

# Trends in the incidence, rate and treatment of miscarriage—nationwide register-study in Finland, 1998–2016

R. Linnakaari<sup>1,2,†</sup>, N. Helle<sup>2,†</sup>, M. Mentula<sup>2</sup>, A. Bloigu<sup>3,4</sup>, M. Gissler<sup>5,6</sup>,  
O. Heikinheimo<sup>2,\*</sup>, M. Niinimäki<sup>3,4,7</sup>

<sup>1</sup>Department of Obstetrics and Gynaecology, South Karelia Central Hospital, 53130 Lappeenranta, Finland <sup>2</sup>Department of Obstetrics and Gynaecology, University of Helsinki and Helsinki University Hospital, 00029 Helsinki, Finland <sup>3</sup>Department of Obstetrics and Gynaecology, Oulu University Hospital, 90220, Oulu, Finland <sup>4</sup>PEDEGO Research Unit, University of Oulu, Oulu, Finland <sup>5</sup>National Institute for Health and Welfare (THL), 00300 Helsinki, Finland <sup>6</sup>Department of Neurobiology, Care Sciences and Society, Karolinska Institute, SE-171 77 Stockholm, Sweden <sup>7</sup>Medical Research Center Oulu (MRC Oulu), University of Oulu, Oulu, Finland

\*Correspondence address. Department of Obstetrics and Gynaecology, Helsinki University Hospital, PO Box 140, FI-00029 HUS Helsinki, Finland. Tel: +358-50-427 1533; E-mail: oskari.heikinheimo@helsinki.fi

Submitted on April 10, 2019; resubmitted on August 2, 2019; editorial decision on September 6, 2019

**STUDY QUESTION:** What changes have occurred in the incidence of miscarriage, its treatment options, and the profile of the women having miscarriages in Finland between 1998 and 2016?

**SUMMARY ANSWER:** The annual incidence of registry-identified miscarriage has declined significantly between 1998 and 2016, and non-surgical management has become the dominant treatment.

**WHAT IS KNOWN ALREADY:** Miscarriage occurs in 8–15% of clinically recognized pregnancies and in ~30% of all pregnancies. Increasing maternal age is associated with an increasing risk of miscarriage. The treatment of miscarriage has evolved significantly in recent years: previously, surgical evacuation of the uterus was the standard of care, but nowadays medical and expectant management are increasingly used.

**STUDY DESIGN, SIZE, DURATION:** We conducted a nationwide retrospective cohort study of 128 381 women that had experienced a miscarriage that was managed in public healthcare between 1998 and 2016 in Finland.

**PARTICIPANTS/MATERIALS, SETTING, METHODS:** We used the National Hospital Discharge Registry for the data. Women aged 15–49 years that had experienced their first miscarriage during the follow-up period and had miscarriage-related diagnoses during their admission to public hospital were included in the study. Miscarriages were defined by the 10<sup>th</sup> Revision of the International Statistical Classification of Diseases and related Medical Problems (ICD-10) diagnostic codes O02\*, O03\* and O08\*. Women with ectopic, molar and continuing pregnancies and induced abortions were excluded. Treatment was divided into surgical and non-surgical treatment using the surgical procedure codes.

**MAIN RESULTS AND THE ROLE OF CHANCE:** The annual incidence of registry-identified miscarriage has declined from 6.8/1000 15–49-year-old women in 1998 to 5.0/1000 in 2016 ( $P < 0.001$ ). Also, the incidence rate of registry-identified miscarriage (i.e. the proportion of miscarriages of registry-identified pregnancies [i.e. deliveries, induced abortions, and miscarriages]) has declined from 112/1000 15–49-year-old pregnant women in 1998 to 83/1000 in 2016 ( $P < 0.001$ ). The largest decrease in this proportion occurred among women over 40 years of age, among whom 26.5% of registry-identified pregnancies in 1998 ended in miscarriage compared to that of 16.4% in 2016. The proportion of missed abortion has increased (30.3 to 38.8%,  $P < 0.001$ ) whereas that of blighted ovum has decreased (25.4 to 12.8%,  $P < 0.001$ ). The proportion of registry-identified miscarriages seen among nulliparous women has increased from 43.7 to 49.6% ( $P < 0.001$ ). Mean age at the time of miscarriage remained at 31 years throughout the study. Altogether, 29% of all miscarriages were treated surgically and 71% underwent medical or expectant management. The proportion of surgical management has decreased from 38.0 to 1.6% for spontaneous abortion, from 60.7 to 9.4% for blighted ovum and 70.9 to 11.2% for missed abortion between 1998 and 2016.

**LIMITATIONS, REASONS FOR CAUTION:** This study includes only women with registry-identified pregnancies, i.e. women who were treated in public hospitals. However, the number of women treated elsewhere is presumed to be small. Neither can this study estimate the number of women having spontaneous miscarriage with no hospital contact.

**WIDER IMPLICATIONS OF THE FINDINGS:** Both the annual incidence and incidence rate of miscarriage of all registry-identified pregnancies has decreased, and non-surgical management has become the standard of care. These findings are of value when planning allocation

<sup>†</sup>The authors consider that the first two authors should be regarded as joint first authors.

