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ORIGINAL RESEARCH ARTICLE

Pregnancy, delivery, and neonatal outcomes among women with spinal cord injury in Sweden 1997–2015: A population-based cohort study

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Abstract

Introduction: The aim of this study was to describe the rate of pregnancy in spinal cord injured women in Sweden as well as pregnancy, delivery, and neonatal outcomes.

Material and Methods: This study was based on data from the Swedish Medical Birth Register and the National Patient Register. The study population included women with spinal cord injury who gave birth in Sweden during the period 1997 to 2015. The general population was used as reference and included all non-spinal cord injured patients who gave birth during the same period of time.

Results: In the spinal cord injury group, 109 births were identified. Eighty-nine (82%) of them were among paraplegic women and 20 (18%) were among tetraplegic women. Women with spinal cord injury in our study population had urinary tract infections during pregnancy in five cases (5%) and anemia during pregnancy in nine cases (8%), compared with 0.2% and 4%, respectively, in the general population. Compared with the general population more deliveries were induced in the study population, 18 (17%) in the spinal cord injury group and 12% in the general population. Vaginal delivery was achieved in 52 (48%) of the births with 42 of them (39%) being non-instrumental and 10 (9%) being instrumental vaginal deliveries. Elective cesarean section rate was 34% ($n = 37$). Sixteen infants (15%) were born preterm (gestational week <37). We found an overall low rate of pregnancy and delivery complications.

Conclusions: Our results show predominantly favorable outcomes of pregnancy and delivery in women with spinal cord injury as well as their infants. These results are in concordance with previous research.

KEYWORDS
delivery, infertility, neonatal outcomes, population-based, pregnancy, spinal cord injury

Abbreviations: BMI, body mass index; GW, gestational week; ICD-10, International Classification of Diseases, 10th revision; MBR, The Swedish Medical Birth Register; NPR, National Patient Register; SCI, spinal cord injury; UTI, urinary tract infection.

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1 | INTRODUCTION

The literature on women with spinal cord injury (SCI) have demonstrated that sexual function is disrupted but achievable no matter the level or extent of the injury. Fertility as such is rarely affected in women with SCI following a short phase of amenorrhea in the acute phase of the injury. This is presumed to be due to a temporary rise in prolactin concentration, caused by stress from the trauma. Thus, women should anticipate to resume their pre-injury reproductivity.[1] Outcomes regarding pregnancy and delivery have been infrequently reported. Previous studies generally indicate good pregnancy outcomes. The three most recent observational studies published in 2013 (Canada), 2017 (France), and 2020 (the United Kingdom) reported a total of 37, 37, and 68 pregnancies respectively in a single-center setting.[2–4] Some of the most commonly reported pregnancy and delivery adverse outcomes include urinary tract infections, high frequency of elective cesarean section, preterm birth, increased spasticity, and worsening of decubitus ulcers.[2–5]

Damage to the spinal cord causes permanent changes in motor and sensory function below the level of the injury. It also affects the bladder, bowel, thermoregulation, and ability to control involuntary muscle movements. This is, among other things, conducive to an augmented susceptibility to infections and dermatological adversities such as pressure ulcers. Patients with SCI at or above the sixth thoracic vertebra are also at risk of developing autonomic dysreflexia, which entails episodic hypertension and concomitant bradycardia in response to visceral or somatic stimuli below the injury level. All of which makes women with SCI entail an increased risk of complications during pregnancy and childbirth.[6] Patients with SCI constitute a heterogeneous group due to the spectrum of disability depending on level and completeness of the injury. Injuries at or above the first thoracic vertebra result in tetraplegia (paresis affecting both upper and lower extremities), whereas injuries below the first thoracic vertebra result in paraplegia (paresis only affecting lower extremities).[6] Each year, 250 000–500 000 people worldwide suffer a SCI.[7] In Sweden, the incidence of traumatic SCI is estimated to be 19.0 per million, with the majority of injured patients being male.[8]

The only study concerning pregnancy and delivery among women with SCI in a Nordic setting was published in 1993. It presented the first population-based study and included 49 pregnancies in 29 SCI women in Sweden during 1980–91. The results of this study showed a successively increased incidence in births among SCI patients during the study period. It also showed generally favorable pregnancy and delivery outcomes.[9]

Limitations of previous studies include small sample sizes, single-center settings, and a retrospective design. The Swedish high-quality and extensive medical registers provide a unique opportunity to investigate this rare occurrence on a population level. The aim of this study is to describe the incidence of pregnancy in SCI women as well as pregnancy, delivery, and neonatal outcomes.

