often  
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36 358 has been question regarding women with children <sup>12</sup>.

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39 359 Familial factors seemed to contribute to the association between hospitalization before and  
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41 360 after  $T_0$  among those who did not give birth. The influence of familial factors may relate to  
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43 361 morbidity among women not giving birth – morbidity that might be more severe and  
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45 362 potentially also being relatively strongly influenced by genetics. Familial factors also played a  
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47 363 role in the associations between hospitalization and future long-term SA. This could be  
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49 364 related to the fact that the hospitalization usually is required for severe conditions that may  
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51 365 have a strong genetic component. However, since genetics have been shown to influence the  
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53 366 risk of DP <sup>60</sup>, and some indications exist that genetics also play a role in long-term SA and  
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3 367 mortality, it can be suspected that the effects of familial factors on SA can be either direct or  
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5 368 through other influential factors.  
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### 8 9 10 **Strengths and limitations**

11 371 The strengths of this study are the population-based prospective cohort study design,  
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13 372 including all in the study population, not a sample, using nationwide registers with high  
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15 373 completeness and validity<sup>41-43</sup>. Further, we used a large study cohort without loss to follow  
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17 374 up. With a twin study design, we were able to take familial influences into account. When  
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19 375 measuring both exposure and outcome with register-based data, we avoid problem with recall  
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21 376 bias.  
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25 377 This study has, however, some limitations. First of all, we do not know whether the women  
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27 378 who did not give birth were childless voluntarily or not. Differences in health between  
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29 379 voluntary and involuntary childlessness have been shown, where voluntarily childless women  
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31 380 showed higher levels of overall well-being<sup>59 61</sup> which might be related to hospitalization  
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33 381 and/or SA. Using inpatient care as a measure of morbidity has both its strengths and  
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35 382 limitations. One limitation is that we thus selected more severe types of morbidity, and hence  
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37 383 that does not include morbidity treated in outpatient care. Having had also other types of  
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39 384 morbidity data might have given another picture and hopefully future studies will have such  
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41 385 information. Another limitation is that the terms for inpatient care have changed during the  
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43 386 studied period. In Sweden, inpatient care has over the years to a great extent been replaced by  
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45 387 outpatient treatment. Therefore, some of the decrease in hospitalization over the years is a  
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47 388 result of a shift in the responsibility for inpatient care from hospitals to outpatient care  
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49 389 facilities<sup>62</sup>, however, this affected all women equally, and is to some extent handled by  
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51 390 adjusting for birth year. The CIs are wider in the years far from T<sub>0</sub>, e.g., T<sub>6</sub>, due to fewer  
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53 391 follow up year for some – e.g., for those who gave birth late during the studied period. Also,  
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3 392 we lack information on the shorter SA spells among those employed. Further, the Swedish  
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5 393 Twin Registry (STR) contains all twin births in Sweden; hence, immigrants are not included  
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7 394 in this study and as a consequence the external validity might be lower to women born outside  
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9 395 of Sweden.

11 396 It is important to be aware of that giving birth is in focus here, irrespective of whether the  
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13 397 child survived or not. Some of the women who did not give birth might be mothers, e.g., due  
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15 398 to adoption. Other studies in this area has 'being mother' or 'living with child' as exposure  
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17 399 term, rather than 'giving birth'.  
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## 22 401 **Conclusion**

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24 402 Women giving birth did not have a higher future SA risk than those not giving birth and  
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26 403 results indicate a positive health selection into giving birth. Mothers with different types of  
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28 404 morbidity, in terms of hospitalization before and/or after giving birth had higher risks for  
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30 405 future SA. Most women had no SA in the six years following childbirth and those who had  
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32 406 SA generally had that for shorter periods. Among the few women who had severe morbidity,  
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34 407 in terms of hospitalization, the future risk for SA was, as expected, higher. Hospitalization  
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36 408 prior to  $T_0$  was strongly associated with later hospitalization and later SA. The high levels of  
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38 409 inpatient care in women who did not give birth suggest that there is a health selection in  
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40 410 giving birth, where the women who give birth have a better health initially. However, most  
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42 411 women had no hospitalization and no SA.  
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5 413 **Ethical approval**  
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7 414 The study was approved by the Regional Ethical Review Board, Stockholm, Sweden  
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9 415 (2007/524-31).  
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11 416

12 417 **Contributorship Statement**  
13

14 418 KA and PS originated the idea. EB analysed the data in consultation with KA, LK, JN, AR,  
15

16 419 and PS. EB wrote the first and subsequent drafts of the manuscript, with important intellectual  
17

18 420 input from all the co-authors. All authors contributed in designing the study and to the  
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20 421 interpretation of the results and to the writing and approval of the final article.  
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24 423 **Competing interest statement**  
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26 424 We declare that no competing interests exist.  
27

28 425  
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31

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33

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35

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40 431 Registry is supported by the Swedish Research Council, the Ministry for Higher Education,  
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42 432 and AstraZeneca. Funding sources had no involvement in this study.  
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46 434 **Data sharing**  
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48 435 No additional data available.  
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3 440 **Figure legends**

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5 441 Figure 1. Flow chart for the study population.

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7 442 Figure 2. Average annual number of days on sickness absence (SA) and hospitalization,  
8 443 respectively, (with 95% CI), six years prior through six year after T<sub>0</sub> for women who gave  
9 444 birth/did not give birth (n=5 118).

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Table 1. Cohort characteristics for twins (women with twin sister) born in Sweden 1959-1990 (excluding those who gave birth before age 16 and those who died before age 16), where at least one in the pair had their first childbirth 1994-2009 and none before 1994.  $T_0$  is defined as year for first childbirth for women who gave birth, and year of twin sister's childbirth for those who did not give birth.

Variables	Twin pairs where only one in the pair gave birth		Total
	Both gave birth	Twin 1 (gave birth)	
N	2 792	1 163	5 118
<b>Number of deliveries</b>			
One delivery	711 (25%)	501 (43%)	
Two or more deliveries	2 081 (75%)	662 (57%)	
<b>Age at <math>T_0</math></b>			
16-19 years	47 (2%)	33 (2%)	
20-24 years	511 (18%)	239 (21%)	
25-29 years	1 150 (41%)	444 (38%)	
30-34 years	847 (30%)	323 (28%)	
35-39 years	207 (7%)	109 (9%)	
>40 years	30 (1%)	15 (1%)	
<b>Zygoty</b>			
Monozygotic	1 726 (62%)	608 (52%)	2 942 (57%)
Dizygotic	1 066 (38%)	555 (48%)	2 176 (43%)
<b>Highest attained education<sup>1</sup></b>			
≤ 9 year	179 (6%)	74 (6%)	308 (6%)
10-12 year	1 434 (51%)	608 (52%)	2 663 (52%)
≥ 13 year	1 173 (42%)	474 (41%)	2 069 (40%)
Information on education missing	6 (0%)	7 (1%)	78 (2%)
<b>Hospitalization<sup>2</sup></b>			
- At least one hospitalization during the period six years prior through six years after $T_0$	2 161 (77%)	703 (60%)	3 189 (62%)
- At least one hospitalization during the period six years prior through six years after $T_0$ (excluding hospitalizations with a diagnosis for pregnancy, childbirth, and the puerperium)	865 (31%)	315 (27%)	1 494 (29%)
- At least one hospitalization during the period six years prior through six years after $T_0$ (excluding hospitalizations with a diagnosis for pregnancy, and childbirth)	1 183 (42%)	407 (35%)	1 915 (37%)
- At least one hospitalization during the period six years prior to $T_0$	679 (24%)	251 (22%)	1 147 (22%)
- At least one hospitalization during the period six years after $T_0$	1 965 (70%)	585 (50%)	2 718 (53%)
- At least one hospitalization both before and after $T_0$	483 (17%)	133 (11%)	676 (13%)
<b>Sickness Absence (SA)<sup>3</sup></b>			
At least one SA during the period six years prior through six years after $T_0$	1 526 (55%)	530 (46%)	2 420 (47%)
At least one SA during the period six years prior to $T_0$	690 (25%)	274 (24%)	1 188 (23%)
At least one SA during the period six years after $T_0$	1 245 (45%)	382 (33%)	1 848 (36%)

<sup>1</sup> At time of  $T_0$

<sup>2</sup> Excluding hospitalizations occurring during  $T_0$

<sup>3</sup> Excluding SA occurring during  $T_0$



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Table 2. Cox proportional hazard ratios (HR) with 95% CI for the association between childbirth, hospitalization before T<sub>0</sub>, and subsequent hospitalization (i.e., during year 3-5 after T<sub>0</sub>) in twins where at least one in the pair had her first childbirth in 1994-2009 and none before 1994, both including and excluding hospitalization related to pregnancy, childbirth, and the puerperium. Two models for adjustments as well as for discordant twin pairs.

Status childbirth and hospitalization	All diagnoses			Diagnoses related to pregnancy, childbirth and the puerperium excluded <sup>1</sup>		
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>3,7</sup>
<b>All women (n=5 118)</b>						
No childbirth, no hospitalization before T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization before T <sub>0</sub> <sup>8</sup>	2.5 (1.7-3.6)	2.3 (1.6-3.3)	2.4 (1.3-4.5)	2.7 (1.8-3.9)	2.3 (1.6-3.4)	1.2 (0.8-1.9)
Childbirth, no hospitalization before T <sub>0</sub> <sup>8</sup>	6.1(5.0-7.5)	5.5 (4.5-6.8)	8.3 (5.8-11.8)	1.1 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.7-1.1)
Childbirth, hospitalization before T <sub>0</sub> <sup>8</sup>	6.5 (5.2-8.1)	5.6 (4.4-7.1)	7.9 (5.4-11.5)	1.9 (1.4-2.5)	1.4 (1.1-1.9)	0.9 (0.7-1.2)
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>4,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>5,7</sup>
<b>Women who had at least one childbirth (n=2 792)</b>						
No hospitalization before T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before T <sub>0</sub> <sup>8</sup>	1.0 (0.9-1.2)	1.0 (0.9-1.1)	1.0 (0.8-1.2)	1.7 (1.3-2.3)	1.5 (1.2-2.0)	1.0 (0.8-1.3)

<sup>1</sup> Diagnoses O00-O99  
<sup>2</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=1 016 pairs)  
<sup>3</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=456 pairs)  
<sup>4</sup> Twin pairs (both giving birth) where one having had a hospitalization during the follow-up and the other not (n=508 pairs)  
<sup>5</sup> Twin pairs (both giving birth) with one had a hospitalization during the follow-up and the other not (n=271 pairs)  
<sup>6</sup> Adjusted for birth year  
<sup>7</sup> Model a, and additional adjustments for delivery year, and educational level  
<sup>8</sup> During the period 1-5 years prior to T<sub>0</sub>

Table 3. Cox proportional HR with 95% CI for the association between childbirth, hospitalization, and new sickness absence (SA) in year 3-5 after  $T_0$ , in twins where at least one in the pair had their first childbirth 1994-2009. Three models for adjustments as well as for discordant twin pairs.

Status childbirth and hospitalization	SA in year 3-5 after $T_0$ (regardless of number of days)				Long-term SA (>90 days) in year 3-5 after $T_0$			
	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>1,7</sup>	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>
<b>All women (n=5 118)</b>								
No childbirth, no hospitalization year 1-2 after $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization year 1-2 after $T_0$ <sup>8</sup>	2.7 (1.8-4.1)	2.2 (1.5-3.4)	2.1 (1.4-3.2)	1.5 (0.8-2.9)	4.5 (2.5-8.2)	3.5 (1.9-6.2)	2.8 (1.5-5.1)	1.1 (0.5-2.3)
Childbirth, no hospitalization year 1-2 after $T_0$ <sup>8</sup>	2.1 (1.8-2.5)	1.8 (1.5-2.2)	1.8 (1.5-2.2)	1.7 (1.3-2.2)	1.1 (0.8-1.6)	1.0 (0.7-1.4)	1.0 (0.7-1.3)	0.8 (0.6-1.2)
Childbirth, hospitalization year 1-2 after $T_0$ <sup>8</sup>	3.0 (2.5-3.6)	2.4 (2.0-2.9)	2.4 (2.0-2.9)	2.0 (1.5-2.6)	2.3 (1.6-3.2)	1.8 (1.3-2.5)	1.8 (1.3-2.5)	1.0 (0.7-1.5)
<b>Women who had at least one childbirth (n=2 792)</b>								
No hospitalization year 1-2 after $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization year 1-2 after $T_0$ <sup>8</sup>	1.3 (1.2-1.5)	1.3 (1.1-1.4)	1.2 (1.1-1.4)	1.2 (1.0-1.5)	2.0 (1.5-2.6)	1.9 (1.4-2.5)	1.8 (1.4-2.4)	1.4 (1.0-1.9)

<sup>1</sup> Twin pairs where one had a SA during the follow-up and the other not (n=835 pairs)

<sup>2</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=277 pairs)

<sup>3</sup> Twin pairs where one had a SA during the follow-up and the other not (n=542 pairs)

<sup>4</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=184 pairs)

<sup>5</sup> Adjusted for birth year

<sup>6</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>7</sup> Model b, and additional adjustments for earlier hospitalization

<sup>8</sup> Diagnoses O00-O99 excluded

Table 4. Cox proportional HR with 95% CI for the association between hospitalization before and after first childbirth, and new sickness absence (SA) in year 3-5 after  $T_0$ , in twins who had their first childbirth 1994-2009 (n=2 792). Three models for adjustments as well as for discordant twin pairs.