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of healthcare resources and at individual level considering fertility and miscarriage questions. We speculate that improving ultrasound diagnostics explains the increasing proportion of missed abortion relative to other types of miscarriage. More investigation is needed to examine potential risk factors, complications and morbidity associated with miscarriages.

**STUDY FUNDING/COMPETING INTEREST(S):** This study was funded by the research funds of the Helsinki and Uusimaa hospital system, by a personal grant from Viipurin Tuberkuloosisäätiö to R.L. and by a personal grant from The Finnish Cultural Foundation to N.H. The authors have no conflicts of interest to declare.

**Key words:** miscarriage / spontaneous abortion / blighted ovum / missed abortion / treatment of miscarriage

## Introduction

Approximately 8–15% of clinically recognized pregnancies end in a miscarriage (Warburton and Fraser, 1964; Regan et al., 1989; Wang et al., 2003). However, it has been estimated that about 30% of all pregnancies result in a miscarriage. (Wilcox et al., 1988; Wang et al., 2003; Griebel et al., 2005). Thus, miscarriage is the most common adverse outcome of pregnancy (Jurkovic et al., 2013; Feodor Nilsson et al., 2014). The majority of miscarriages occur in the first trimester of pregnancy (Regan and Rai, 2000).

The treatment of early miscarriage has evolved significantly in recent years. Previously, the standard treatment of miscarriage was surgical evacuation of the uterus, but medical and expectant management is now increasingly used (Graziosi et al., 2006; Smith et al., 2009). For a long time, it was assumed that the surgical evacuation decreases the risk of gynaecologic infection and haemorrhage. However, it has recently been recognized that surgical management carries certain risks as well. In a randomized controlled MIST trial performed in the UK, there were no significant differences in the rate of infections after surgical versus expectant or medical management of miscarriage (Trinder et al., 2006). Medical management using misoprostol is the newest treatment option and also recommended by the current WHO guideline (Lemmers et al., 2016b; World Health Organization, 2018). A recent randomized study showed that pre-treatment with mifepristone prior to misoprostol administration leads to better outcome and reduces the need for subsequent uterine evacuation for retained products of conception (Schreiber et al., 2018).

Following approval of mifepristone in several EU countries in the early 2000s, the use of medically induced abortion has increased rapidly, especially in northern European countries (Männistö et al., 2013; THL (National Institute for Health and Welfare), 2019). Similarly, medical management of miscarriage is being increasingly used (Zhang et al., 2005). There are several studies concerning the use and outcomes of medical termination of pregnancy, but much less has been published concerning use of the various treatment options for miscarriage (Kulier et al., 2011; Wildschut et al., 2011; Al Wattar et al., 2019).

The aim of the present population-based study was to analyse the profile of women and the trends in incidence and proportions and in treatment of miscarriage at a national level. To this end, we used the high-quality Finnish healthcare registers between 1998 and 2016.

## Materials and Methods

### Study population and design

This nationwide retrospective cohort study included all miscarriages managed in public hospitals in Finland between 1998 and 2016. Data

were derived from the National Hospital Discharge Registry maintained by the National Institute for Health and Welfare. Miscarriage was defined based on the diagnostic codes (10<sup>th</sup> version of International Classification of Diseases and related Health Conditions, ICD-10): O02\*, O03\* and O08\*. Fertile-age women (15–49 years) who had one or more miscarriages leading to inpatient or outpatient admission to hospital were included in the study (Fig. 1). The first miscarriage during the follow-up period was studied.