Key message

Women with spinal cord injury in Sweden have predominantly favorable outcomes of pregnancy and delivery with an overall low rate of pregnancy and delivery complications. The elevated rate of prematurity did not influence neonatal morbidity or neonatal intensive care unit admission.

2 | MATERIAL AND METHODS

Parts of this study have previously been published in a statistical report by the Swedish National Board of Health and Welfare.[10] This study was based on data from the Swedish Medical Birth Register (MBR) and the National Patient Register (NPR) provided by the Swedish National Board of Health and Welfare. The MBR contains information on antenatal, obstetric, and neonatal care and is prospectively recorded on standardized forms on more than 98% of all births in Sweden. Ninety-five percent of all pregnant women have their first antenatal visit before gestational week (GW) 15.[11] The NPR provide diagnostic codes on all hospital inpatient care since 1987. The NPR also contains data regarding sex, age, hospital, clinic, and, when applicable, external cause of injury.[12] Diagnoses in the MBR and NPR are classified according to the International Classification of Diseases 10th revision (ICD-10).

Our study population included all births in Sweden during the period 1997–2015. Women with SCI were identified with traumatic SCI, or certain disease-related SCI (eg myelitis, abscess, aortal aneurysm), in MBR (during pregnancy) and/or NPR (before pregnancy). In all cases, the SCI had occurred before delivery. The study period (from 1997) was chosen with the intention to avoid misclassification due to changes in coding policy across ICD versions. In the NPR, inclusions of women with SCI were restricted to individuals who were hospitalized for at least 30 days during the first 6 months post SCI (in order to exclude patients with less severe injuries and sequelae). The reference population consisted of all deliveries among non-SCI women in Sweden 1997–2015.

The following ICD-10 diagnoses were used to identify SCI: G82.0–5, S14.0–1, S24.0–1, S34.0–1, S34.3, T06.1, T09.3, T91.3. Restricted to the following diagnoses as main diagnosis: G042B, G048B, G048C, G049B, G06, G82, I71, M48, R, S, T, Z033, Z038, Z041, Z290, Z478, Z479, Z488, Z489, Z508, Z509, Z519, Z867, Z951.

The study population were categorized into two subgroups, tetraparesis and paraparesis, according to diagnosis (NPR and MBR does not include further information on level of lesion or completeness of injury):

Paraparesis: G82.0–2, S24.0–1, S34.0–1, S34.3

Tetraparesis: G82.3–5, S14.0–1

Unspecified (classified as paraparesis in the results): T06.1, T09.3, T91.3.

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Maternal age was categorized into younger than 20, 20–24, 25–29, 30–34, and older than 34 years. Parity was categorized as primiparous or multiparous. Body mass index (BMI) was calculated at the first antenatal visit. BMI was categorized according to the World Health Organization's definitions as underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), and obesity (BMI >29.9 kg/m^2). Data on infertility were collected from MBR and consisted of standardized questions asked at the first antenatal visit.

Ultrasound for estimating gestational age and expected date of delivery has been offered to all women in Sweden since 1990 and 95% of all women accept to undergo this procedure.[13] Gestational age at birth was based on ultrasound dating performed at GW 17–18 and defined as completed weeks. Gestational age at birth was categorized as extremely preterm (GW 22–28), very preterm (GW 29–32), preterm (GW 33–36), early term (GW 37–38), term (GW 39–41), and post-term (GW >41). Mode of delivery was categorized into non-instrumental vaginal delivery, instrumental vaginal delivery (vacuum extraction), planned cesarean section, and non-planned cesarean section. Data on analgesia and anesthesia were coded as yes/no.

We extracted the following complications from the MBR (according to ICD-10): anemia (O99.0), group B streptococcus colonization (O98.8[A]), diabetes during pregnancy (O24.0–4, O24.9), hypertension, preeclampsia and eclampsia during pregnancy (O10–O15), deep vein thrombosis (O87.1, O22.3), cerebral vein thrombosis (O87.3, O22.5), pyelonephritis (O23.0), liver disorders in pregnancy (O26.6), urinary tract infection (O23.1–2) and placental abruption (O45.8–9).