Status hospitalization before and after childbirth	SA in year 3-5 after $T_0$ (regardless of number of days)				Long-term SA (>90 days) in year 3-5 after $T_0$			
	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>1,4</sup>	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>2,4</sup>
No hospitalization either before $T_0$ <sup>6</sup> or during year 1-2 after $T_0$ <sup>7</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before $T_0$ <sup>6</sup> but not during year 1-2 after $T_0$ <sup>7</sup>	1.2 (1.0-1.5)	1.2 (1.0-1.4)	1.2 (1.0-1.4)	1.0 (0.8-1.3)	2.3 (1.6-3.4)	2.1 (1.5-3.1)	2.2 (1.5-3.1)	1.2 (0.8-1.7)
No hospitalization before $T_0$ <sup>6</sup> but during year 1-2 after $T_0$ <sup>7</sup>	1.2 (1.1-1.4)	1.2 (1.0-1.4)	1.1 (0.9-1.2)	1.1 (0.9-1.4)	2.0 (1.5-2.8)	1.9 (1.4-2.7)	1.9 (1.4-2.7)	1.4 (1.0-2.1)
Hospitalization before $T_0$ <sup>6</sup> and during year 1-2 after $T_0$ <sup>7</sup>	2.0 (1.6-2.5)	1.8 (1.4-2.2)	1.6 (1.3-2.1)	1.6 (1.1-2.2)	4.2 (2.7-6.4)	3.5 (2.3-5.3)	3.5 (2.3-5.4)	1.5 (0.9-2.4)

<sup>1</sup> Twin pairs where one had an SA during the follow-up and the other not (n=542)

<sup>2</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=184)

<sup>3</sup> Adjusted for birth year

<sup>4</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>5</sup> Model b, and additional adjustments for subsequent deliveries

<sup>6</sup> During the period 1-5 years prior to  $T_0$

<sup>7</sup> Diagnoses O00-O99 excluded

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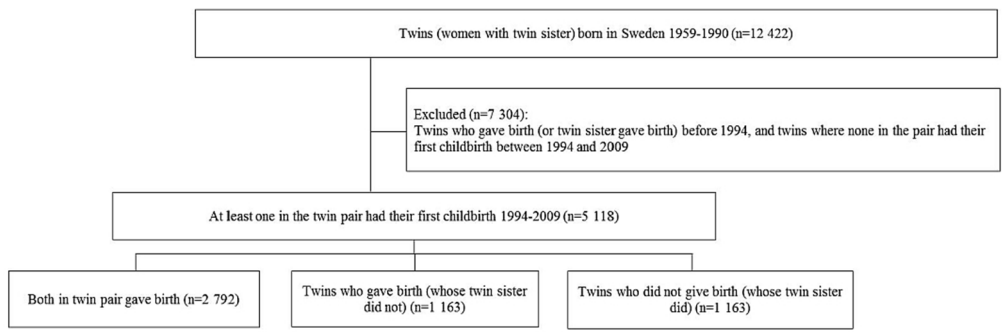


Figure 1  
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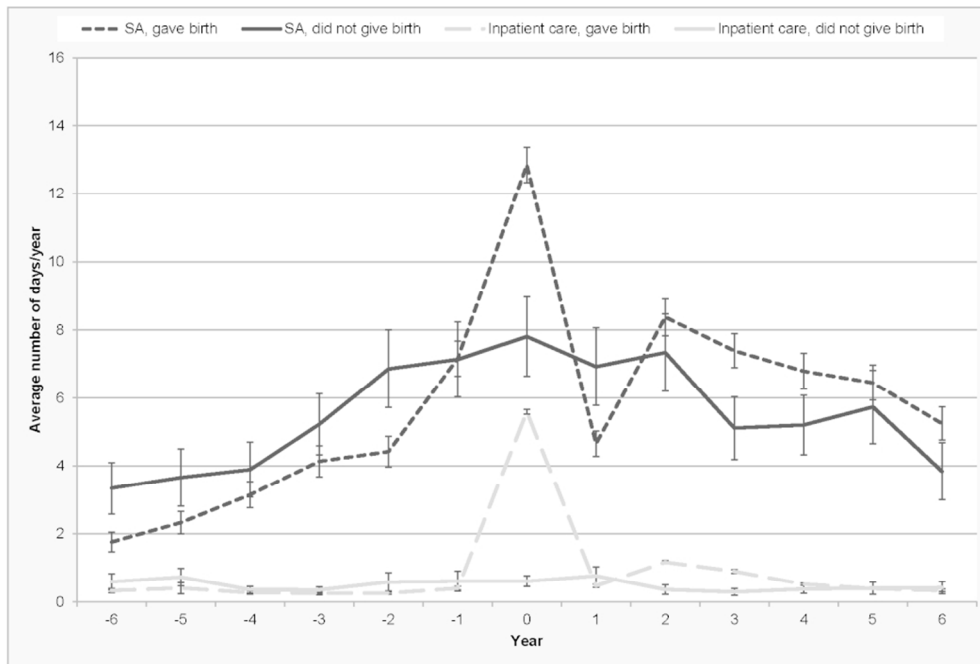


Figure 2  
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BMJ Open - Childbirth, hospitalization, and sickness absence: a study of female twins

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

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b>
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 2</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 4</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 6</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 7</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 7-10</b>
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 7-10</b>
		(b) For matched studies, give matching criteria and number of exposed and unexposed N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 8-9</b>
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 <b>Page 7-10</b>
Bias	9	Describe any efforts to address potential sources of bias N/A
Study size	10	Explain how the study size was arrived at <b>Page 7</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Page 8-9</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 9-10</b>
		(b) Describe any methods used to examine subgroups and interactions <b>Page 9-10</b>
		(c) Explain how missing data were addressed N/A
		(d) If applicable, explain how loss to follow-up was addressed

		N/A
		(e) Describe any sensitivity analyses
<b>Results</b>		
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>Page 7, and page 22</b>
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram <b>Page 22</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 23</b>
		(b) Indicate number of participants with missing data for each variable of interest N/A
		(c) Summarise follow-up time (eg, average and total amount) N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time <b>Page 23</b>
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>Page 24-25</b>
		(b) Report category boundaries when continuous variables were categorized <b>Page 23</b>
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 24-25</b>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <b>Page 2 and page 13</b>
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 <b>Page 16</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 13 – 15</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 13-16</b>
<b>Other information</b>		
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 <b>Page 18</b>

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\*Give information separately for exposed and unexposed groups.

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# BMJ Open

## Childbirth, hospitalization, and sickness absence: a study of female twins

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2014-006033.R2
Article Type:	Research
Date Submitted by the Author:	15-Dec-2014
Complete List of Authors:	Björkenstam, Emma; University of California Los Angeles, Alexanderson, Kristina; karolinska institutet, Department of Clinical Neuroscience Narusyte, Jurgita; Karolinska Institutet, Department of Clinical Neuroscience Kjeldgård, Linnea; Karolinska Institutet, Department of Clinical Neuroscience, Division of Insurance Medicine Ropponen, Annina; Finnish Institute of Occupational Health, Svedberg, Pia; Karolinska Institutet, Department of Clinical Neuroscience
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Obstetrics and gynaecology
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, childbirth, sick leave, childbirth, hospitalization

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3 1 **Childbirth, hospitalization, and sickness absence: a study of female twins**  
4 2

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3 **Abstract**

4 **Objective:** To investigate associations of giving birth with morbidity in terms of  
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6 hospitalization and social consequences of morbidity in terms of sickness absence (SA), while  
7  
8 taking familial (genetics and shared environmental) factors into account.  
9

10 **Design:** Prospective register-based cohort study. Estimates of risk of hospitalization and SA  
11  
12 were calculated as hazard ratios (HR) with 95% confidence intervals (CI).  
13

14 **Setting:** All female twins, i.e., women with twin sister, born in Sweden.  
15

16 **Participants:** 5118 Swedish female twins (women with twin sister), born 1959-1990, where  
17  
18 at least one in the twin pair had their first childbirth ( $T_0$ ) 1994-2009 and none gave birth  
19  
20 before 1994.  
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22

23 **Main outcome measures:** Hospitalization and SA during year 3-5 after first delivery or  
24  
25 equivalent.  
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28 **Results:** Preceding the first childbirth, the mean annual number of SA days increased for  
29  
30 mothers, and then decreased again. Hospitalization after  $T_0$  was associated with higher HRs of  
31  
32 short-term and long-term SA (HR for short-term SA: 3.0; 95% CI 2.5-3.6 and for long-term  
33  
34 SA: 2.3; 95% CI 1.6-3.2). Hospitalization both before and after first childbirth was associated  
35  
36 with a higher risk of future SA (HR for long-term SA: 4.2; 95% CI 2.7-6.4). Familial factors  
37  
38 influenced the association between hospitalization and long-term SA, regardless of childbirth  
39  
40 status.  
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43 **Conclusion:** Women giving birth did not have a higher risk for SA than those not giving birth  
44  
45 and results indicate a positive health selection into giving birth. Mothers hospitalized before  
46  
47 and/or after giving birth had higher risks for future SA, that is, there was a strong association  
48  
49 between morbidity and future SA.  
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52 **Keywords:** sick leave, childbirth, inpatient care, hospitalization, cohort study, population  
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54 based, twins  
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3 51 **Article Summary**

4 52 **Article focus:**

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6 53 To investigate associations of giving birth with morbidity in terms of hospitalization and  
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8 54 social consequences of morbidity in terms of sickness absence (SA), while taking familial  
9  
10 55 (genetics and shared environmental) factors into account.

11  
12  
13 56 **Key messages:**

- 14  
15 57 - Women giving birth did not have a higher future SA risk than those not giving birth  
16  
17 58 and results indicate a positive health selection into giving birth  
18  
19 59 - The high levels of inpatient care in women who did not give birth suggest that there is  
20  
21 60 a health selection in giving birth, where the women who give birth have a better health  
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23 61 initially

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26 62 **Strengths and limitations:**

- 27  
28 63 - The strengths of the study include the population-based prospective design, using  
29  
30 64 national registers with high completeness and validity  
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32 65 - With a twin study design, we were able to take familial influences into account  
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34 66 - As inpatient care to a great extent has been replaced by outpatient treatment, some of  
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36 67 the decrease in hospitalization over the years is a result of a shift in the responsibility  
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38 68 for inpatient care from hospitals to outpatient care facilities  
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## 71 Introduction

72 In most countries with high labor force participation, women have higher levels of sickness  
73 absence (SA) than men<sup>1-4</sup>. Many theories and mechanism regarding this have been suggested,  
74 e.g., women having higher morbidity, higher workload (when combining paid and unpaid  
75 work), tougher situation on the labor market, men being the norm for how the labor market is  
76 organized, gender bias in healthcare and social insurance systems, discrimination, and  
77 domestic violence, etcetera<sup>5-9</sup>. Another hypothesis behind this gender difference in SA  
78 focuses on SA during pregnancy and after childbirth<sup>6 10-13</sup>. Several studies show that women  
79 have higher SA during pregnancy<sup>10 14</sup> and that pregnancy-related SA explains half of the  
80 gender differences in SA in fertile ages<sup>15</sup>.

81 One of the changes in society that may affect health after childbirth is that the mean age for  
82 having the first child has increased over the last years and that women with higher level of  
83 morbidity now give birth. Further, nowadays, the proportion of caesarean sections has  
84 increased as well as vacuum extraction deliveries, leading to risk of later health problems<sup>16 17</sup>.

85 In this study, focus is on childbirth, morbidity, and SA among women, to get a better  
86 understanding of mechanisms behind SA among women in fertile ages. There are hardly any  
87 studies on the associations between giving birth and morbidity and SA, and those conducted  
88 have focused on a relatively short time period right after childbirth, most often within the first  
89 year following the child delivery<sup>18 19</sup>, while prospective studies with longer follow-up of  
90 mothers are rare<sup>6 12 20</sup>.

91 Pregnancy, delivery, and the postpartum period may imply large physical, mental, and  
92 social changes during a short period of time, increasing the risk for disease and injury<sup>21 22</sup>.  
93 Different types of physical and mental disorders are common during pregnancy and after  
94 childbirth – and can in some cases be longstanding or even permanent – however, this is  
95 hardly studied at all<sup>19</sup>. Giving birth may be associated with a higher risk of certain diseases  
96 demanding hospitalization, such as cardiovascular diseases, musculoskeletal diseases, mental

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3 97 disorders, and different types of injuries<sup>23-26</sup>. For women with a disease present before the  
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5 98 childbirth, the disorder might deteriorate after childbirth<sup>23 24</sup>. Regarding symptoms related to  
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7 99 childbirth, high prevalence has been shown six months after childbirth for e.g., low back pain,  
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10 100 fatigue, headache, and sleep disorders<sup>19 27</sup>. Most of these symptoms seem to remain up to one  
11  
12 101 year after childbirth<sup>17</sup>. Besides physical health effects, also depression and other mental  
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14 102 disorders have been linked to childbirth<sup>26 28</sup>, but again, prospective studies with longer  
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16 103 follow-up are lacking<sup>27</sup>. Even though having children has been shown to contribute to an  
17  
18 104 overall wellbeing, this is not the case for everybody and especially not among single mothers  
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20 105 whose economic situation and thereby possibilities for good health care might be worse<sup>29-31</sup>.

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23 106 Morbidity can be measured in different ways, e.g., through self-reports or visits to  
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25 107 healthcare. Here we will use data on more severe morbidity that involves assessments from  
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27 108 physicians, that is, morbidity that has led to hospitalization, a measure so far not used in this  
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29 109 type of studies. Sickness absence is not a good measure of morbidity—most people with  
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31 110 morbidity are not on SA<sup>4</sup>. Instead SA is considered a very good measure of social  
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33 111 consequences of morbidity, in terms of not being able to support yourself from work<sup>4</sup>. Yet,  
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35 112 there are surprisingly few studies on the association between morbidity and SA and in media  
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37 113 and among some researchers sometimes the level of morbidity among sickness absentees even  
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39 114 is questioned, especially for female sickness absentees – their sickness absence is rather  
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43 115 considered related to attitudes than to morbidity<sup>12 32 33</sup>.