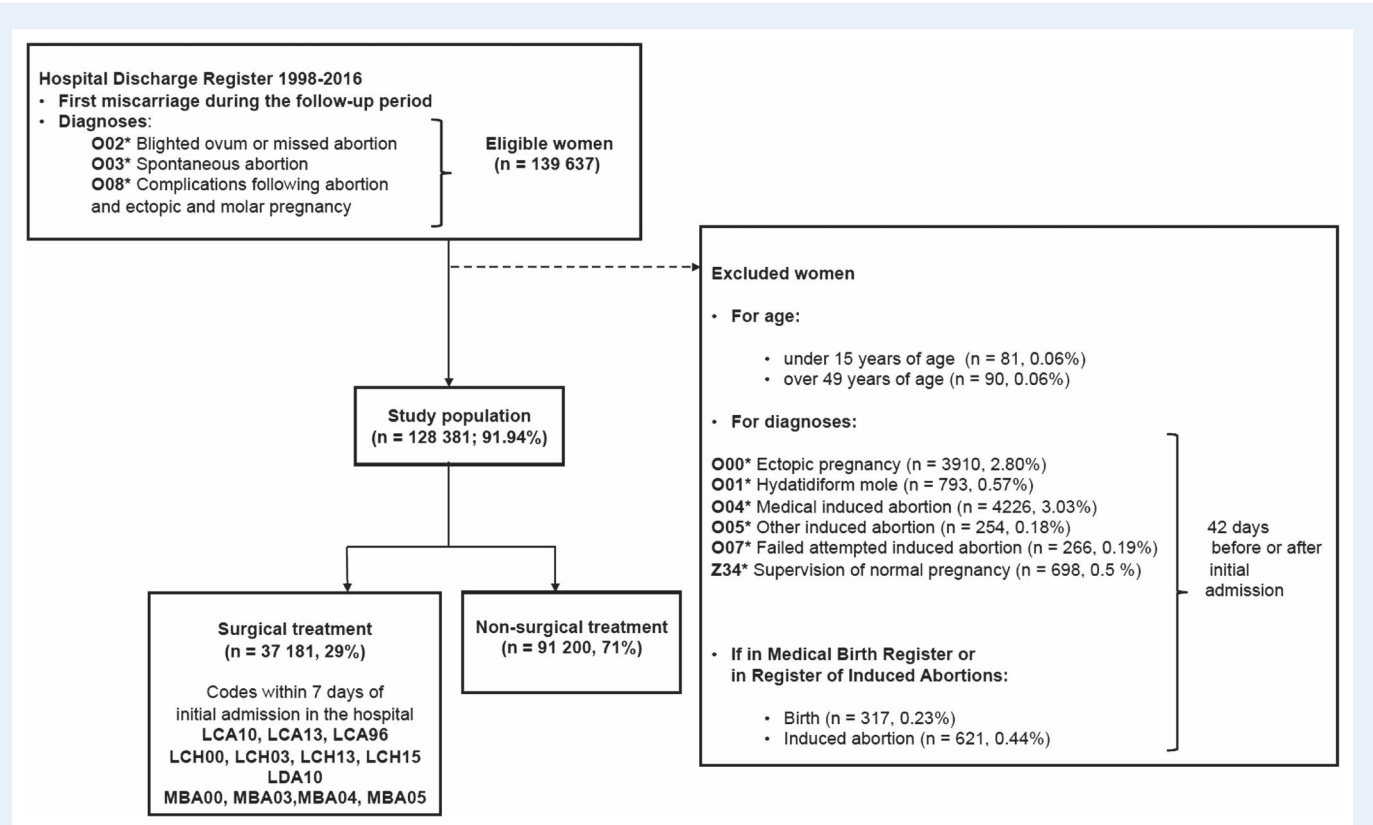
In order to identify true miscarriages, women with the diagnostic code of ectopic pregnancy (O00\*), molar pregnancy (O01\*), induced abortions (O04\*, O05\*, O07\*) or continuing pregnancy (Z34\*) were excluded ( $n = 10\,147$ ). This was performed by comparing the ICD-10 diagnostic codes at the time of miscarriage and during the 42 days following the first diagnosis. Women with note of a birth or an induced abortion 42 days before or after the first miscarriage diagnosis in the Medical Birth Register (MBR) or Register of Induced Abortions (RIA) were also excluded (Fig. 1).

Based on the diagnostic codes, miscarriages were classified into four groups: blighted ovum (O02.0), missed abortion (O02.1), spontaneous abortion (O03.9) and others (including e.g. incomplete spontaneous abortion; incomplete spontaneous abortion, complicated by delayed or excessive haemorrhage and complete or unspecified spontaneous abortion, complicated by delayed or excessive haemorrhage). We used MBR and RIA to identify the possible previous deliveries and induced abortions. MBR was started in 1987 so we could not obtain any data before that year. The data from RIA, about induced abortions, was gathered from the year 1998. We had no information on the parity of altogether 132 women (0.1%).

We further evaluated the trends in the treatment of registry-identified miscarriage. The treatment procedures were divided into surgical and non-surgical (medical or expectant). We identified the surgical treatments using NOMESCO Classification of Surgical Procedures (NCSP) codes (Fig. 1). We included all codes indicative of surgical treatment of miscarriage within 7 days and within 1 month after the initial admission to the hospital. The expectant management and medical treatment could not be reliably differentiated from each other by using ICD-10 and NCSP codes, and thus, they were analysed as one group.

### Study approvals

We obtained an approval for this study from the National Institute for Health and Welfare (THL/841/5.05.00/2017). The data were anonymized prior to analyses. Because of the retrospective nature of the register-based study, no approval was required from the local ethics committee.



**Figure 1 Flow diagram of the study.** The procedure codes, which defined the surgical treatment were LCA10 (curettage of body of uterus), LCA13 (curettage of cervix and body of uterus), LCA96 (other intrauterine operation), LCH00 (evacuation of retained products of conception; vacuum aspiration or curettage), LCH03 (evacuation of products of conception and curettage of uterus), LCH13 (evacuation of retained products of conception after medically induced abortion; vacuum aspiration or curettage), LCH15 (evacuation of retained products of conception after surgical induced abortion; vacuum aspiration or curettage), LDA10 (curettage of cervix uteri), MBA00 (Vacuum aspiration from uterus after delivery or abortion), MBA03 (curettage of uterus after delivery or abortion), MBA04 (curettage of uterus after delivery) and MBA05 (curettage of uterus after abortion).