We extracted the following delivery complications from the MBR (according to ICD-10): Fetal stress (O68.0–9), premature rupture of membranes (O42.0–2, 9), fetal asphyxia (O68.0–3, O68.8–9), puerperal sepsis (O85.9), other specified puerperal infections (O86.8), postpartum hemorrhage (O72), retained placenta (O73.0), labor dystocia (O62, O63) and umbilical cord prolapse (O69.0). Anal sphincter rupture (grade 3–4) was categorized as yes/no.

The following neonatal outcomes were included: Fetal presentation (occiput anterior, occiput posterior, breech, other), infant birthweight (categorized into <3000 g, 3000–4000 g, 4001–4500 g, >4500 g), small for gestational age (ICD-10 P05.1), large for gestational age (ICD-10 P08.1), Apgar score less than 7 at 5 min postpartum, and admission to neonatal intensive care unit (categorized as yes/no).

2.1 | Statistical analyses

Data were analyzed using SAS Enterprise Guide version 8.3. Births in women with SCI were categorized into births to women with paraplegia, tetraplegia or both, and were compared with births among all other, non-SCI women using frequency and proportions. The results are presented as descriptive statistics, rather than inferential statistics, as our study population is neither a random sample nor a total population. The study population consists of all traumatic SCI and a selection of non-traumatic SCI. Fifty-four deliveries were identified in NPR and 55 deliveries were identified in MBR. As the study period in NPR is the same as in the MBR, the number of women identified in NPR will increase as time goes by, eg in 1998 the study population included women injured in 1997–98, and in 2015 the study population included women injured in 1997–2015. Hence, even though this study covers all births in Sweden 1997–2015 and the national registers are of high quality and coverage, the definition of the study population (at our best effort according to register data) gives that the conditions for statistical testing are not met. Therefore, the results shall merely be interpreted as a description of deliveries in this specific study population.

2.2 | Ethics statement

This study was conducted within the responsibility of the Swedish National Board of Health and Welfare, which is a governmental agency. The population registers may be used for studies of health and medical care as well as social services. All data were obtained from registers kept by the Swedish National Board of Health and Welfare and all methods were carried out in accordance with relevant guidelines and regulations. The registers used in this study are highly protected; only pseudonymized data are used and all work was conducted within the Agency's firewall. Hence, no ethical approval was needed.

3 | RESULTS

Between 1997 and 2015, 109 infants were born to 89 women with SCI. Of these, 89 deliveries were in women with paraplegia and 20 in women with tetraplegia. The SCI population represented less than 0.0005% of all births in Sweden during the study period. A majority of the deliveries took place in the last 6 years of the study period (16 deliveries in 1997–2003, 34 deliveries in 2004–09, and 59 deliveries in 2010–15). Women with SCI in our study population were leaner in general with 8% being underweight (BMI <18.5 kg/m^2) and 61% being normal weight (BMI 18.5–24.9 kg/m^2) compared with the general population, where the corresponding numbers were 2% and 55%, respectively. Table 1 shows maternal characteristics of the paraplegic and tetraplegic deliveries, respectively.

The self-reported prevalence of recurrent urinary tract infections (UTI) before pregnancy was 62% among women with paraplegia and 40% among women with tetraplegia. The corresponding number in the general population was 12%. Pre-conception morbidity is further described in Table 1. In this study population, UTI during pregnancy was reported in 6% of women in the paraplegic group and none in the tetraplegic group compared with 0.2% in the general population. Eight percent of women with SCI in our study population had pregnancies complicated by anemia, compared with 4% in the general population. Group B streptococcus colonization was present in 6% of SCI pregnancies compared with 2% in the reference group. No cases of gestational diabetes, cerebral venous thromboembolism, deep vein thrombosis, or pregnancy-related liver

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TABLE 1 Maternal characteristics in spinal cord injured women and the general population in Sweden 1997–2015