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45 116 Studies examining the role of familial factors (i.e., genetic and shared (mainly childhood)  
46  
47 117 environment) on morbidity have shown that genetics tends to explain a moderate to large  
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49 118 extent of the variability in most of the chronic diseases<sup>34 35</sup>. For example, heritability for  
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51 119 mental disorders varies between 30-90%<sup>36</sup>, whereas genetic factors have been shown to  
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53 120 explain 30-60% of the total variation in musculoskeletal disorders<sup>37 38</sup>. Taken together,  
54  
55 121 familial factors are important to account for when studying the association between morbidity  
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3 122 (here in terms of hospitalization) and SA as studies otherwise could lead to erroneous  
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5 123 conclusions. Twin settings provide a powerful tool for studies of these aspects in research of  
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7 124 SA, a research area where different selection biases otherwise might have an impact on  
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9 125 results. Twins in a pair are optimally matched on genetic (100% for MZ pairs and on average  
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11 126 50% for DZ pairs) and common environmental factors through childhood (100% for both MZ  
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14 127 and DZ twin pairs when reared together) in addition to age and sex (for the same-sexed pairs).  
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16 128 An experimental design, which can control for these familial influences, is to examine  
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18 129 discordant twin sisters, that is, where one twin sister has given birth and the other has not. If  
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21 130 discordant twin sisters show similar associations as the analyses of the whole cohort, this  
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23 131 would indicate that the childbirth may actually be a contributing cause of the future SA. If  
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25 132 instead the association found among the whole cohort cannot be replicated within discordant  
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27 133 twin sisters, then familial factors are of importance. Influence of familial factors (genetic and  
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29 134 common environment) is indicated if the association found in the analyses of the whole cohort  
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31 135 disappear or change considerably in the analyses of discordant twin pairs<sup>39</sup>.

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36 137 The aim of the study was to investigate the associations of giving birth with subsequent  
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38 138 morbidity in terms of hospitalization and SA. Familial factors (genetics and shared/early  
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40 139 environmental) were taken into account in order to assess if familial factors explain a  
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42 140 potential association between childbirth and future hospitalization and SA.  
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## 142 **Methods**

### 143 **Participants and data sources**

144 We performed a prospective population-based cohort study of female twins. All female twins,  
145 i.e., women with a twin sister, born in Sweden between 1959 and 1990 were selected from the  
146 Swedish Twin Registry (STR)<sup>40</sup>. After excluding women who delivered their first child  
147 before 1994 or whose twin sister had her first delivery before 1994, and twins where none in  
148 the pair had their first delivery between 1994 and 2009 (n=7 304), the final cohort comprised  
149 5 118 women of which 95% had income from work, the others had income from parental  
150 benefits, unemployment benefits, student benefits, different types of sickness benefits, or a  
151 mixture of those (in the year prior to the birth year, i.e., T(-1). All had some of those types of  
152 income, all granting rights to SA benefits. The Swedish Twin Registry (STR) is the largest  
153 population-based register of twin births in the world, with information such as birth date, sex,  
154 zygosity, and pair identification<sup>40 41</sup>. The selection of the study population is illustrated in  
155 Figure 1.

156 The unique personal identity number assigned to each Swedish resident<sup>42</sup> was used to link  
157 information from several nationwide population-based registers at an individual level up  
158 through 2009, as follows. The Causes of Death Register was used to obtain information on  
159 date of death<sup>43</sup>. This register contains information on all deceased Swedish residents since  
160 1952. Information on all deliveries (including still births) was derived from the Medical Birth  
161 Register, which was established in 1973 and includes information on almost all births in  
162 Sweden<sup>44</sup>. In order to increase the coverage on delivery, we also used the National Patient  
163 Register (NPR) to obtain information on all deliveries. This register was founded in 1964 and  
164 includes all individuals admitted to any psychiatric or general hospital<sup>45</sup>. Information on  
165 hospitalization with a principal diagnosis for delivery (as defined by the International  
166 Classification of Disease (ICD): ICD-9: 650, 651.9, 652.2, 669.5-8; and ICD-10: O80-84) was  
167 obtained. The NPR was also used to obtain annual information on other hospitalizations, i.e.,



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3 168 inpatient care. Annual information on educational level and on SA days was obtained from  
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5 169 Statistics Sweden.

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10 171 **Time in relation to childbirth**

11 172 The studied women were followed in relation to year of first childbirth, referred to as  $T_0$ . In  
12  
13 173 order to compare those who gave birth to those who did not,  $T_0$  for the women who did not  
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15 174 give birth was defined as year of her twin sister's first childbirth.

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21 176 **Hospitalization**

22 177 Data on hospitalization covered the period six years prior to, and six years after year of first  
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24 178 childbirth ( $T_0$ ) or equivalent. For descriptive purposes, the total and the average number of  
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26 179 hospitalization days per year were calculated.

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29 180 In order to examine if hospitalization prior to (or after) childbirth increases the risk for future  
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31 181 hospitalization, the first part of the regression analyses considered hospitalization as both  
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33 182 exposure and outcome. We created one dichotomous variable for hospitalization before  $T_0$   
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35 183 (i.e., exposure), and two dichotomous outcome variables for hospitalization during year 3-5  
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37 184 after  $T_0$ : one for hospitalization with any diagnosis and one excluding hospitalization with  
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39 185 diagnoses related to pregnancy, childbirth, and the postpartum period.

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42 186 In order to answer the research question "Does hospitalization prior to (or after) childbirth  
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44 187 increase the risk for future SA?", we created two dichotomous hospitalization exposure  
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46 188 variables: one for hospitalization before  $T_0$  and one variable: hospitalization year 1-2 after  $T_0$   
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48 189 (excluding diagnoses related to pregnancy, childbirth, and the postpartum period).

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54 191 **Sickness absence**

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3 192 SA can be measured in several ways, related to duration and incidence<sup>46</sup>. Here we used the  
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5 193 following four measures: total and average number of SA days per year; number of SA days  
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7 194 during year 3-5 after T<sub>0</sub>; and number of SA days >90 sick-leave days during year 3-5 after  
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9 195 T<sub>0</sub>.

### 196 **Sickness insurance in Sweden**

197 In Sweden, all residents aged 16-65 years who have income from work, unemployment  
198 benefits, parental benefits, or student benefits are entitled to sickness benefits from the  
199 Swedish Social Insurance Agency, if unable to work due to disease or injury. Among  
200 employed individuals, sick pay was in most cases paid by the employer during the first 14  
201 days of a sick-leave spell, which means that we do not have data on most of the short sick-  
202 leave spells. In most of the years studied, there was no limitation to duration of a sick-leave  
203 spell. Sickness benefits covered 80% of lost income, up to a certain level. All were covered by  
204 a health care insurance covering the right to hospital care when needed, at a much reduced  
205 cost, less than 10 Euros a day. Care during pregnancy and delivery was free.

### 207 **Potential confounding factor**

208 As research has shown socioeconomic disparities in age at first birth (e.g., the higher the  
209 education, the later the first birth)<sup>47 48</sup>, we adjusted for educational level at T<sub>0</sub>. Years of  
210 education was classified into four categories; <9 years of compulsory school, 10-12 years of  
211 education (senior high school), ≥13 years of education (college/university), missing.

### 213 **Statistical analysis**

214 First, Cox proportional hazard models with constant time-at-risk<sup>49</sup> were applied to estimate  
215 hazard ratios (HR) with 95% confidence intervals (CI) for having at least one hospitalization  
216 after childbirth (T<sub>0</sub>). In a first model (model a), adjustments were made for age. Second

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3 217 (model b), additional adjustments were made for delivery year and educational level at time of  
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5 218  $T_0$ . Thereafter, twin pairs who were discordant with respect to outcomes, i.e., having at least  
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7 219 one hospitalization after  $T_0$ , were analyzed using Conditional Cox regression. In the next step,  
8  
9 220 we analyzed the associations between childbirth, hospitalization, and SA by fitting three Cox  
10  
11 221 regression models (table 3). The first (model a) was adjusted for birth year. In the second  
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13 222 model (model b), additional adjustments were made for delivery year and educational level at  
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15 223 time of  $T_0$ . In the third model (model c), previous hospitalization was included. Thereafter,  
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17 224 twin pairs who were discordant (Conditional Cox regression) with respect to outcomes i.e.,  
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19 225 having had SA or long-term SA (>90 days) were analyzed.  
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23 226 Finally, in the step where we analyzed the association between hospitalization before and  
24  
25 227 after first childbirth, and subsequent SA (table 4), we adopted the first two models (model a-  
26  
27 228 b) from table 3. In a third model (model c), we fitted an additional model in which  
28  
29 229 adjustments were made for subsequent deliveries.  
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32 230 The proportional hazards assumption was checked by including time-dependent versions of  
33  
34 231 all the covariates in the models. This did not indicate a violation of the proportionality  
35  
36 232 assumption.  
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38 233 All statistical analyses were performed with SAS 9.3 and STATA 12.1.  
39

40 234 The STROBE checklist was used in designing and reporting the study.  
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42 235 The project was approved by the Regional Ethical Review Board of Stockholm.  
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**Results**

Of the 5 118 women included in the study, 77% had given birth at least once between 1994 and 2009 (Table 1). Of these women, nearly 70% also had given birth later, at least once. A majority of the women who gave birth had their first delivery before the age of 30 (61%). The educational level distribution was rather similar when comparing those who gave birth to those who did not. When hospitalizations with diagnoses for pregnancy and childbirth were excluded, 30% of the women, i.e., the 1 183 where both in a pair gave birth and the 407 twins where only one in the pair gave birth had at least one hospitalization during the period six years prior to and six years after their first delivery (the delivery year excluded). The corresponding rate for the women who had not given birth was 27%. Half of the women who gave birth had at least one day of SA during the period six years prior to or the six years after first delivery, when the year for childbirth was excluded. The majority of the women had no SA at all in the six years following childbirth.

The average annual number of days with inpatient care and SA, respectively, is presented in Figure 2. Up to year  $T_0$ , women who did not give birth had a higher average number of hospitalization days and SA days compared to those who gave birth. Women who gave birth had approximately 0.3 hospitalization days per year whereas those who did not give birth had around 0.5 hospitalization days per year. The average number of SA days for women giving birth was 3.8 days/year and for those not giving birth 5.0 days/year. SA differences between those giving birth and women not giving birth were statistically significant with the exception of year (-4) and (-3). For inpatient care, the differences between those giving birth and women not giving birth were not statistically significant. The average number of inpatient days increased rapidly during  $T_0$  for women who gave birth, especially because of hospitalization due to pregnancy and childbirth. After  $T_0$ , the number of SA days decreased quickly among these women. For women who gave birth, days with inpatient care and SA the years following  $T_0$  were to a large extent associated with subsequent childbirths.

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3 262 Table 2 presents HR for the association between childbirth and hospitalization, for all  
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5 263 diagnoses and for diagnoses where those related to pregnancy, childbirth, and the postpartum  
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7 264 period were excluded. When these diagnoses were removed, women who did not give birth  
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9 265 and who had been hospitalized at least once before  $T_0$  had twice the risk of future  
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11 266 hospitalization compared to those not hospitalized prior to  $T_0$  (HR: 2.3; 95% CI 1.6-3.3) after  
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13 267 adjustments for birth year, delivery year, and educational level. The association was explained  
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15 268 by familial factors in the analysis of discordant twin pairs (HR: 1.2; 0.8-1.9).

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17 269 When restricting the analyses to women who gave birth, a total of 2 792 women were  
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19 270 studied, i.e., 1 396 complete pairs in which both twins had given birth. The reference group  
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21 271 constituted of mothers who had not been hospitalized prior to their first childbirth. Mothers  
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23 272 who had been hospitalized before their first childbirth had a slightly higher HR for future  
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25 273 hospitalization when diagnoses related to pregnancy and childbirth were excluded (HR 1.5;  
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27 274 1.2-2.0). This association disappeared in the analyses of discordant twin pairs, suggesting an  
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29 275 influence of familial factors (HR: 1.0; 0.8-1.3).