## Statistical analyses

For the annual incidence of registry-identified miscarriage, we divided the number of miscarriages by the total number of 15–49-year-old fertile-aged women in Finland and the incidence rate by 15–49-year-old pregnant women in Finland (women with pregnancy ending in birth, induced abortion or miscarriage according to register-based data). The chi-square test for trend was used to assess significant trends in proportions over the study period. The possible trend in average age over time was examined using analysis of variance with linear trend test. Correlations were tested using Spearman's correlation coefficient. Analyses were carried out with IBM SPSS Statistics 24.0 (Armonk, NY: IBM Corp., USA).

Joinpoint Regression Program 4.7.0.0 (Statistical Research and Applications Branch, National Cancer Institute, USA) was used to analyse the miscarriage incidence trends. Joinpoint analysis identifies the best inflexion points at which the trend line changes significantly in direction or in magnitude using permutation tests. The joinpoint analysis further generates the estimates of the annual percentage change (APC) with 95% confidence intervals (95% CI) for the time segments. A significance level of 0.05 was used for all analyses.

## Results

### Incidence of miscarriage

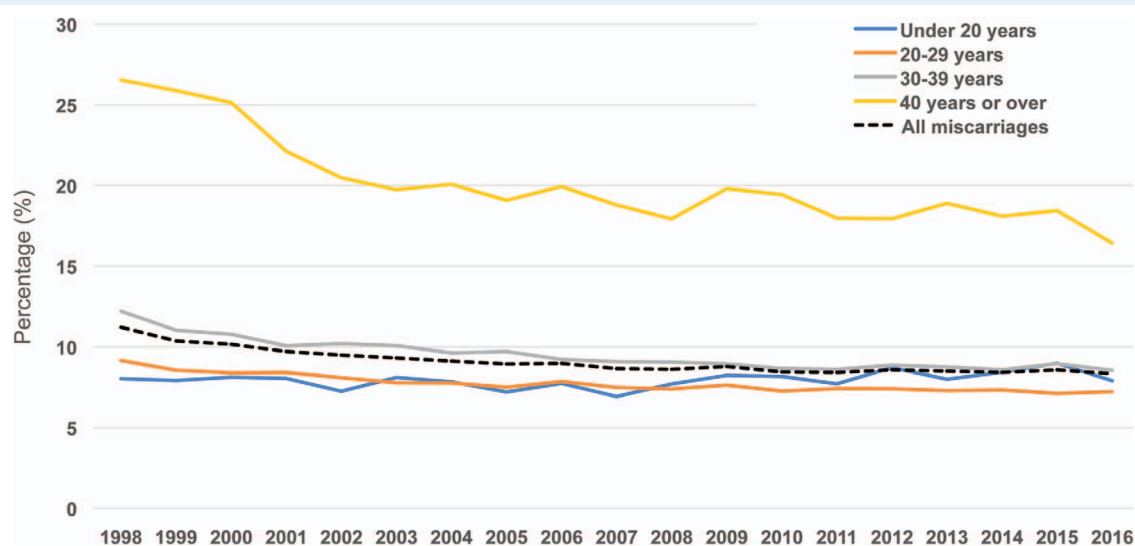
Between 1998 and 2016, we identified altogether 128 381 women that had experienced miscarriage (Fig. 1). Table 1 shows the baseline characteristics of the study subjects. Data on previous miscarriages and induced abortions were obtained from MBR and RIA for women with a history of delivery ( $n = 69 561$ ).

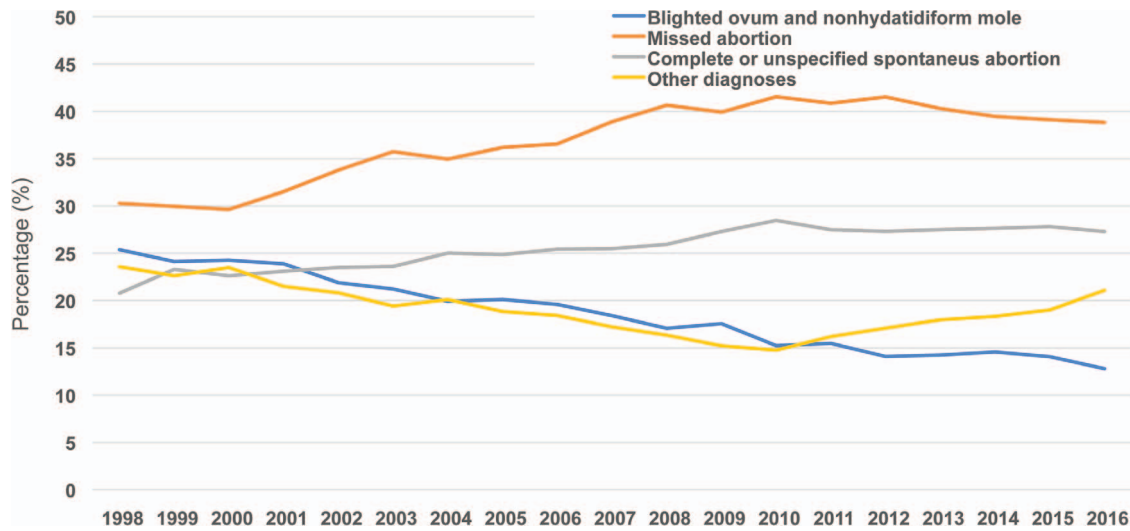
The annual incidence of registry-identified miscarriage has declined from 6.8/1000 15–49-year-old women in 1998 to 5.0/1000 in 2016 ( $P < 0.001$ ). Also, the incidence rate of registry-identified miscarriage (i.e. the proportion of miscarriages of registry-identified pregnancies [i.e. deliveries, induced abortions and miscarriages]) has declined from 112/1000 15–49-year-old pregnant women in 1998, to 83/1000 in 2016 ( $P < 0.001$ ). The total number of miscarriages during the study period in relation to registry-identified pregnancies and in different age groups is presented in Fig. 2. Among women aged 40 years or more, the incidence rate of miscarriage declined from 265/1000 registry-identified pregnancies in 1998, to 164/1000 in 2016 ( $P < 0.001$ ).