	General population	Paraplegia	Tetraplegia	Total SCI
Total no. of pregnancies	*n* = 1 949 688	*n* = 89	*n* = 20	*n* = 109
	n (%)	*n* (%)	*n* (%)	*n* (%)
Maternal age at delivery (years)				
<20	31 785 (2)	[a]	[a]	[a]
20–29	852 325 (44)	43 (48)	5 (25)	48 (44)
30–34	666 660 (34)	24 (27)	10 (50)	34 (31)
>34	391 450 (20)	19 (21)	5 (25)	24 (22)
Data missing	7468 (0)	[a]	[a]	[a]
Body mass index (at first antenatal visit)				
Underweight	43 209 (2)	[a]	[a]	9 (8)
Normal weight	1 066 085 (55)	56 (63)	10 (50)	66 (61)
Overweight	433 230 (22)	12 (13)	3 (15)	15 (14)
Obesity	203 130 (10)	[a]	[a]	5 (5)
Data missing	204 034 (10)	10 (11)	4 (20)	14 (13)
Parity				
Primipara	846 350 (43)	51 (57)	9 (45)	60 (55)
Multipara	1 100 463 (56)	38 (43)	11 (55)	49 (45)
Cigarette smoker				
Yes	153 789 (8)	[a]	[a]	10 (9)
Data missing	107 364 (5)	[a]	[a]	3 (3)
Preconception morbidity (self-reported)				
Recurrent urinary tract infections	233 544 (12)	55 (62)	8 (40)	63 (58)
Epilepsy	8547 (0.4)	0	0	0
Hypertension	7552 (0.4)	[a]	[a]	[a]
Diabetes type 1	10 254 (0.5)	0	0	0

[a]Not reported because *n* was less than 3 in one or more categories.

TABLE 2 Antenatal complications in spinal cord injured women and the general population in Sweden 1997–2015

	General population	Paraplegia	Tetraplegia	Total SCI
Total no. of pregnancies	*n* = 1 949 688	*n* = 89	*n* = 20	*n* = 109
	n (%)	*n* (%)	*n* (%)	*n* (%)
Gestational diabetes	30 561 (2)	0	0	0
Pre-eclampsia	73 592 (4)	[a]	[a]	8 (7)
Multiple pregnancy	57 388 (3)	[a]	[a]	[a]
Urinary tract infection	4588 (0.2)	5 (6)	0	5 (5)
Anemia	71.305 (4)	[a]	[a]	9 (8)
Group B streptococcus	29.990 (2)	[a]	[a]	7 (6)

[a]Not reported because *n* was less than 3 in one or more categories.

disorder were reported among the deliveries by SCI women in this material. Pregnancy complications are further described in Table 2.

Twenty percent of paraplegic women and none of the tetraplegic women had induced onset of delivery. Instrumental vaginal birth occurred in in 9% of women with SCI. Thirty-six percent of the deliveries in women with paraplegia and 50% in women with tetraplegia were non-instrumental vaginal deliveries, compared with 71% in the general population. Cesarean section (planned and non-planned) was the most common mode of delivery among women with SCI with general anesthesia being used in 49%. The corresponding number in the general population was 18%. Epidural analgesia was used less often in women with SCI than in the reference population, 10% in the

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paraplegic group and none in the tetraplegic group compared with 29% in the general population. Few adverse outcomes could be observed in the SCI group, obstetric outcomes are further described in Table 3.

A total of 15% of infants born to women with SCI were born preterm (GW <37), most were born term (GW 37–41). In the general population, 5% of infants were born preterm. Very few infants (<2%) had an Apgar score below 7 at 5 min. Four percent ($n = 4$) of 89 infants of paraplegic women in this study population were cared for at the neonatal unit; however, none of the 20 infants of tetraplegic women needed neonatal intensive care. Less than 2% of infants among the SCI mothers were considered small for gestational age and none was deemed large for gestational age. Neonatal outcomes are further described in Table 4.

A slightly higher percentage of women with SCI in this population sought medical care for infertility lasting more than 1 year

TABLE 3 Obstetric outcomes in spinal cord injured women and the general population in Sweden 1997–2015