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31 276 Regardless of childbirth status, hospitalization year 1-2 after  $T_0$  was a predictor of having a  
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33 277 new SA in year 3-5 after  $T_0$  (Table 3). Compared to women who did not give birth and who  
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35 278 were not hospitalized the first two years after  $T_0$ , mothers hospitalized after first childbirth  
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37 279 had an HR of 2.4 (2.0-2.9) for a new SA after adjustments for birth year, delivery year, and  
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39 280 educational level. Hospitalization after  $T_0$  was also associated with a new long-term SA (>90  
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41 281 days) in year 3-5 after  $T_0$  (Table 3). Women who did not give birth had a nearly three-fold  
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43 282 risk of a new long-term SA year 3-5 after  $T_0$  (HR 2.8; 1.5-5.1), whereas women who gave  
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45 283 birth had an HR of 1.8 (1.3-2.5). The analyses of twin pairs discordant for having a new long-  
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47 284 term SA year 3-5 after  $T_0$ , showed attenuated point estimates, hence suggesting that familial  
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49 285 effects may play a role.  
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3 286 The analyses, in which we considered hospitalization before and after first childbirth as  
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5 287 exposure, and outcome was a new SA year 3-5 after  $T_0$  (Table 4) show that mothers who had  
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7 288 been hospitalized at least once both before and after their first child birth had a higher risk of  
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9 289 future SA (HR 1.8; 1.4-2.2). These women also had a higher risk of long-term SA; however,  
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11 290 these risk estimates were not statistically significant. After controlling for familial  
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13 291 confounding, the estimated risk for long-term SA for those who had been hospitalized before  
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15 292  $T_0$  was in the same direction but the HR was reduced, which suggest that also familial factors  
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17 293 may have an influence on the studied association.  
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3 294 **Discussion**

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5 295 In this register study of a population-based Swedish cohort of female twins born between  
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7 296 1959 and 1990, the associations of delivery with hospitalization and SA were examined as  
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9 297 well as whether familial (i.e., genetic and shared, mainly childhood, environmental) factors  
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11 298 were contributing to these associations. Just before the first childbirth, the SA days increased  
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13 299 much for mothers, an increase that gradually decreased during the years after the delivery. We  
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15 300 found hospitalization prior to T<sub>0</sub> to be a risk factor for future hospitalization, regardless of  
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17 301 childbirth status, also when excluding hospitalization due to childbirth. Furthermore,  
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19 302 hospitalization after the first childbirth was associated with a higher HR of both short-term  
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21 303 and long-term future SA. An additional analysis focusing solely on the women who gave birth  
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23 304 showed that hospitalization both before and after the first childbirth was associated with a  
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25 305 higher risk of future SA. Familial factors seemed to have an influence on the association  
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27 306 between hospitalization and long-term SA, regardless of childbirth status.

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29 307 In line with some previous studies<sup>10 20 50 51</sup>, we found that SA increased in women during  
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31 308 the time before the first childbirth. Giving birth was also associated with a future somewhat  
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33 309 higher risk for SA, in line with that of those not giving birth. However, this higher risk could  
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35 310 be due to subsequent pregnancies. A recent Norwegian study found that the increased SA risk  
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37 311 in women in the years after pregnancy disappeared when SA during subsequent pregnancies  
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39 312 were accounted for<sup>20</sup>. Several explanations have been suggested for such higher levels of SA,  
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41 313 among others the double burden hypothesis<sup>20 52-54</sup>. This hypothesis has been questioned, as  
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43 314 research has indeed shown that women who occupy multiple roles tend to be healthier than  
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45 315 those who enact fewer roles<sup>55-57</sup>. Thus, the combination of employment and parenthood does  
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47 316 not seem to imply worse health, on the contrary. In our study, the annual rates of SA  
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49 317 decreased steadily after the first childbirth, speaking in favor of this hypothesis. Further  
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51 318 studies of this are warranted.

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3 319 To our best knowledge, this is the first study to examine long-term associations between  
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5 320 childbirth, hospitalization and both short- and long-term SA. Women who gave birth did not  
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7 321 have a higher risk for long-term SA nor for hospitalization (besides hospitalization due to  
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9 322 subsequent pregnancy and childbirth) when compared to women who did not give birth.

11 323 Those who did not give birth had a more stable pattern of SA during the studied period,  
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13 324 however, with a slight increase in annual SA days over the years. This is in line with a  
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15 325 Swedish study examining whether family obligations influence the risk of SA in publicly  
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17 326 employed women and found a slight risk increase for SA among women without children<sup>58</sup>.  
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19 327 Further, a broad systematic literature review published in 2004 provided no evidence of an  
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21 328 association between having children in the household and an increased risk of SA<sup>59</sup>. It is  
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23 329 important to consider family situation when examining the association between having  
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25 330 children and morbidity, as single women with children have been shown to have worse health  
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27 331<sup>30 31 60</sup> and higher levels of SA<sup>6 58</sup>.

31 332 Even though pregnancy, delivery, and the postpartum period may increase the risk for  
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33 333 disease and injury<sup>25 27</sup>, our findings do not suggest that women who gave birth are more  
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35 334 likely to be hospitalized after their first childbirth, except for hospitalizations related to  
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37 335 subsequent deliveries. We found no differences in risk for future hospitalization when  
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39 336 comparing those who gave birth to those who did not. Thus, giving birth does not have to be  
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41 337 associated with subsequent health problems. The fact that we found no differences in future  
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43 338 hospitalization between those who gave birth and those who did not, may have different  
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45 339 explanations. As mentioned above, one could expect that there is a health selection, where  
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47 340 women who do not give birth may have worse health and choose not to have or cannot have a  
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49 341 child. Also, giving birth is in itself a risk factor for future morbidity<sup>16 19 22</sup>. Further, during the  
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51 342 last decades, the number of women who voluntarily do not want to become parents has  
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53 343 increased worldwide<sup>61</sup>.



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3 344 Hospitalization prior to the first childbirth or equivalent ( $T_0$ ) was a risk factor for future SA  
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5 345 for all women, regardless of childbirth status. In particular, women who had been hospitalized  
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7 346 both before and after  $T_0$  were at risk for future SA. Furthermore, we found an association  
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9 347 between hospitalization and future long-term SA.

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11 348 When comparing women who gave birth to those who did not, with respect to exposure to  
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13 349 hospitalization and risk of SA, mothers hospitalized at least once after the first childbirth had  
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15 350 slightly higher risk for future SA regardless of duration, whereas those who did not give birth  
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17 351 hospitalized after  $T_0$  had higher risk for long-term SA.

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20 352 Hospitalization both before and after the year  $T_0$  seems to be the strongest indicator, i.e.,  
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22 353 these individuals had the highest risk for future SA. Consequently, the women who had been  
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24 354 hospitalized both before and after  $T_0$  had the highest risk for future SA. Our analyses of  
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26 355 women who gave birth revealed a graded association between hospitalization and SA, where  
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28 356 those who only were hospitalized before *or* after their first childbirth had a higher risk of SA,  
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30 357 whereas those who were hospitalized both before and after the first childbirth had even higher  
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32 358 risks. Thus, we found a strong association between morbidity, here measured as  
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34 359 hospitalization, and future SA among women who have given birth – an association that often  
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36 360 has been question regarding women with children <sup>12</sup>.

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39 361 Familial factors seemed to contribute to the association between hospitalization before and  
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41 362 after  $T_0$  among those who did not give birth. The influence of familial factors may relate to  
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43 363 morbidity among women not giving birth – morbidity that might be more severe and  
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45 364 potentially also being relatively strongly influenced by genetics. Familial factors also played a  
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47 365 role in the associations between hospitalization and future long-term SA. This could be  
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49 366 related to the fact that the hospitalization usually is required for severe conditions that may  
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51 367 have a strong genetic component. However, since genetics have been shown to influence the  
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53 368 risk of DP <sup>62</sup>, and some indications exist that genetics also play a role in long-term SA and  
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3 369 mortality, it can be suspected that the effects of familial factors on SA can be either direct or  
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5 370 through other influential factors.  
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### 8 9 372 **Strengths and limitations**

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11 373 The strengths of this study are the population-based prospective cohort study design,  
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13 374 including all in the study population, not a sample, using nationwide registers with high  
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15 375 completeness and validity<sup>43-45</sup>. Further, we used a large study cohort without loss to follow  
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17 376 up. With a twin study design, we were able to take familial influences into account. When  
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19 377 measuring both exposure and outcome with register-based data, we avoid problem with recall  
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21 378 bias.  
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25 379 This study has, however, some limitations. First of all, we do not know whether the women  
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27 380 who did not give birth were childless voluntarily or not. Differences in health between  
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29 381 voluntary and involuntary childlessness have been shown, where voluntarily childless women  
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31 382 showed higher levels of overall well-being<sup>61 63</sup> which might be related to hospitalization  
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33 383 and/or SA. Using inpatient care as a measure of morbidity has both its strengths and  
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35 384 limitations. One limitation is that we thus selected more severe types of morbidity, and hence  
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37 385 that does not include morbidity treated in outpatient care. Having had also other types of  
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39 386 morbidity data might have given another picture and hopefully future studies will have such  
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41 387 information. Another limitation is that the terms for inpatient care have changed during the  
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43 388 studied period. In Sweden, inpatient care has over the years to a great extent been replaced by  
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45 389 outpatient treatment. Therefore, some of the decrease in hospitalization over the years is a  
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47 390 result of a shift in the responsibility for inpatient care from hospitals to outpatient care  
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49 391 facilities<sup>64</sup>, however, this affected all women equally, and is to some extent handled by  
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51 392 adjusting for birth year. The CIs are wider in the years far from T<sub>0</sub>, e.g., T<sub>6</sub>, due to fewer  
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53 393 follow up year for some – e.g., for those who gave birth late during the studied period. Also,  
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3 394 we lack information on the shorter SA spells among those employed. Further, the Swedish  
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5 395 Twin Registry (STR) contains all twin births in Sweden; hence, immigrants are not included  
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7 396 in this study and as a consequence the external validity might be lower to women born outside  
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9 397 of Sweden.

11 398 It is important to be aware of that giving birth is in focus here, irrespective of whether the  
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13 399 child survived or not. Some of the women who did not give birth might be mothers, e.g., due  
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15 400 to adoption. Other studies in this area has 'being mother' or 'living with child' as exposure  
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17 401 term, rather than 'giving birth'.  
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### 22 403 **Conclusion**

24 404 Women giving birth did not have a higher future SA risk than those not giving birth and  
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26 405 results indicate a positive health selection into giving birth. Mothers with different types of  
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28 406 morbidity, in terms of hospitalization before and/or after giving birth had higher risks for  
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30 407 future SA. Most women had no SA in the six years following childbirth and those who had  
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32 408 SA generally had that for shorter periods. Among the few women who had severe morbidity,  
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34 409 in terms of hospitalization, the future risk for SA was, as expected, higher. Hospitalization  
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36 410 prior to  $T_0$  was strongly associated with later hospitalization and later SA. The high levels of  
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38 411 inpatient care in women who did not give birth suggest that there is a health selection in  
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40 412 giving birth, where the women who give birth have a better health initially. However, most  
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42 413 women had no hospitalization and no SA.  
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5 **415 Ethical approval**6  
7 416 The study was approved by the Regional Ethical Review Board, Stockholm, Sweden8  
9 417 (2007/524-31).10  
11 41812  
13 **419 Contributorship Statement**14  
15 420 KA and PS originated the idea. EB analysed the data in consultation with KA, LK, JN, AR,16  
17 421 and PS. EB wrote the first and subsequent drafts of the manuscript, with important intellectual18  
19 422 input from all the co-authors. All authors contributed in designing the study and to the20  
21 423 interpretation of the results and to the writing and approval of the final article.22  
23 42424  
25 **425 Competing interest statement**26  
27 426 We declare that no competing interests exist.28  
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41 433 Registry is supported by the Swedish Research Council, the Ministry for Higher Education,42  
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45 43546  
47 **436 Data sharing**48  
49 437 No additional data available.50  
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442 **Figure legends**

443 Figure 1. Flow chart for the study population.

444 Figure 2. Average annual number of days on sickness absence (SA) and hospitalization,  
 445 respectively, (with 95% CI), six years prior through six year after T<sub>0</sub> for women who gave  
 446 birth/did not give birth (n=5 118).

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Table 1. Cohort characteristics for twins (women with twin sister) born in Sweden 1959-1990 (excluding those who gave birth before age 16 and those who died before age 16), where at least one in the pair had their first childbirth 1994-2009 and none before 1994.  $T_0$  is defined as year for first childbirth for women who gave birth, and year of twin sister's childbirth for those who did not give birth.

Variables	Both gave birth		Twin pairs where only one in the pair gave birth		Total
	birth	Twin 1 (gave birth)	Twin 2 (did not give birth)		
N	2 792	1 163	1 163	5 118	
<b>Number of deliveries</b>					
One delivery	711 (25%)	501 (43%)			
Two or more deliveries	2 081 (75%)	662 (57%)			
<b>Age at <math>T_0</math></b>					
16-19 years	47 (2%)	33 (2%)			
20-24 years	511 (18%)	239 (21%)			
25-29 years	1 150 (41%)	444 (38%)			
30-34 years	847 (30%)	323 (28%)			
35-39 years	207 (7%)	109 (9%)			
>40 years	30 (1%)	15 (1%)			
<b>Zygoty</b>					
Monozygotic	1 726 (62%)	608 (52%)	608 (52%)	2 942 (57%)	
Dizygotic	1 066 (38%)	555 (48%)	555 (48%)	2 176 (43%)	
<b>Highest attained education<sup>1</sup></b>					
≤ 9 year	179 (6%)	74 (6%)	55 (5%)	308 (6%)	
10-12 year	1 434 (51%)	608 (52%)	621 (53%)	2 663 (52%)	
≥ 13 year	1 173 (42%)	474 (41%)	422 (36%)	2 069 (40%)	
Information on education missing	6 (0%)	7 (1%)	65 (6%)	78 (2%)	
<b>Hospitalization<sup>2</sup></b>					
- At least one hospitalization during the period six years prior through six years after $T_0$	2 161 (77%)	703 (60%)	325 (28%)	3 189 (62%)	
-At least one hospitalization during the period six years prior through six years after $T_0$ (excluding hospitalizations with a diagnosis for pregnancy, childbirth, and the puerperium)	865 (31%)	315 (27%)	314 (27%)	1 494 (29%)	
- At least one hospitalization during the period six years prior through six years after $T_0$ (excluding hospitalizations with a diagnosis for pregnancy, and childbirth)	1 183 (42%)	407 (35%)	325 (28%)	1 915 (37%)	
- At least one hospitalization during the period six years prior to $T_0$	679 (24%)	251 (22%)	217 (19%)	1 147 (22%)	
- At least one hospitalization during the period six years after $T_0$	1 965 (70%)	585 (50%)	168 (14%)	2 718 (53%)	
- At least one hospitalization both before and after $T_0$	483 (17%)	133 (11%)	60 (5%)	676 (13%)	
<b>Sickness Absence (SA)<sup>3</sup></b>					
At least one SA during the period six years prior through six years after $T_0$	1 526 (55%)	530 (46%)	365 (31%)	2 420 (47%)	
At least one SA during the period six years prior to $T_0$	690 (25%)	274 (24%)	224 (19%)	1 188 (23%)	
At least one SA during the period six years after $T_0$	1 245 (45%)	382 (33%)	221 (19%)	1 848 (36%)	

<sup>1</sup> At time of  $T_0$

<sup>2</sup> Excluding hospitalizations occurring during  $T_0$

<sup>3</sup> Excluding SA occurring during  $T_0$



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Table 2. Cox proportional hazard ratios (HR) with 95% CI for the association between childbirth, hospitalization before T<sub>0</sub>, and subsequent hospitalization (i.e., during year 3-5 after T<sub>0</sub>) in twins where at least one in the pair had her first childbirth in 1994-2009 and none before 1994, both including and excluding hospitalization related to pregnancy, childbirth, and the puerperium. Two models for adjustments as well as for discordant twin pairs.