According to the joinpoint analyses, miscarriage incidence declined significantly during the study period. In relation to fertile-aged

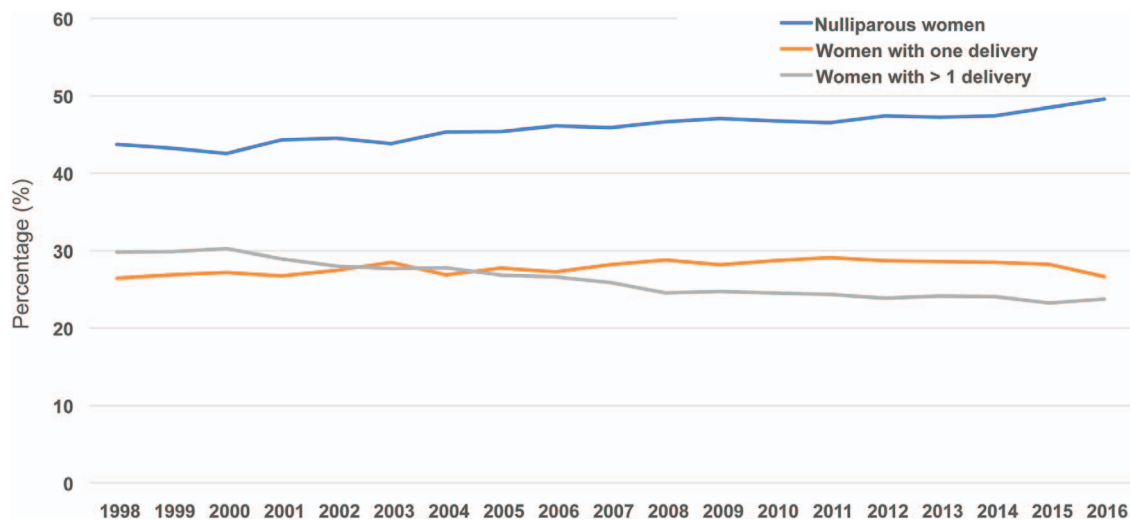
**Table 1** Demographic characteristics according to time and age group (years).

Years	Age group	Miscarriages, n (% of group)	Parity % <sup>a</sup>		Induced abortions in parous women % <sup>b</sup>			Miscarriages in parous women % <sup>c</sup>			Mean age at the time of miscarriage (SD)
			0	≥1	0	1	≥2	0	1	≥2	
1998–2001	15–19	1369 (4.4)	91.5	8.5	82.8	16.4	0.9	97.4	0.9	1.7	18.4
	20–29	11 805 (38.2)	54.2	45.8	88	9.2	2.9	86.3	11.2	2.5	25.8
	30–39	14 460 (46.8)	31.1	68.9	88.4	8.5	3.1	78	16.1	5.9	34.5
	40–49	3263 (10.6)	39.4	60.6	89.3	7.7	3	62.3	22.6	15.1	42.5
	Total n	30 897	13 401	17 437	14 599	1433	493	13 746	2647	1019	31.3 (6.6)
2002–2006	15–19	1669 (4.9)	91.2	8.8	77.6	19	3.4	93.9	6.1	0	18.5
	20–29	13 651 (40.1)	56.5	43.5	82.8	12.7	4.5	92.8	5.9	1.3	25.8
	30–39	15 354 (45.1)	33.3	66.7	83.4	11.3	5.2	85.2	11.4	3.4	34.6
	40–49	3343 (9.8)	28.9	71.1	80.9	12.1	7	74.4	17.6	8	42.3
	Total n	34 017	15 306	18 676	15 214	2190	954	16 117	1938	612	31.0 (6.6)
2007–2011	15–19	1457 (4.4)	91.7	8.3	81.8	15.7	2.5	95	5	0	18.6
	20–29	13 327 (40.6)	57.8	42.2	80.5	14.4	5.1	94.2	5.1	0.7	25.8
	30–39	14 821 (45.2)	35.8	64.2	82.3	12.3	5.4	90	8.2	1.8	34.3
	40–49	3184 (9.7)	28.8	71.2	76.6	15.1	8.3	79.7	15.4	4.9	42.3
	Total n	32 789	15 260	17 497	14 101	2330	982	15 754	1415	322	31.0 (6.5)
2012–2016	15–19	1142 (3.7)	93.5	6.5	79.7	16.2	4.1	100	0	0	18.6
	20–29	11 753 (38.3)	57.8	42.2	79.8	14.4	5.8	92.4	6.4	1.2	25.9
	30–39	14 893 (48.5)	39.8	60.2	81.4	12.6	6	90.9	7.5	1.6	34.3
	40–49	2890 (9.4)	32.5	67.5	74.8	15.8	9.4	84.4	11.9	3.7	42.3
	Total n	30 678	14 721	15 951	12 756	2158	1011	14 448	1224	272	31.3 (6.4)