	General population	Paraplegia	Tetraplegia	Total SCI
Total no. of pregnancies	$n = 1\,949\,688$	$n = 89$	$n = 20$	$n = 109$
	n (%)	*n* (%)	*n* (%)	*n* (%)
Mode of delivery				
Non-instrumental vaginal	1 377 609 (71)	32 (36)	10 (50)	42 (39)
Instrumental vaginal	132 135 (7)	[a]	[a]	10 (9)
Planned CS	166 592 (9)	29 (33)	8 (40)	37 (34)
Non-planned CS	165 989 (9)	[a]	[a]	16 (15)
Induction of labor	243 021 (12)	18 (20)	0 (0)	18 (17)
Stillbirth	7027 (0.4)	[a]	[a]	[a]
Pain relief				
Nitrous oxide	1 361 209 (70)	34 (38)	7 (35)	41 (38)
Epidural analgesia	566 190 (29)	9 (10)	0 (0)	9 (8)
Spinal analgesia	253 398 (13)	16 (18)	6 (30)	22 (20)
Fetal presentation				
Occiput anterior	1 673 148 (86)	74 (83)	15 (75)	89 (82)
Occiput posterior	77 553 (4)	[a]	[a]	3 (3)
Breech	72 891 (4)	[a]	[a]	7 (6)
Other	37 969 (2)	[a]	[a]	6 (6)
Data missing	88 127 (5)	[a]	[a]	4 (4)
Total no. of cesarean sections	$n = 332\,581$	$n = 44$	$n = 9$	$n = 53$
	n (%)	*n* (%)	*n* (%)	*n* (%)
General anesthesia	59 923 (18)	23 (52)	3 (33)	26 (49)
Total no. of vaginal births	$n = 1\,509\,744$	$n = 41$	$n = 11$	$n = 52$
	n (%)	*n* (%)	*n* (%)	*n* (%)
Signs of fetal distress	128 849 (7)	[a]	[a]	6 (6)
Premature rupture of membranes	31 392 (2)	[a]	[a]	3 (3)
Labor dystocia	203 415 (10)	6 (7)	0 (0)	6 (6)
Anal sphincter tears	37 738 (2)	[a]	[a]	[a]
Umbilical cord prolapse	8121 (0.4)	[a]	[a]	[a]
Postpartum hemorrhage	89 193 (5)	3 (3)	0 (0)	3 (3)
Retained placenta	163 696 (8)	[a]	[a]	4 (4)

Abbreviations: CS, cesarean section; Other, face presentation, brow presentation, and transverse lie.

[a]Not reported because *n* was less than 3 in one or more categories.

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TABLE 4 Neonatal outcomes in spinal cord injured women and the general population in Sweden 1997–2015

	General population	Paraplegia	Tetraplegia	Total SCI
Total no. of pregnancies	*n* = 1 949 688	*n* = 89	*n* = 20	*n* = 109
	n (%)	*n* (%)	*n* (%)	*n* (%)
Length of gestation (completed weeks at birth)				
22–28	9028 (0.5)	[a]	[a]	[a]
29–32	1071 (0.9)	4 (4)	0 (0)	4 (4)
33–36	93 903 (5)	[a]	[a]	11 (10)
37–38	371 758 (19)	30 (34)	9 (45)	39 (36)
39–41	1 321 643 (68)	38 (43)	8 (40)	46 (42)
>41	134 996 (7)	[a]	[a]	[a]
Birthweight (g)				
<3000	297 976 (15)	30 (34)	3 (15)	33 (30)
3000–4000	1 286 929 (66)	53 (60)	15 (75)	68 (62)
4001–4500	288 684 (15)	[a]	[a]	7 (6)
>4500	70 764 (4)	[a]	[a]	[a]
Apgar score <7 at 5 min postpartum	26 247 (1)	5 (6)	0 (0)	5 (5)
Data missing	17 157 (0.9)	[a]	[a]	[a]
SGA	44 653 (2)	[a]	[a]	[a]
LGA	68 501 (4)	0 (0)	0 (0)	0 (0)
Neonatal intensive care admission	134 872 (7)	4 (4)	0 (0)	4 (4)

Abbreviations: LGA, large for gestational age; SGA, small for gestational age.

[a]Not reported because *n* was less than 3 in one or more categories.