Status childbirth and hospitalization	All diagnoses			Diagnoses related to pregnancy, childbirth and the puerperium excluded <sup>1</sup>		
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>3,7</sup>
<b>All women (n=5 118)</b>						
No childbirth, no hospitalization before T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization before T <sub>0</sub> <sup>8</sup>	2.5 (1.7-3.6)	2.3 (1.6-3.3)	2.4 (1.3-4.5)	2.7 (1.8-3.9)	2.3 (1.6-3.4)	1.2 (0.8-1.9)
Childbirth, no hospitalization before T <sub>0</sub> <sup>8</sup>	6.1(5.0-7.5)	5.5 (4.5-6.8)	8.3 (5.8-11.8)	1.1 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.7-1.1)
Childbirth, hospitalization before T <sub>0</sub> <sup>8</sup>	6.5 (5.2-8.1)	5.6 (4.4-7.1)	7.9 (5.4-11.5)	1.9 (1.4-2.5)	1.4 (1.1-1.9)	0.9 (0.7-1.2)
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>4,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>5,7</sup>
<b>Women who had at least one childbirth (n=2 792)</b>						
No hospitalization before T <sub>0</sub> <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before T <sub>0</sub> <sup>8</sup>	1.0 (0.9-1.2)	1.0 (0.9-1.1)	1.0 (0.8-1.2)	1.7 (1.3-2.3)	1.5 (1.2-2.0)	1.0 (0.8-1.3)

<sup>1</sup> Diagnoses O00-O99  
<sup>2</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=1 016 pairs)  
<sup>3</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=456 pairs)  
<sup>4</sup> Twin pairs (both giving birth) where one having had a hospitalization during the follow-up and the other not (n=508 pairs)  
<sup>5</sup> Twin pairs (both giving birth) with one had a hospitalization during the follow-up and the other not (n=271 pairs)  
<sup>6</sup> Adjusted for birth year  
<sup>7</sup> Model a, and additional adjustments for delivery year, and educational level  
<sup>8</sup> During the period 1-5 years prior to T<sub>0</sub>

Table 3. Cox proportional HR with 95% CI for the association between childbirth, hospitalization, and new sickness absence (SA) in year 3-5 after  $T_0$ , in twins where at least one in the pair had their first childbirth 1994-2009. Three models for adjustments as well as for discordant twin pairs.

Status childbirth and hospitalization	SA in year 3-5 after $T_0$ (regardless of number of days)				Long-term SA (>90 days) in year 3-5 after $T_0$			
	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>1,7</sup>	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>
<b>All women (n=5 118)</b>								
No childbirth, no hospitalization year 1-2 after $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization year 1-2 after $T_0$ <sup>8</sup>	2.7 (1.8-4.1)	2.2 (1.5-3.4)	2.1 (1.4-3.2)	1.5 (0.8-2.9)	4.5 (2.5-8.2)	3.5 (1.9-6.2)	2.8 (1.5-5.1)	1.1 (0.5-2.3)
Childbirth, no hospitalization year 1-2 after $T_0$ <sup>8</sup>	2.1 (1.8-2.5)	1.8 (1.5-2.2)	1.8 (1.5-2.2)	1.7 (1.3-2.2)	1.1 (0.8-1.6)	1.0 (0.7-1.4)	1.0 (0.7-1.3)	0.8 (0.6-1.2)
Childbirth, hospitalization year 1-2 after $T_0$ <sup>8</sup>	3.0 (2.5-3.6)	2.4 (2.0-2.9)	2.4 (2.0-2.9)	2.0 (1.5-2.6)	2.3 (1.6-3.2)	1.8 (1.3-2.5)	1.8 (1.3-2.5)	1.0 (0.7-1.5)
<b>Women who had at least one childbirth (n=2 792)</b>								
No hospitalization year 1-2 after $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization year 1-2 after $T_0$ <sup>8</sup>	1.3 (1.2-1.5)	1.3 (1.1-1.4)	1.2 (1.1-1.4)	1.2 (1.0-1.5)	2.0 (1.5-2.6)	1.9 (1.4-2.5)	1.8 (1.4-2.4)	1.4 (1.0-1.9)

<sup>1</sup> Twin pairs where one had a SA during the follow-up and the other not (n=835 pairs)

<sup>2</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=277 pairs)

<sup>3</sup> Twin pairs where one had a SA during the follow-up and the other not (n=542 pairs)

<sup>4</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=184 pairs)

<sup>5</sup> Adjusted for birth year

<sup>6</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>7</sup> Model b, and additional adjustments for earlier hospitalization

<sup>8</sup> Diagnoses O00-O99 excluded

Table 4. Cox proportional HR with 95% CI for the association between hospitalization before and after first childbirth, and new sickness absence (SA) in year 3-5 after  $T_0$ , in twins who had their first childbirth 1994-2009 (n=2 792). Three models for adjustments as well as for discordant twin pairs.

Status hospitalization before and after childbirth	SA in year 3-5 after $T_0$ (regardless of number of days)				Long-term SA (>90 days) in year 3-5 after $T_0$			
	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>1,4</sup>	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>2,4</sup>
No hospitalization either before $T_0$ <sup>6</sup> or during year 1-2 after $T_0$ <sup>7</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before $T_0$ <sup>6</sup> but not during year 1-2 after $T_0$ <sup>7</sup>	1.2 (1.0-1.5)	1.2 (1.0-1.4)	1.2 (1.0-1.4)	1.0 (0.8-1.3)	2.3 (1.6-3.4)	2.1 (1.5-3.1)	2.2 (1.5-3.1)	1.2 (0.8-1.7)
No hospitalization before $T_0$ <sup>6</sup> but during year 1-2 after $T_0$ <sup>7</sup>	1.2 (1.1-1.4)	1.2 (1.0-1.4)	1.1 (0.9-1.2)	1.1 (0.9-1.4)	2.0 (1.5-2.8)	1.9 (1.4-2.7)	1.9 (1.4-2.7)	1.4 (1.0-2.1)
Hospitalization before $T_0$ <sup>6</sup> and during year 1-2 after $T_0$ <sup>7</sup>	2.0 (1.6-2.5)	1.8 (1.4-2.2)	1.6 (1.3-2.1)	1.6 (1.1-2.2)	4.2 (2.7-6.4)	3.5 (2.3-5.3)	3.5 (2.3-5.4)	1.5 (0.9-2.4)

<sup>1</sup> Twin pairs where one had an SA during the follow-up and the other not (n=542)

<sup>2</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=184)

<sup>3</sup> Adjusted for birth year

<sup>4</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>5</sup> Model b, and additional adjustments for subsequent deliveries

<sup>6</sup> During the period 1-5 years prior to  $T_0$

<sup>7</sup> Diagnoses O00-O99 excluded

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3 1 **Childbirth, hospitalization, and sickness absence: a study of female twins**  
4 2

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2  
3 **Abstract**

4 **Objective:** To investigate associations of giving birth with morbidity in terms of  
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6 hospitalization and social consequences of morbidity in terms of sickness absence (SA), while  
7  
8 taking familial (genetics and shared environmental) factors into account.  
9

10 **Design:** Prospective register-based cohort study. Estimates of risk of hospitalization and SA  
11  
12 were calculated as hazard ratios (HR) with 95% confidence intervals (CI).  
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15 **Setting:** All female twins, i.e., women with twin sister, born in Sweden.  
16

17 **Participants:** 5118 Swedish female twins (women with twin sister), born 1959-1990, where  
18  
19 at least one in the twin pair had their first childbirth ( $T_0$ ) 1994-2009 and none gave birth  
20  
21 before 1994.  
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24 **Main outcome measures:** Hospitalization and SA during year 3-5 after first delivery or  
25  
26 equivalent.  
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28 **Results:** Preceding the first childbirth, the mean annual number of SA days increased for  
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30 mothers, and then decreased again. Hospitalization after  $T_0$  was associated with higher HRs of  
31  
32 short-term and long-term SA (HR for short-term SA: 3.0; 95% CI 2.5-3.6 and for long-term  
33  
34 SA: 2.3; 95% CI 1.6-3.2). Hospitalization both before and after first childbirth was associated  
35  
36 with a higher risk of future SA (HR for long-term SA: 4.2; 95% CI 2.7-6.4). Familial factors  
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38 influenced the association between hospitalization and long-term SA, regardless of childbirth  
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40 status.  
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44 **Conclusion:** Women giving birth did not have a higher risk for SA than those not giving birth  
45  
46 and results indicate a positive health selection into giving birth. Mothers hospitalized before  
47  
48 and/or after giving birth had higher risks for future SA, that is, there was a strong association  
49  
50 between morbidity and future SA.  
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52 **Keywords:** sick leave, childbirth, inpatient care, hospitalization, cohort study, population  
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54 based, twins  
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For peer review only

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3 51 **Article Summary**

4 52 **Article focus:**

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6 53 To investigate associations of giving birth with morbidity in terms of hospitalization and  
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8 54 social consequences of morbidity in terms of sickness absence (SA), while taking familial  
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10 55 (genetics and shared environmental) factors into account.

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12  
13 56 **Key messages:**

- 14  
15 57 - Women giving birth did not have a higher future SA risk than those not giving birth  
16  
17 58 and results indicate a positive health selection into giving birth  
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19 59 - The high levels of inpatient care in women who did not give birth suggest that there is  
20  
21 60 a health selection in giving birth, where the women who give birth have a better health  
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23 61 initially

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26 62 **Strengths and limitations:**

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28 63 - The strengths of the study include the population-based prospective design, using  
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30 64 national registers with high completeness and validity  
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32 65 - With a twin study design, we were able to take familial influences into account  
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34 66 - As inpatient care to a great extent has been replaced by outpatient treatment, some of  
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36 67 the decrease in hospitalization over the years is a result of a shift in the responsibility  
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38 68 for inpatient care from hospitals to outpatient care facilities  
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## 71 Introduction

72 In most countries with high labor force participation, women have higher levels of sickness  
73 absence (SA) than men<sup>1-4</sup>. Many theories and mechanism regarding this have been suggested,  
74 e.g., women having higher morbidity, higher workload (when combining paid and unpaid  
75 work), tougher situation on the labor market, men being the norm for how the labor market is  
76 organized, gender bias in healthcare and social insurance systems, discrimination, and  
77 domestic violence, etcetera<sup>5-9</sup>. Another hypothesis behind this gender difference in SA  
78 focuses on SA during pregnancy and after childbirth<sup>6 10-13</sup>. Several studies show that women  
79 have higher SA during pregnancy<sup>10 14</sup> and that pregnancy-related SA explains half of the  
80 gender differences in SA in fertile ages<sup>15</sup>.

81 One of the changes in society that may affect health after childbirth is that the mean age for  
82 having the first child has increased over the last years and that women with higher level of  
83 morbidity now give birth. Further, nowadays, the proportion of caesarean sections has  
84 increased as well as vacuum extraction deliveries, leading to risk of later health problems<sup>16 17</sup>.

85 In this study, focus is on childbirth, morbidity, and SA among women, to get a better  
86 understanding of mechanisms behind SA among women in fertile ages. There are hardly any  
87 studies on the associations between giving birth and morbidity and SA, and those conducted  
88 have focused on a relatively short time period right after childbirth, most often within the first  
89 year following the child delivery<sup>18 19</sup>, while prospective studies with longer follow-up of  
90 mothers are rare<sup>6 12 20</sup>.

91 Pregnancy, delivery, and the postpartum period may imply large physical, mental, and  
92 social changes during a short period of time, increasing the risk for disease and injury<sup>21 22</sup>.  
93 Different types of physical and mental disorders are common during pregnancy and after  
94 childbirth – and can in some cases be longstanding or even permanent – however, this is  
95 hardly studied at all<sup>19</sup>. Giving birth may be associated with a higher risk of certain diseases  
96 demanding hospitalization, such as cardiovascular diseases, musculoskeletal diseases, mental

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3 97 disorders, and different types of injuries<sup>23-26</sup>. For women with a disease present before the  
4  
5 98 childbirth, the disorder might deteriorate after childbirth<sup>23 24</sup>. Regarding symptoms related to  
6  
7 99 childbirth, high prevalence has been shown six months after childbirth for e.g., low back pain,  
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9  
10 100 fatigue, headache, and sleep disorders<sup>19 27</sup>. Most of these symptoms seem to remain up to one  
11  
12 101 year after childbirth<sup>17</sup>. Besides physical health effects, also depression and other mental  
13  
14 102 disorders have been linked to childbirth<sup>26 28</sup>, but again, prospective studies with longer  
15  
16 103 follow-up are lacking<sup>27</sup>. Even though having children has been shown to contribute to an  
17  
18 104 overall wellbeing, this is not the case for everybody and especially not among single mothers  
19  
20 105 whose economic situation and thereby possibilities for good health care might be worse<sup>29-31</sup>.