<sup>a</sup>Parity data missing (n = 132, 0.10%)<sup>b</sup>Induced abortion data missing (n = 1340, 1.9% of delivered women)<sup>c</sup>Miscarriage data missing (n = 47, 0.068%)**Figure 2** Miscarriages in relation to registry-identified pregnancies (i.e. deliveries + miscarriages + induced abortions) over time according to age groups.



**Figure 3** Distribution over time of miscarriage types: blighted ovum and non-hydatidiform mole, missed abortion, spontaneous abortion and other diagnosis (such as incomplete spontaneous abortion, incomplete spontaneous abortion; complicated by delayed or excessive haemorrhage, and complete or unspecified spontaneous abortion; complicated by delayed or excessive haemorrhage).



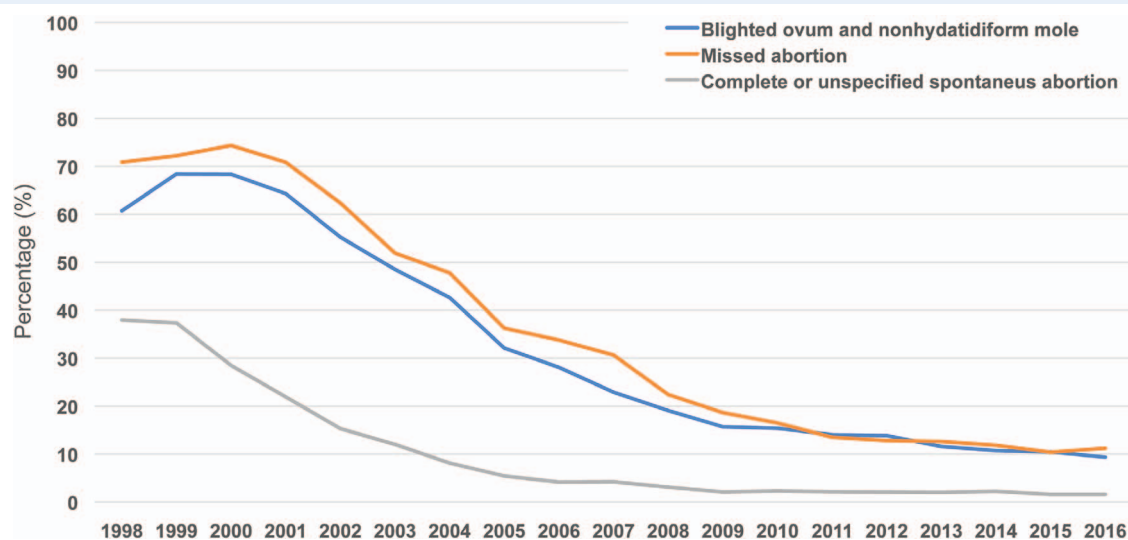
**Figure 4** Miscarriages according to parity over time.

women time segments were 1998–2001, 2001–2013 and 2013–2016. APCs were  $-5.0$  for 1998–2001 (95% CI  $[-7.1, -2.1]$ ),  $-0.5$  for 2001–2013 (95% CI  $[-0.8, -0.1]$ ) and  $-3.1$  for 2013–2016 (95% CI  $[-5.7, -0.5]$ ) ( $P < 0.001$ ). The inflexion points were years 2001 and 2013. In relation to pregnant women, time segments were 1998–2001, 2001–2007 and 2007–2016. APCs were  $-4.5$  for 1998–2001 (95% CI  $[-6.4, -2.6]$ ) ( $P < 0.001$ ),  $-1.8$  for 2001–2007 (95% CI  $[-2.7, -0.8]$ ) ( $P < 0.001$ ) and  $-0.4$  for 2007–2016 (95% CI  $[-0.8, 0.1]$ ) ( $P = 0.1$ ). With time segment 1998–2016, APC was  $-1.5$  (95% CI  $[-2.0, -1.1]$ ) ( $P < 0.001$ ).

The number of miscarriages managed in public hospitals declined over time; there were 8440 women with registry-identified miscarriage

in 1998 and 5673 women in 2016 ( $P < 0.001$ ). The annual number of all miscarriages did not correlate significantly with the total number of registry-identified pregnancies ( $r_s = 0.158$ ,  $P = 0.519$ ). The mean age at the time of miscarriage (mean 31.2 [SD 6.5]) remained unchanged during the study period ( $P = 0.639$ ; Table I). Of the 30 897 miscarriages registered in 1998–2001, 4.4, 38.2, 46.8 and 10.6% of miscarriages occurred in women in aged 15–19, 20–29, 30–39 and 40–49 years of age, respectively. This pattern did not change substantially over the years.