TABLE 5 Infertility in spinal cord injured women and the general population in Sweden 1997–2015

	General population	Paraplegia	Tetraplegia	Total SCI
Total no. of pregnancies	*n* = 1 949 688	*n* = 89	*n* = 20	*n* = 109
	n (%)	*n* (%)	*n* (%)	*n* (%)
Infertility duration (self-reported at first antenatal visit)				
1 year	54 844 (3)	[a]	[a]	4 (4)
2 years	46 343 (2)	[a]	[a]	4 (4)
>2 years	60 558 (3)	5 (6)	0 (0)	5 (5)
Reproductive technology (self-reported at first antenatal visit)				
In vitro fertilization	49 211 (3)	[a]	[a]	[a]
Ovulation stimulation	25 272 (1)	[a]	[a]	[a]
Other	13 830 (0.7)	[a]	[a]	[a]
		[a]	[a]	

[a]Not reported because *n* was less than 3 in one or more categories.

(self-reported at the first antenatal visit) compared with the reference population. Detailed information regarding duration of infertility and use of assisted reproductive technology is presented in Table 5.

4 | DISCUSSION

In this nationwide cohort study, we found that women with SCI generally had favorable obstetric and neonatal outcomes. Pregnancy in women with SCI is increasing but is still a rare event because women constitute a minority of the total SCI patient population. Not all women have children post-SCI and age at SCI onset is steadily increasing.[10] Women with SCI in this study population had higher rates of cesarean sections and preterm birth compared with the general population. Otherwise, the difference in investigated adverse outcomes for both mother and infant were marginal compared with the normal population. This should be regarded in light of Sweden having no centralized SCI care and that the women in this study gave

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birth at hospitals throughout Sweden. A potential reason for the overall favorable results may be that the women who do get pregnant and have children post SCI represent a natural selection of the healthiest women of fertile age in the SCI group.

A large proportion of SCI women in our material reported repeated UTIs before pregnancy. UTIs are common in SCI patients because of bladder management.[5,14] The most common method among SCI patients, in Stockholm as of 2019, being intermittent catheterization followed by normal, voluntary micturition and suprapubic catheter.[15] We did not have access to data regarding type of bladder management in our described cohort. What was unexpected was the low incidence of UTIs during pregnancy in our sample. It has previously been reported as one of the most common pregnancy complications among SCI women.[5] There might have been underreporting but, considering the high quality and coverage of the registers used in this study, we consider the impact of this to be marginal. We cannot exclude that prophylactic antibiotics have been administered during pregnancy due to history of recurrent UTI. There is no consensus regarding the use of prophylactic antibiotics, and clinical practice may differ in the various antenatal clinics throughout the country.[5]

Colonization of group B streptococcus was slightly higher in women with SCI in our material compared with the normal population, 6% and 2%, respectively. There is no routine group B streptococcus screening of pregnant women in Sweden, one could hypothesize that women with SCI have more urine cultures analyzed, which could result in the increase that we have observed.

We also found a high frequency of cesarean sections among women with SCI in our study population, albeit lower than in comparable studies.[2–4,16] The reason for this is unclear, whether the predominant indications for the elevated cesarean section rates are obstetric or whether medical providers were unfamiliar with how to deal with patients with SCI. This cannot be elucidated from our data. An American study from 2013 concluded that routine indications for cesarean section in this population were "elective repeat procedure, failure in progress in labor, and pelvic instability".[2] Women with SCI are able to deliver vaginally and it has previously been demonstrated that obstetric outcomes are predominantly favorable.[16] The internationally reported elevated rate of elective cesarean section in the SCI population is probably also influenced by the rate of elective cesarean section in the general population of the country or hospital studied. This can make results less generalizable depending on nationality.

The majority of studies on women with SCI conclude that cesarean section should only be performed on individual preference, obstetric or acute indications and that the majority of women with SCI are able to, and benefit from, giving birth vaginally.[4,16,17] A recent study from Stoke Mandeville Hospital in the UK, an internationally renowned National Spinal Injuries Center and one of the largest specialist SCI units in the world, reported that 77% of their SCI women delivered vaginally (during a study period from 1991 to 2016).[4] Our study showed a non-instrumental vaginal birth rate of 39% and an instrumental vaginal birth rate of 9% with births occurring in non-specialized units, which we believe highlights the need for specialized obstetric care in this patient population.