21  
22  
23 106 Morbidity can be measured in different ways, e.g., through self-reports ~~and-or~~ visits to  
24  
25 107 healthcare. Here we will use data on more severe morbidity that involves assessments from  
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27 108 physicians, that is, morbidity that has led to hospitalization, a measure so far not used in this  
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29 109 type of studies. Sickness absence is not a good measure of morbidity—most people with  
30  
31 110 morbidity are not on SA<sup>4</sup>. Instead SA is considered a very good measure of social  
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33 111 consequences of morbidity, in terms of not being able to support yourself from work<sup>4</sup>. Yet,  
34  
35 112 there are surprisingly few studies on the association between morbidity and SA and in media  
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37  
38 113 and among some researchers sometimes ~~even~~ the level of morbidity among sickness absentees  
39  
40 114 even is questioned, especially for female sickness absentees – their sickness absence is rather  
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42 115 considered related to attitudes than to morbidity<sup>12 32 33</sup>.

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45 116 Studies examining the role of familial factors (i.e., genetic and shared (mainly childhood)  
46  
47 117 environment) on morbidity have shown that genetics tends to explain a moderate to large  
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49 118 extent of the variability in most of the chronic diseases<sup>34 35</sup>. For example, heritability for  
50  
51 119 mental disorders varies between 30-90%<sup>36</sup>, whereas genetic factors have been shown to  
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53 120 explain 30-60% of the total variation in musculoskeletal disorders<sup>37 38</sup>. Taken together,  
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55 121 familial factors are important to account for when studying the association between morbidity  
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3 122 (here in terms of hospitalization) and SA as studies otherwise could lead to erroneous  
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5 123 conclusions. Twin settings provide a powerful tool for studies of these aspects in research of  
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7 124 SA, a research area where different selection biases otherwise might have an impact on  
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9 125 results. Twins in a pair are optimally matched on genetic (100% for MZ pairs and on average  
10  
11 126 50% for DZ pairs) and common environmental factors through childhood (100% for both MZ  
12  
13  
14 127 and DZ twin pairs when reared together) in addition to age and sex (for the same-sexed pairs).  
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16 128 An experimental design, which can control for these familial influences, is to examine  
17  
18 129 discordant twin sisters, that is, where one twin sister has given birth and the other has not. If  
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21 130 discordant twin sisters show similar associations as the analyses of the whole cohort, this  
22  
23 131 would indicate that the childbirth may actually be a contributing cause of the future SA. If  
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25 132 instead the association found among the whole cohort cannot be replicated within discordant  
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27 133 twin sisters, then familial factors are of importance. Influence of familial factors (genetic and  
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29 134 common environment) is indicated if the association found in the analyses of the whole cohort  
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31 135 disappear or change considerably in the analyses of discordant twin pairs<sup>39</sup>.  
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36 137 The aim of the study was to investigate the associations of giving birth with subsequent  
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38 138 morbidity in terms of hospitalization and SA. Familial factors (genetics and shared/early  
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40 139 environmental) were taken into account in order to assess if familial factors explain a  
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43 140 potential association between childbirth and future hospitalization and SA.  
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## 142 **Methods**

### 143 **Participants and data sources**

144 We performed a prospective population-based cohort study of female twins. All female twins,  
145 i.e., women with a twin sister, born in Sweden between 1959 and 1990 were selected from the  
146 Swedish Twin Registry (STR)<sup>40</sup>. After excluding women who delivered their first child  
147 before 1994 or whose twin sister had her first delivery before 1994, and twins where none in  
148 the pair had their first delivery between 1994 and 2009 (n=7 304), the final cohort comprised  
149 5 118 women of which 95% had income from work, the others had income from parental  
150 benefits, unemployment benefits, student benefits, different types of sickness benefits, or a  
151 mixture of those (in the year prior to the birth year, i.e., T(-1). All had some of those types of  
152 income, all granting rights to SA benefits. The Swedish Twin Registry (STR) is the largest  
153 population-based register of twin births in the world, with information such as birth date, sex,  
154 zygosity, and pair identification<sup>40 41</sup>. The selection of the study population is illustrated in  
155 Figure 1.

156 The unique personal identity number assigned to each Swedish resident<sup>42</sup> was used to link  
157 information from several nationwide population-based registers at an individual level up  
158 through 2009, as follows. The Causes of Death Register was used to obtain information on  
159 date of death<sup>43</sup>. This register contains information on all deceased Swedish residents since  
160 1952. Information on all deliveries (including still births) was derived from the Medical Birth  
161 Register, which was established in 1973 and includes information on almost all births in  
162 Sweden<sup>44</sup>. In order to increase the coverage on delivery, we also used the National Patient  
163 Register (NPR) to obtain information on all deliveries. This register was founded in 1964 and  
164 includes all individuals admitted to any psychiatric or general hospital<sup>45</sup>. Information on  
165 hospitalization with a principal diagnosis for delivery (as defined by the International  
166 Classification of Disease (ICD): ICD-9: 650, 651.9, 652.2, 669.5-8; and ICD-10: O80-84) was  
167 obtained. The NPR was also used to obtain annual information on other hospitalizations, i.e.,

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3 168 inpatient care. Annual information on educational level and on SA days was obtained from  
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5 169 Statistics Sweden.

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10 171 **Time in relation to childbirth**

11 172 The studied women were followed in relation to year of first childbirth, referred to as  $T_0$ . In  
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13 173 order to compare those who gave birth to those who did not,  $T_0$  for the women who did not  
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15 174 give birth was defined as year of her twin sister's first childbirth.

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21 176 **Hospitalization**

22 177 Data on hospitalization covered the period six years prior to, and six years after year of first  
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24 178 childbirth ( $T_0$ ) or equivalent. For descriptive purposes, the total and the average number of  
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26 179 hospitalization days per year were calculated.

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29 180 In order to examine if hospitalization prior to (or after) childbirth increases the risk for future  
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31 181 hospitalization, the first part of the regression analyses considered hospitalization as both  
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33 182 exposure and outcome. We created one dichotomous variable for hospitalization before  $T_0$   
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35 183 (i.e., exposure), and two dichotomous outcome variables for hospitalization during year 3-5  
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37 184 after  $T_0$ : one for hospitalization with any diagnosis and one excluding hospitalization with  
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39 185 diagnoses related to pregnancy, childbirth, and the postpartum period.

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41  
42 186 In order to answer the research question "Does hospitalization prior to (or after) childbirth  
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44 187 increase the risk for future SA?", we created two dichotomous hospitalization exposure  
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46 188 variables: one for hospitalization before  $T_0$  and one variable: hospitalization year 1-2 after  $T_0$   
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48 189 (excluding diagnoses related to pregnancy, childbirth, and the postpartum period).

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54 191 **Sickness absence**

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3 192 SA can be measured in several ways, related to duration and incidence<sup>46</sup>. Here we used the  
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5 193 following four measures: total and average number of SA days per year; number of SA days  
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7 194 during year 3-5 after T<sub>0</sub>; and number of SA days >90 sick-leave days during year 3-5 after  
8  
9 195 T<sub>0</sub>.

### 196 **Sickness insurance in Sweden**

197 In Sweden, all residents aged 16-65 years who have income from work, unemployment  
198 benefits, parental benefits, or student benefits are entitled to sickness benefits from the  
199 Swedish Social Insurance Agency, if unable to work due to disease or injury. Among  
200 employed individuals, sick pay was in most cases paid by the employer during the first 14  
201 days of a sick-leave spell, which means that we do not have data on most of the short sick-  
202 leave spells. In most of the years studied, there was no limitation to duration of a sick-leave  
203 spell. Sickness benefits covered 80% of lost income, up to a certain level. All were covered by  
204 a health care insurance covering the right to hospital care when needed, at a much reduced  
205 cost, less than 10 Euros a day. Care during pregnancy and delivery was free.

### 207 **Potential confounding factor**

208 As research has shown socioeconomic disparities in age at first birth (e.g., the higher the  
209 education, the later the first birth)<sup>47 48</sup>, we adjusted for educational level at T<sub>0</sub>. Years of  
210 education was classified into four categories; <9 years of compulsory school, 10-12 years of  
211 education (senior high school), ≥13 years of education (college/university), missing.

### 213 **Statistical analysis**

214 First, Cox proportional hazard models with constant time-at-risk<sup>49</sup> were applied to estimate  
215 hazard ratios (HR) with 95% confidence intervals (CI) for having at least one hospitalization  
216 after childbirth (T<sub>0</sub>). In a first model (model a), adjustments were made for age. Second

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3 217 (model b), additional adjustments were made for delivery year and educational level at time of  
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5 218  $T_0$ . Thereafter, twin pairs who were discordant with respect to outcomes, i.e., having at least  
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7 219 one hospitalization after  $T_0$ , were analyzed using Conditional Cox regression. In the next step,  
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9 220 we analyzed the associations between childbirth, hospitalization, and SA by fitting three Cox  
10  
11 221 regression models (table 3). The first (model a) was adjusted for birth year. In the second  
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13 222 model (model b), additional adjustments were made for delivery year and educational level at  
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15 223 time of  $T_0$ . In the third model (model c), previous hospitalization was included. Thereafter,  
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17 224 twin pairs who were discordant (Conditional Cox regression) with respect to outcomes i.e.,  
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19 225 having had SA or long-term SA (>90 days) were analyzed.  
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22  
23 226 Finally, in the step where we analyzed the association between hospitalization before and  
24  
25 227 after first childbirth, and subsequent SA (table 4), we adopted the first two models (model a-  
26  
27 228 b) from table 3. In a third model (model c), we fitted an additional model in which  
28  
29 229 adjustments were made for subsequent deliveries.  
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32 230 The proportional hazards assumption was checked by including time-dependent versions of  
33  
34 231 all the covariates in the models. This did not indicate a violation of the proportionality  
35  
36 232 assumption.  
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38 233 All statistical analyses were performed with SAS 9.3 and STATA 12.1.

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40 234 The STROBE checklist was used in designing and reporting the study.

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42 235 The project was approved by the Regional Ethical Review Board of Stockholm.  
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**Results**

Of the 5 118 women included in the study, 77% had given birth at least once between 1994 and 2009 (Table 1). Of these women, nearly 70% also had given birth later, at least once. A majority of the women who gave birth had their first delivery before the age of 30 (61%). The educational level distribution was rather similar when comparing those who gave birth to those who did not. When hospitalizations with diagnoses for pregnancy and childbirth were excluded, 30% of the women, i.e., the 1 183 where both in a pair gave birth and the 407 twins where only one in the pair gave birth had at least one hospitalization during the period six years prior to and six years after their first delivery (the delivery year excluded). The corresponding rate for the women who had not given birth was 27%. Half of the women who gave birth had at least one day of SA during the period six years prior to or the six years after first delivery, when the year for childbirth was excluded. The majority of the women had no SA at all in the six years following childbirth.

The average annual number of days with inpatient care and SA, respectively, is presented in Figure 2. Up to year  $T_0$ , women who did not give birth had a higher average number of hospitalization days and SA days compared to those who gave birth. Women who gave birth had approximately 0.3 hospitalization days per year whereas those who did not give birth had around 0.5 hospitalization days per year. The average number of SA days for women giving birth was 3.8 days/year and for those not giving birth 5.0 days/year. SA differences between those giving birth and women not giving birth were statistically significant with the exception of year (-4) and (-3). For inpatient care, the differences between those giving birth and women not giving birth were not statistically significant. The average number of inpatient days increased rapidly during  $T_0$  for women who gave birth, especially because of hospitalization due to pregnancy and childbirth. After  $T_0$ , the number of SA days decreased quickly among these women. For women who gave birth, days with inpatient care and SA the years following  $T_0$  were to a large extent associated with subsequent childbirths.

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3 262 Table 2 presents HR for the association between childbirth and hospitalization, for all  
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5 263 diagnoses and for diagnoses where those related to pregnancy, childbirth, and the postpartum  
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7 264 period were excluded. When these diagnoses were removed, women who did not give birth  
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9 265 and who had been hospitalized at least once before  $T_0$  had twice the risk of future  
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11 266 hospitalization compared to those not hospitalized prior to  $T_0$  (HR: 2.3; 95% CI 1.6-3.3) after  
12  
13 267 adjustments for birth year, delivery year, and educational level. The association was explained  
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15 268 by familial factors in the analysis of discordant twin pairs (HR: 1.2; 0.8-1.9).

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17 269 When restricting the analyses to women who gave birth, a total of 2 792 women were  
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19 270 studied, i.e., 1 396 complete pairs in which both twins had given birth. The reference group  
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21 271 constituted of mothers who had not been hospitalized prior to their first childbirth. Mothers  
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23 272 who had been hospitalized before their first childbirth had a slightly higher HR for future  
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25 273 hospitalization when diagnoses related to pregnancy and childbirth were excluded (HR 1.5;  
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27 274 1.2-2.0). This association disappeared in the analyses of discordant twin pairs, suggesting an  
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29 275 influence of familial factors (HR: 1.0; 0.8-1.3).