In the age groups of underlying population of pregnant women, there were some changes during the time frame of our study. In 1998–2001, 57/1000 pregnant women were 15–19-year-old, and in 2012–2016 the



**Figure 5** Trend over time in surgical treatment (within 7 days of initial admission) according to miscarriage type.

rate was 38/1000 ( $P < 0.001$ ). For the 20–29-year-old women, the corresponding rates were 459/1000 and 447/1000 ( $P < 0.001$ ), for 30–39-year-old women 440/1000 and 471/1000 ( $P < 0.001$ ) and for the women aged 40 years or more 44/1000 and 45/1000 pregnant women ( $P = 0.745$ ).

### Miscarriage types

The proportion of blighted ovum of all miscarriages decreased from 25.4% in 1998 to 12.8% in 2016. In contrast, the proportion of missed abortion has increased from 30.3 to 38.8% and that of spontaneous abortion from 20.8% in 1998 to 27.3% in 2016 ( $P < 0.001$ ; Fig. 3).

### Miscarriage and parity

Miscarriages were more common among nulliparous than among parous women as we categorized women in three groups: nulliparous women, women with history of one delivery and women with more than one deliveries. The proportion of all miscarriages among registry-identified pregnancies in 1998 was as follows: 43.7% occurred among nulliparous women, 26.4% occurred among women with a history of one delivery and 29.8% occurred among women with a history of more than one delivery. In 2016, these proportions increased to 49.6% among nulliparous women ( $P < 0.001$ ), increased to 26.7% among women with a history of one delivery ( $P < 0.001$ ) and decreased to 23.8% among women with a history of more than one delivery ( $P < 0.001$ ) (Fig. 4).

### Treatment of miscarriage

Over the entire study period, altogether 29% underwent surgical treatment and 71% medical or expectant management within the first week of miscarriage diagnosis (Fig. 1). Of the surgically treated women, 1.4% had more than one procedural code. Surgery was the dominant means of treatment before the year 2002, but thereafter its use has decreased ( $P < 0.001$ ). In 1998, 57.7% of women received surgical treatment, whereas in 2016 only 9.6% underwent surgical

treatment within 7 days of the initial admission. Within 1 month, the corresponding proportions were 58.9% in 1998 and 13.0% in 2016.

The women experiencing spontaneous abortion received less surgical management compared to women that had blighted ovum and missed abortion. In 1998, 38.0% of the women that experienced spontaneous abortion were treated surgically within the first week of miscarriage diagnosis whereas 60.7% of the women with blighted ovum and 70.9% with missed abortion underwent surgical treatment. In 2016, the corresponding figures were 1.6, 9.4 and 11.2%, respectively ( $P$  for trend  $< 0.001$ ). The proportion of surgical treatment within 1 month in 1998 and 2016 was 39.0 and 2.4% for spontaneous abortion, 63.3 and 15.2% for blighted ovum and 72.0 and 16.1% for missed abortion ( $P$  for trend  $< 0.001$ ). Figure 5 displays the proportion of women undergoing surgical treatment within 1 week according to the type of miscarriage between 1998 and 2016. The corresponding proportions for surgical treatment within 1 month are demonstrated in Supplementary Figure S1.

## Discussion

This nationwide register-based study shows that the incidence, the incidence rate and the number of registry-identified miscarriages managed in public healthcare have diminished, and the proportion of surgical treatment of miscarriage has declined during 1998 to 2016. Overall, in 1998, 11.2% of registry-identified pregnancies resulted in miscarriage; in 2016, their proportion was 8.3%. To our knowledge, the present study is the first large study that has noted an overall declining incidence rate of miscarriage.

In accordance with other studies, our study demonstrates increasing incidence of miscarriage with increasing maternal age in women aged more than 30 years and very clearly in women aged 40 years or more (Nybo Andersen et al., 2000; Feodor Nilsson et al., 2014). However, it is remarkable that among women aged 40 years or more, the incidence rate of miscarriage has declined from 265/1000 registry-identified pregnancies in 1998 to 164/1000 in 2016. On the other hand, the underlying population of women aged 40 or more has diminished,

but that should not affect the incidence rate of miscarriage in this group over time. Additionally, in Finland there is a lack of cycle-based register on assisted reproductive treatments (ARTs); it is thus impossible to determine its effects on the miscarriages in the current study. Comparison to other countries is challenging due to a limited number of studies of a similar kind. A recent Norwegian register-based study demonstrated, according to expectations, that the risk of miscarriage is highest in women aged 45 years or more, but the risk is also slightly increased among women aged under 20 years (Magnus *et al.*, 2019).

Missed abortion was the dominant type of miscarriage, and its proportion has increased. Conversely, the proportion of blighted ovum has clearly decreased. A possible explanation for this might be the enhanced quality of ultrasound scans used, providing better detection rate of the foetal pole in early pregnancy.