We also found that 49% of all cesarean sections (planned and non-planned) in women with SCI used general anesthesia, compared with 18% in the general population. There was a slightly higher frequency of non-planned cesarean sections in the SCI group in this material (15% in women with SCI compared with 9% in women in the general population), which may account for some of the increase in general anesthesia. There is also the mechanical aspect of spinal or epidural analgesia in patients with a previously broken back. Patients with SCI might have remaining spinal osteosynthetic metalware and a permanently altered spinal anatomy, making spinal or epidural analgesia unfeasible.[18] The literature on obstetric anesthesia in women with SCI is sparse and the lack of evidence is probably exacerbated by the lack of experience of labor and delivery in this patient group. It is not unreasonable to believe that the number of women undergoing general anesthesia in order to deliver by cesarean section could be lower if treated by an anesthesiologist with experience in SCI.

There was also less use of epidural analgesia during birth in women with SCI in our material. Women with spinal lesions at or above the sixth thoracic vertebra can develop potentially life-threatening autonomic dysreflexia during vaginal birth as the result of painful stimuli below the injury level, the risk of this attenuates with epidural analgesia.[19] In our material, we found that none of the 11 tetraplegic women who went through instrumental and non-instrumental vaginal delivery had epidural analgesia during delivery. As with general anesthesia during cesarean section, anatomy of the spine, lack of evidence, and lack of experience in this patient category probably influence these results. This potentially exacerbates the risk of autonomic dysreflexia during vaginal birth and may in turn increase the risk of acute cesarean section and potential harm for mother and infant.

In our study population 16 infants (15%) were born preterm (GW <37), which is in line with previous studies. Several theories regarding the high prematurity rate in this population have previously been proposed. Possible reasons include lack of sensation in the uterus and cervix as well as high rates of infection, primarily from the urinary tract.[1,5,17] Sensation in the uterus and cervix propagates at the 10th thoracic vertebra, which indicates that women with spinal lesions below the 10th thoracic vertebra have a higher chance to perceive preterm delivery and therefore seek care in time to counteract it.[6] As a result of the nature of the register data, we are not able to draw any conclusions regarding reasons for preterm birth in our study population. We did however observe a low rate of neonatal morbidity with very few cases being admitted to a neonatal intensive care unit. With the small study population, this could of course be due to chance and these data should be considered with caution.

Fertility in women is generally not affected by SCI once the acute phase of the injury has passed and women with SCI should recover their pre-injury reproductivity.[1] To our knowledge this study is among the first to cover infertility in the female SCI population. However, our results are limited by several factors. The data are self-reported, we are also not able to distinguish between primary

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vs secondary infertility and we lack data regarding miscarriages. It is of course also possible that male factors may have influenced the data. However, we did not find any cases of intracytoplasmic sperm injection. Regardless of these limitations, the data should mirror the reference population fairly well because they are reported to the register in the same way. We observed a slightly lower need for treatment in order to conceive compared with the general population. The reasons for this are unclear. It is not possible to draw any major conclusions regarding this because of the few infertility cases.

A main strength of this study was the national cohort design with a large sample size based on registers with a high coverage of pregnancy and delivery characteristics, which strengthens the reliability of our data. This made us able to retain and analyze rare diagnoses and outcomes. Information in the registers is collected prospectively, which limits recall bias. The reference population was very large, which makes it a trustworthy comparison group.

A major limitation of this study is that registers do not provide detailed information about many important factors and decisions in the clinical environment. As a result of the pseudonymized nature of the register, we are not able to verify information to the individual patient's medical records. We are also not able to connect the different outcome data points to each other and therefore are not able to address causality in the different outcomes. Another limitation is the lack of information regarding level and completeness of SCI. The ICD classification is blunt and only categorizes patients into tetraplegic or paraplegic. The results are presented as descriptive statistics, rather than inferential statistics, as our study population is neither a random sample nor a total population, and so the results should be interpreted with caution.

5 | CONCLUSION

Although there is no specialized obstetric SCI care in Sweden, our results show that outcomes of pregnancy and delivery in women with SCI are predominantly favorable with marginal discrepancies in adverse outcomes compared with the normal population. In our population, the elevated prematurity rate did not influence neonatal morbidity or admission to the neonatal intensive care unit.

AUTHOR CONTRIBUTIONS

MK contributed to conceptualization, formal analysis, writing (original draft, review and editing), and project administration. MB contributed to methodology, formal analysis, and data curation. KP contributed to writing (review) and clinical consulting. CL contributed to writing (review and editing). CH contributed to conceptualization and writing (review and editing). CE contributed to conceptualization, writing (review and editing), and supervision.

CONFLICT OF INTEREST

None.

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