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31 276 Regardless of childbirth status, hospitalization year 1-2 after  $T_0$  was a predictor of having a  
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33 277 new SA in year 3-5 after  $T_0$  (Table 3). Compared to women who did not give birth and who  
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35 278 were not hospitalized the first two years after  $T_0$ , mothers hospitalized after first childbirth  
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37 279 had an HR of 2.4 (2.0-2.9) for a new SA after adjustments for birth year, delivery year, and  
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39 280 educational level. Hospitalization after  $T_0$  was also associated with a new long-term SA (>90  
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41 281 days) in year 3-5 after  $T_0$  (Table 3). Women who did not give birth had a nearly three-fold  
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43 282 risk of a new long-term SA year 3-5 after  $T_0$  (HR 2.8; 1.5-5.1), whereas women who gave  
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45 283 birth had an HR of 1.8 (1.3-2.5). The analyses of twin pairs discordant for having a new long-  
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47 284 term SA year 3-5 after  $T_0$ , showed attenuated point estimates, hence suggesting that familial  
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49 285 effects may play a role.  
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3 286 The analyses, in which we considered hospitalization before and after first childbirth as  
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5 287 exposure, and outcome was a new SA year 3-5 after  $T_0$  (Table 4) show that mothers who had  
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7 288 been hospitalized at least once both before and after their first child birth had a higher risk of  
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9 289 future SA (HR 1.8; 1.4-2.2). These women also had a higher risk of long-term SA; however,  
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11 290 these risk estimates were not statistically significant. After controlling for familial  
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13 291 confounding, the estimated risk for long-term SA for those who had been hospitalized before  
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15 292  $T_0$  was in the same direction but the HR was reduced, which suggest that also familial factors  
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17 293 may have an influence on the studied association.  
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3 294 **Discussion**

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5 295 In this register study of a population-based Swedish cohort of female twins born between  
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7 296 1959 and 1990, the associations of delivery with hospitalization and SA were examined as  
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9 297 well as whether familial (i.e., genetic and shared, mainly childhood, environmental) factors  
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11 298 were contributing to these associations. Just before the first childbirth, the SA days increased  
12  
13 299 much for mothers, an increase that gradually decreased during the years after the delivery. We  
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15 300 found hospitalization prior to T<sub>0</sub> to be a risk factor for future hospitalization, regardless of  
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17 301 childbirth status, also when excluding hospitalization due to childbirth. Furthermore,  
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19 302 hospitalization after the first childbirth was associated with a higher HR of both short-term  
20  
21 303 and long-term future SA. An additional analysis focusing solely on the women who gave birth  
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23 304 showed that hospitalization both before and after the first childbirth was associated with a  
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25 305 higher risk of future SA. Familial factors seemed to have an influence on the association  
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27 306 between hospitalization and long-term SA, regardless of childbirth status.

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29 307 In line with some previous studies<sup>10 20 50 51</sup>, we found that SA increased in women during  
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31 308 the time before the first childbirth. Giving birth was also associated with a future somewhat  
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33 309 higher risk for SA, in line with that of those not giving birth. However, this higher risk could  
34  
35 310 be due to subsequent pregnancies. A recent Norwegian study found that the increased SA risk  
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37 311 in women in the years after pregnancy disappeared when SA during subsequent pregnancies  
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39 312 were accounted for<sup>20</sup>. Several explanations have been suggested for such higher levels of SA,  
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41 313 among others the double burden hypothesis<sup>20 52-54</sup>. This hypothesis has been questioned, as  
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43 314 research has indeed shown that women who occupy multiple roles tend to be healthier than  
44  
45 315 those who enact fewer roles<sup>55-57</sup>. Thus, the combination of employment and parenthood does  
46  
47 316 not seem to imply worse health, on the contrary. In our study, the annual rates of SA  
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49 317 decreased steadily after the first childbirth, speaking in favor of this hypothesis. Further  
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51 318 studies of this are warranted.

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3 319 To our best knowledge, this is the first study to examine long-term associations between  
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5 320 childbirth, hospitalization and both short- and long-term SA. Women who gave birth did not  
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7 321 have a higher risk for long-term SA nor for hospitalization (besides hospitalization due to  
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9 322 subsequent pregnancy and childbirth) when compared to women who did not give birth.

11 323 Those who did not give birth had a more stable pattern of SA during the studied period,  
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13 324 however, with a slight increase in annual SA days over the years. This is in line with a  
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15 325 Swedish study examining whether family obligations influence the risk of SA in publicly  
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17 326 employed women and found a slight risk increase for SA among women without children<sup>58</sup>.  
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19 327 Further, a broad systematic literature review published in 2004 provided no evidence of an  
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21 328 association between having children in the household and an increased risk of SA<sup>59</sup>. It is  
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23 329 important to consider family situation when examining the association between having  
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25 330 children and morbidity, as single women with children have been shown to have worse health  
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27 331<sup>30 31 60</sup> and higher levels of SA<sup>6 58</sup>.

31 332 Even though pregnancy, delivery, and the postpartum period may increase the risk for  
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33 333 disease and injury<sup>25 27</sup>, our findings do not suggest that women who gave birth are more  
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35 334 likely to be hospitalized after their first childbirth, except for hospitalizations related to  
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37 335 subsequent deliveries. We found no differences in risk for future hospitalization when  
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39 336 comparing those who gave birth to those who did not. Thus, giving birth does not have to be  
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41 337 associated with subsequent health problems. The fact that we found no differences in future  
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43 338 hospitalization between those who gave birth and those who did not, may have different  
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45 339 explanations. As mentioned above, one could expect that there is a health selection, where  
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47 340 women who do not give birth may have worse health and choose not to have or cannot have a  
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49 341 child. Also, giving birth is in itself a risk factor for future morbidity<sup>16 19 22</sup>. Further, during the  
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51 342 last decades, the number of women who voluntarily do not want to become parents has  
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53 343 increased worldwide<sup>61</sup>.

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3 344 Hospitalization prior to the first childbirth or equivalent ( $T_0$ ) was a risk factor for future SA  
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5 345 for all women, regardless of childbirth status. In particular, women who had been hospitalized  
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7 346 both before and after  $T_0$  were at risk for future SA. Furthermore, we found an association  
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9 347 between hospitalization and future long-term SA.

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11 348 When comparing women who gave birth to those who did not, with respect to exposure to  
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13 349 hospitalization and risk of SA, mothers hospitalized at least once after the first childbirth had  
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15 350 slightly higher risk for future SA regardless of duration, whereas those who did not give birth  
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17 351 hospitalized after  $T_0$  had higher risk for long-term SA.

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20 352 Hospitalization both before and after the year  $T_0$  seems to be the strongest indicator, i.e.,  
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22 353 these individuals had the highest risk for future SA. Consequently, the women who had been  
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24 354 hospitalized both before and after  $T_0$  had the highest risk for future SA. Our analyses of  
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26 355 women who gave birth revealed a graded association between hospitalization and SA, where  
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28 356 those who only were hospitalized before *or* after their first childbirth had a higher risk of SA,  
29  
30 357 whereas those who were hospitalized both before and after the first childbirth had even higher  
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32 358 risks. Thus, we found a strong association between morbidity, here measured as  
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34 359 hospitalization, and future SA among women who have given birth – an association that often  
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36 360 has been question regarding women with children <sup>12</sup>.

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39 361 Familial factors seemed to contribute to the association between hospitalization before and  
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41 362 after  $T_0$  among those who did not give birth. The influence of familial factors may relate to  
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43 363 morbidity among women not giving birth – morbidity that might be more severe and  
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45 364 potentially also being relatively strongly influenced by genetics. Familial factors also played a  
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47 365 role in the associations between hospitalization and future long-term SA. This could be  
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49 366 related to the fact that the hospitalization usually is required for severe conditions that may  
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51 367 have a strong genetic component. However, since genetics have been shown to influence the  
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53 368 risk of DP <sup>62</sup>, and some indications exist that genetics also play a role in long-term SA and  
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3 369 mortality, it can be suspected that the effects of familial factors on SA can be either direct or  
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5 370 through other influential factors.  
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### 8 9 372 **Strengths and limitations**

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11 373 The strengths of this study are the population-based prospective cohort study design,  
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13 374 including all in the study population, not a sample, using nationwide registers with high  
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15 375 completeness and validity<sup>43-45</sup>. Further, we used a large study cohort without loss to follow  
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17 376 up. With a twin study design, we were able to take familial influences into account. When  
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19 377 measuring both exposure and outcome with register-based data, we avoid problem with recall  
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21 378 bias.  
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25 379 This study has, however, some limitations. First of all, we do not know whether the women  
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27 380 who did not give birth were childless voluntarily or not. Differences in health between  
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29 381 voluntary and involuntary childlessness have been shown, where voluntarily childless women  
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31 382 showed higher levels of overall well-being<sup>61 63</sup> which might be related to hospitalization  
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33 383 and/or SA. Using inpatient care as a measure of morbidity has both its strengths and  
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35 384 limitations. One limitation is that we thus selected more severe types of morbidity, and hence  
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37 385 that does not include morbidity treated in outpatient care. Having had also other types of  
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39 386 morbidity data might have given another picture and hopefully future studies will have such  
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41 387 information. Another limitation is that the terms for inpatient care have changed during the  
42  
43 388 studied period. In Sweden, inpatient care has over the years to a great extent been replaced by  
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45 389 outpatient treatment. Therefore, some of the decrease in hospitalization over the years is a  
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47 390 result of a shift in the responsibility for inpatient care from hospitals to outpatient care  
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49 391 facilities<sup>64</sup>, however, this affected all women equally, and is to some extent handled by  
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51 392 adjusting for birth year. The CIs are wider in the years far from T<sub>0</sub>, e.g., T<sub>6</sub>, due to fewer  
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53 393 follow up year for some – e.g., for those who gave birth late during the studied period. Also,  
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3 394 we lack information on the shorter SA spells among those employed. Further, the Swedish  
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5 395 Twin Registry (STR) contains all twin births in Sweden; hence, immigrants are not included  
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7 396 in this study and as a consequence the external validity might be lower to women born outside  
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9 397 of Sweden.

11 398 It is important to be aware of that giving birth is in focus here, irrespective of whether the  
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13 399 child survived or not. Some of the women who did not give birth might be mothers, e.g., due  
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15 400 to adoption. Other studies in this area has 'being mother' or 'living with child' as exposure  
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17 401 term, rather than 'giving birth'.  
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### 22 403 **Conclusion**

24 404 Women giving birth did not have a higher future SA risk than those not giving birth and  
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26 405 results indicate a positive health selection into giving birth. Mothers with different types of  
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28 406 morbidity, in terms of hospitalization before and/or after giving birth had higher risks for  
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30 407 future SA. Most women had no SA in the six years following childbirth and those who had  
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32 408 SA generally had that for shorter periods. Among the few women who had severe morbidity,  
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34 409 in terms of hospitalization, the future risk for SA was, as expected, higher. Hospitalization  
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36 410 prior to  $T_0$  was strongly associated with later hospitalization and later SA. The high levels of  
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38 411 inpatient care in women who did not give birth suggest that there is a health selection in  
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40 412 giving birth, where the women who give birth have a better health initially. However, most  
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42 413 women had no hospitalization and no SA.  
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### **Ethical approval**

The study was approved by the Regional Ethical Review Board, Stockholm, Sweden (2007/524-31).

### **Contributorship Statement**

KA and PS originated the idea. EB analysed the data in consultation with KA, LK, JN, AR, and PS. EB wrote the first and subsequent drafts of the manuscript, with important intellectual input from all the co-authors. All authors contributed in designing the study and to the interpretation of the results and to the writing and approval of the final article.

### **Competing interest statement**

We declare that no competing interests exist.

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### **Data sharing**

No additional data available.

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3 442 **Figure legends**

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5 443 Figure 1. Flow chart for the study population.

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7 444 Figure 2. Average annual number of days on sickness absence (SA) and hospitalization,  
8 445 respectively, (with 95% CI), six years prior through six year after T<sub>0</sub> for women who gave  
9 446 birth/did not give birth (n=5 118).

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Table 1. Cohort characteristics for twins (women with twin sister) born in Sweden 1959-1990 (excluding those who gave birth before age 16 and those who died before age 16), where at least one in the pair had their first childbirth 1994-2009 and none before 1994. T<sub>0</sub> is defined as year for first childbirth for women who gave birth, and year of twin sister's childbirth for those who did not give birth.