A recent study from Israel concluded that the rate of miscarriage increases according to women's parity (Cohain *et al.*, 2017). In contrast, we found that the proportion of all registry-identified miscarriages seen among nulliparous women (43.7% in 1998, 49.6% in 2016) was higher than the proportions among women with history of one delivery (26.4% in 1998, 26.7% in 2016) or more than one delivery (29.8% in 1998, 23.8% in 2016). Thus, if nulliparous and parous women are compared, less than half of all registry-identified miscarriages occurred among nulliparous women. The number of deliveries in Finland has decreased particularly after 2010, and thus, the number of intended pregnancies has probably also declined in both groups. On the other hand, the voluntary childlessness is estimated to be increasing. A US study found no association between parity and incidence of miscarriage (Sundermann *et al.*, 2017). Of course, the increasing average age of primigravidas can be one reason for the increasing proportion of miscarriages among nulliparous women.

The use of surgical treatment of miscarriage has diminished markedly in all types of miscarriages examined. This might be explained, for example, by the higher costs and lower availability of surgical compared to medical treatment or expectant management. The medical management of miscarriage is also often recommended by health professionals in Finland. Similarly, the use of medical management for induced abortion has increased from 10.6% in 2000, to 97.7% in 2017 (THL (National Institute for Health and Welfare), 2019). Moreover, the invasive nature of surgical management with associated risks might be less appealing to women. Especially surgical treatment with general anaesthesia, as it usually is performed in Finland, has been stated to be more expensive than medical treatment of miscarriage (Rausch *et al.*, 2012). Nevertheless, in a randomized study comparing the cost-effectiveness in medical and surgical treatment of miscarriage, the difference in cost-effectiveness diminished when adverse events after primary management were taken into account (Niinimäki *et al.*, 2009). There is a general agreement in the literature that non-surgical treatment of miscarriage is somewhat less effective than surgical treatment of miscarriage (Wieringa-de Waard *et al.*, 2002; Niinimäki *et al.*, 2006; Trinder *et al.*, 2006). Regardless, surgical treatment of miscarriage has recently been associated with subsequent preterm birth (Lemmers *et al.*, 2016a). A higher risk of infection has also been connected to surgical treatment (Niinimäki *et al.*, 2006). We found a higher use of conservative treatment in the management of spontaneous abortion throughout the study period, whereas surgical treatment of missed

miscarriage declined remarkably from 70.9 to 11.2% and blighted ovum from 60.7 to 9.4%.

The present study has considerable strengths. The large study sample and the high number of miscarriages enabled reliable estimation of the trends in miscarriages at a national level. In addition, the Finnish registers allowed the combination and linking of the register information. The high quality of the Finnish register data is also a strength of the study (Gissler and Haukka, 2004).

This study also has limitations. First of all, the present study relies on registry data, which were used to identify miscarriages. The registers have information only for those miscarriages diagnosed and treated in the public specialized healthcare, and thus, women with early post-implantation pregnancy losses are likely not to be included in the study. Conversely, the proportion of miscarriages treated elsewhere is estimated to be relatively small as all Finnish residents are entitled to treatment in the public healthcare system and are charged the same low user fee. The determination of accurate proportions is difficult, but for example only 1% of all induced abortions are performed in private settings (THL National Institute for Health and Welfare, Register on Induced Abortion, unpublished data). In addition, we studied the number of miscarriages in relation to registry-identified pregnancies (i.e. miscarriages, births and induced abortions); however, ectopic and molar pregnancies were not included. The surgical procedure codes have changed in time, so it was necessary to use both older and new codes in defining surgical and non-surgical treatment. Medical and expectant management could not be separated reliably enough with the use of procedural codes, because there is no procedural code for expectant management and the procedural code for medical management is often not used. Therefore, the distinction between these two methods of treatment could not be made. Furthermore, some of the women might have experienced a miscarriage before the year 1998 and it is not possible to identify these women because in Finland the codes for diagnoses and procedures of the outpatient appointments were registered 1998 onwards. Also, it was not possible to clarify the multiple pregnancies, the duration of gestation at the time of miscarriage diagnosis or the socioeconomic status of the women as these data are not included in the registries used.

In conclusion, the present study demonstrates national trends in a large scale—both the incidence and the incidence rate of registry-identified miscarriage have decreased, and the treatment of miscarriage is increasingly non-surgical. These findings are of value when planning allocation of healthcare resources. For instance, the use of surgical evacuation, previously performed under general anaesthesia and also during late hours, is nowadays a rarity. This is likely to reduce the need for operating room resources and thereby reduce healthcare costs. At the individual level, these findings are of value while counselling women or couples with miscarriage- or fertility-related questions. In addition, formation of the present nationwide cohort of miscarriage allows for further register linkages to examine the associated general and reproductive health outcomes of miscarriage.

## Supplementary data

Supplementary data are available at *Human Reproduction* online.

## Authors' roles

All authors have contributed to planning the study protocol and to writing of the manuscript and have approved this submission for publication. A.B. has performed the statistical analysis. M.G. was responsible for the registry data. R.L. and N.H. have written the first draft of the report with input from M.N., M.M. and O.H. M.N., M.M. and O.H. were responsible for the overall study, and O.H. obtained funding.

## Funding

Helsinki and Uusimaa Hospital System; Viipurin Tuberkuloosisäätiö (to R.L.); The Finnish Cultural Foundation (to N.H.).

## Conflict of interest

None declared in relation to the present work.

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