Variables	Both gave birth		Twin pairs where only one in the pair gave birth		Total
	birth	Twin 1 (gave birth)	Twin 2 (did not give birth)		
N	2 792	1 163	1 163	5 118	
<b>Number of deliveries</b>					
One delivery	711 (25%)	501 (43%)			
Two or more deliveries	2 081 (75%)	662 (57%)			
<b>Age at T<sub>0</sub></b>					
16-19 years	47 (2%)	33 (2%)			
20-24 years	511 (18%)	239 (21%)			
25-29 years	1 150 (41%)	444 (38%)			
30-34 years	847 (30%)	323 (28%)			
35-39 years	207 (7%)	109 (9%)			
>40 years	30 (1%)	15 (1%)			
<b>Zygoty</b>					
Monozygotic	1 726 (62%)	608 (52%)	608 (52%)	2 942 (57%)	
Dizygotic	1 066 (38%)	555 (48%)	555 (48%)	2 176 (43%)	
<b>Highest attained education<sup>1</sup></b>					
≤ 9 year	179 (6%)	74 (6%)	55 (5%)	308 (6%)	
10-12 year	1 434 (51%)	608 (52%)	621 (53%)	2 663 (52%)	
≥ 13 year	1 173 (42%)	474 (41%)	422 (36%)	2 069 (40%)	
Information on education missing	6 (0%)	7 (1%)	65 (6%)	78 (2%)	
<b>Hospitalization<sup>2</sup></b>					
- At least one hospitalization during the period six years prior through six years after T <sub>0</sub>	2 161 (77%)	703 (60%)	325 (28%)	3 189 (62%)	
-At least one hospitalization during the period six years prior through six years after T <sub>0</sub> (excluding hospitalizations with a diagnosis for pregnancy, childbirth, and the puerperium)	865 (31%)	315 (27%)	314 (27%)	1 494 (29%)	
- At least one hospitalization during the period six years prior through six years after T <sub>0</sub> (excluding hospitalizations with a diagnosis for pregnancy, and childbirth)	1 183 (42%)	407 (35%)	325 (28%)	1 915 (37%)	
- At least one hospitalization during the period six years prior to T <sub>0</sub>	679 (24%)	251 (22%)	217 (19%)	1 147 (22%)	
- At least one hospitalization during the period six years after T <sub>0</sub>	1 965 (70%)	585 (50%)	168 (14%)	2 718 (53%)	
- At least one hospitalization both before and after T <sub>0</sub>	483 (17%)	133 (11%)	60 (5%)	676 (13%)	
<b>Sickness Absence (SA)<sup>3</sup></b>					
At least one SA during the period six years prior through six years after T <sub>0</sub>	1 526 (55%)	530 (46%)	365 (31%)	2 420 (47%)	
At least one SA during the period six years prior to T <sub>0</sub>	690 (25%)	274 (24%)	224 (19%)	1 188 (23%)	
At least one SA during the period six years after T <sub>0</sub>	1 245 (45%)	382 (33%)	221 (19%)	1 848 (36%)	

<sup>1</sup> At time of T<sub>0</sub>

<sup>2</sup> Excluding hospitalizations occurring during T<sub>0</sub>

<sup>3</sup> Excluding SA occurring during T<sub>0</sub>

Table 2. Cox proportional hazard ratios (HR) with 95% CI for the association between childbirth, hospitalization before  $T_0$ , and subsequent hospitalization (i.e., during year 3-5 after  $T_0$ ) in twins where at least one in the pair had her first childbirth in 1994-2009 and none before 1994, both including and excluding hospitalization related to pregnancy, childbirth, and the puerperium. Two models for adjustments as well as for discordant twin pairs.

Status childbirth and hospitalization	All diagnoses			Diagnoses related to pregnancy, childbirth and the puerperium excluded <sup>1</sup>		
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>3,7</sup>
<b>All women (n=5 118)</b>						
No childbirth, no hospitalization before $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization before $T_0$ <sup>8</sup>	2.5 (1.7-3.6)	2.3 (1.6-3.3)	2.4 (1.3-4.5)	2.7 (1.8-3.9)	2.3 (1.6-3.4)	1.2 (0.8-1.9)
Childbirth, no hospitalization before $T_0$ <sup>8</sup>	6.1 (5.0-7.5)	5.5 (4.5-6.8)	8.3 (5.8-11.8)	1.1 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.7-1.1)
Childbirth, hospitalization before $T_0$ <sup>8</sup>	6.5 (5.2-8.1)	5.6 (4.4-7.1)	7.9 (5.4-11.5)	1.9 (1.4-2.5)	1.4 (1.1-1.9)	0.9 (0.7-1.2)
	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>4,7</sup>	Model a <sup>6</sup>	Model b <sup>7</sup>	Discordant twin pairs <sup>5,7</sup>
<b>Women who had at least one childbirth (n=2 792)</b>						
No hospitalization before $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before $T_0$ <sup>8</sup>	1.0 (0.9-1.2)	1.0 (0.9-1.1)	1.0 (0.8-1.2)	1.7 (1.3-2.3)	1.5 (1.2-2.0)	1.0 (0.8-1.3)

<sup>1</sup> Diagnoses O00-O99

<sup>2</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=1 016 pairs)

<sup>3</sup> Twin pairs where one had a hospitalization during the follow-up and the other not (n=456 pairs)

<sup>4</sup> Twin pairs (both giving birth) where one having had a hospitalization during the follow-up and the other not (n=508 pairs)

<sup>5</sup> Twin pairs (both giving birth) with one had a hospitalization during the follow-up and the other not (n=271 pairs)

<sup>6</sup> Adjusted for birth year

<sup>7</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>8</sup> During the period 1-5 years prior to  $T_0$

Table 3. Cox proportional HR with 95% CI for the association between childbirth, hospitalization, and new sickness absence (SA) in year 3-5 after  $T_0$ , in twins where at least one in the pair had their first childbirth 1994-2009. Three models for adjustments as well as for discordant twin pairs.

Status childbirth and hospitalization	SA in year 3-5 after $T_0$ (regardless of number of days)				Long-term SA (>90 days) in year 3-5 after $T_0$			
	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>1,7</sup>	Model a <sup>5</sup>	Model b <sup>6</sup>	Model c <sup>7</sup>	Discordant twin pairs <sup>2,7</sup>
<b>All women (n=5 118)</b>								
No childbirth, no hospitalization year 1-2 after $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
No childbirth, hospitalization year 1-2 after $T_0$ <sup>8</sup>	2.7 (1.8-4.1)	2.2 (1.5-3.4)	2.1 (1.4-3.2)	1.5 (0.8-2.9)	4.5 (2.5-8.2)	3.5 (1.9-6.2)	2.8 (1.5-5.1)	1.1 (0.5-2.3)
Childbirth, no hospitalization year 1-2 after $T_0$ <sup>8</sup>	2.1 (1.8-2.5)	1.8 (1.5-2.2)	1.8 (1.5-2.2)	1.7 (1.3-2.2)	1.1 (0.8-1.6)	1.0 (0.7-1.4)	1.0 (0.7-1.3)	0.8 (0.6-1.2)
Childbirth, hospitalization year 1-2 after $T_0$ <sup>8</sup>	3.0 (2.5-3.6)	2.4 (2.0-2.9)	2.4 (2.0-2.9)	2.0 (1.5-2.6)	2.3 (1.6-3.2)	1.8 (1.3-2.5)	1.8 (1.3-2.5)	1.0 (0.7-1.5)
<b>Women who had at least one childbirth (n=2 792)</b>								
No hospitalization year 1-2 after $T_0$ <sup>8</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization year 1-2 after $T_0$ <sup>8</sup>	1.3 (1.2-1.5)	1.3 (1.1-1.4)	1.2 (1.1-1.4)	1.2 (1.0-1.5)	2.0 (1.5-2.6)	1.9 (1.4-2.5)	1.8 (1.4-2.4)	1.4 (1.0-1.9)

<sup>1</sup> Twin pairs where one had a SA during the follow-up and the other not (n=835 pairs)

<sup>2</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=277 pairs)

<sup>3</sup> Twin pairs where one had a SA during the follow-up and the other not (n=542 pairs)

<sup>4</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=184 pairs)

<sup>5</sup> Adjusted for birth year

<sup>6</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>7</sup> Model b, and additional adjustments for earlier hospitalization

<sup>8</sup> Diagnoses O00-O99 excluded

Table 4. Cox proportional HR with 95% CI for the association between hospitalization before and after first childbirth, and new sickness absence (SA) in year 3-5 after  $T_0$ , in twins who had their first childbirth 1994-2009 (n=2 792). Three models for adjustments as well as for discordant twin pairs.

Status hospitalization before and after childbirth	SA in year 3-5 after $T_0$ (regardless of number of days)				Long-term SA (>90 days) in year 3-5 after $T_0$			
	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>1,4</sup>	Model a <sup>3</sup>	Model b <sup>4</sup>	Model c <sup>5</sup>	Discordant twin pairs <sup>2,4</sup>
No hospitalization either before $T_0$ <sup>6</sup> or during year 1-2 after $T_0$ <sup>7</sup>	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)	1 (REF)
Hospitalization before $T_0$ <sup>6</sup> but not during year 1-2 after $T_0$ <sup>7</sup>	1.2 (1.0-1.5)	1.2 (1.0-1.4)	1.2 (1.0-1.4)	1.0 (0.8-1.3)	2.3 (1.6-3.4)	2.1 (1.5-3.1)	2.2 (1.5-3.1)	1.2 (0.8-1.7)
No hospitalization before $T_0$ <sup>6</sup> but during year 1-2 after $T_0$ <sup>7</sup>	1.2 (1.1-1.4)	1.2 (1.0-1.4)	1.1 (0.9-1.2)	1.1 (0.9-1.4)	2.0 (1.5-2.8)	1.9 (1.4-2.7)	1.9 (1.4-2.7)	1.4 (1.0-2.1)
Hospitalization before $T_0$ <sup>6</sup> and during year 1-2 after $T_0$ <sup>7</sup>	2.0 (1.6-2.5)	1.8 (1.4-2.2)	1.6 (1.3-2.1)	1.6 (1.1-2.2)	4.2 (2.7-6.4)	3.5 (2.3-5.3)	3.5 (2.3-5.4)	1.5 (0.9-2.4)

<sup>1</sup> Twin pairs where one had an SA during the follow-up and the other not (n=542)

<sup>2</sup> Twin pairs where one had a long-term SA during the follow-up and the other not (n=184)

<sup>3</sup> Adjusted for birth year

<sup>4</sup> Model a, and additional adjustments for delivery year, and educational level

<sup>5</sup> Model b, and additional adjustments for subsequent deliveries

<sup>6</sup> During the period 1-5 years prior to  $T_0$

<sup>7</sup> Diagnoses O00-O99 excluded

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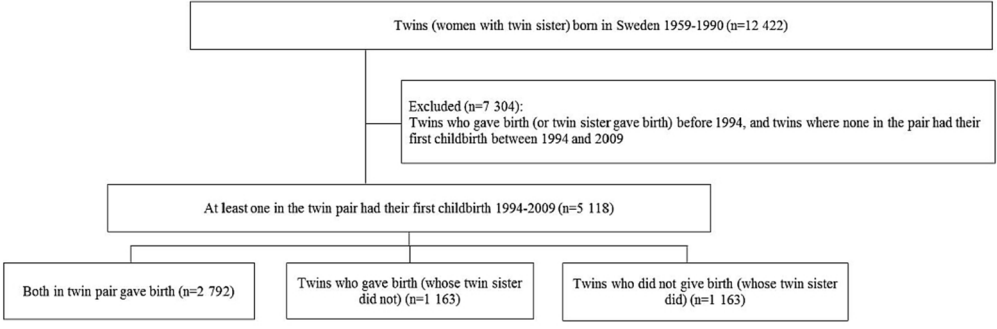


Figure 1  
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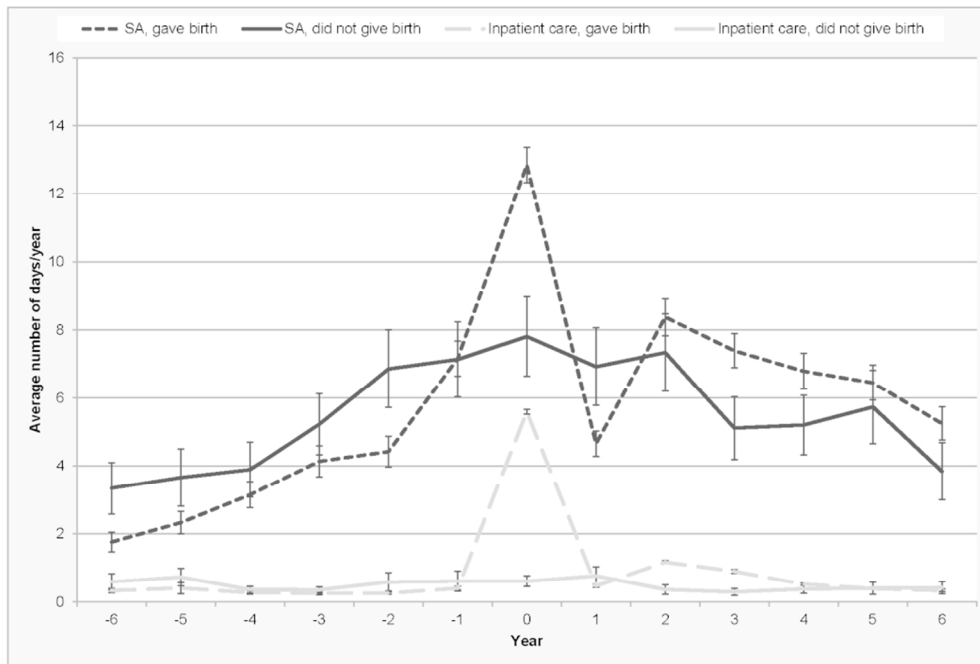


Figure 2  
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1 BMJ Open - Childbirth, hospitalization, and sickness absence: a study of female  
2 twins  
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4 STROBE Statement—Checklist of items that should be included in reports of *cohort studies*  
5

	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>Page 1</b>
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 2</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 5</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 7</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 8</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 8-11</b>
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 8-11</b>
		(b) For matched studies, give matching criteria and number of exposed and unexposed N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 9-10</b>
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 <b>Page 8-11</b>
Bias	9	Describe any efforts to address potential sources of bias N/A
Study size	10	Explain how the study size was arrived at <b>Page 8</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Page 9-10</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 10-11</b>
		(b) Describe any methods used to examine subgroups and interactions <b>Page 10-11</b>
		(c) Explain how missing data were addressed N/A
		(d) If applicable, explain how loss to follow-up was addressed

		N/A
		(e) Describe any sensitivity analyses
<b>Results</b>		
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>Page 8, and page 24</b>
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram <b>Page 21</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 24</b>
		(b) Indicate number of participants with missing data for each variable of interest N/A
		(c) Summarise follow-up time (eg, average and total amount) N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time <b>Page 24</b>
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>Page 24-25</b>
		(b) Report category boundaries when continuous variables were categorized <b>Page 23</b>
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 25-26</b>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <b>Page 2, 4 and page 15</b>
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 <b>Page 18</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 15-17</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 15-17</b>
<b>Other information</b>		
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 <b>Page 20</b>



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\*Give information separately for exposed and unexposed groups.

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