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Anal incontinence after vaginal delivery or cesarean section

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Conflict of interest notification

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Abstract

Introduction: Uncertainties remain as to whether cesarean section is protective for short and long term development of anal incontinence. Our aim was to explore whether women who had only delivered vaginally were at greater risk of anal incontinence compared to nulliparous women and women who had undergone caesarean sections only.

Material and methods: Background information, medical history and data on anal incontinence (defined as fecal or flatus incontinence weekly or more) reported by women participating in a large population-based health survey in Norway (HUNT 3) during the period October 2006-June 2008, was collected and linked to data from the Medical Birth Registry of Norway. Anal incontinence prevalence was calculated and multivariable logistic regression analyses were applied.

Results: Mean age amongst the 12.567 women was 49.9 years. Age and educational level were similar in women with caesarean sections only and those with vaginal delivery and obstetric anal sphincter injuries (OASIS). Nulliparas and women with vaginal delivery and no OASIS were older and had higher educational achievements. One in four women with OASIS reported anal incontinence compared to one in six amongst the other women($p<.001$). Age, educational level, diarrhea, constipation, birthweight and OASIS increased the risk of anal incontinence in all women. Parity was associated with anal incontinence in parous women only. No differences were found for fecal urgency.

Conclusions: Women with vaginal deliveries complicated by OASIS were at increased risk of anal incontinence. However, no increased risk of anal incontinence was found in nulliparous women or women with cesarean sections only or vaginal deliveries not complicated by OASIS.

Keywords

Anal incontinence, cesarean section, HUNT – study, population based study, Norway, vaginal delivery

Abbreviations

AI: anal incontinence;
CI: confidence interval;
CS: cesarean section;
FI: fecal incontinence;
HUNT 3, the Nord-Trøndelag Health Study in Norway;
IBS irritable bowel syndrome
MBRN Norwegian Medical Birth Registry
OASIS: obstetric anal sphincter injuries;
VD: vaginal delivery.

Key message

Delivering exclusively by cesarean section does not protect against anal incontinence in the long term. However, the risk of anal incontinence increased when vaginal delivery was complicated by obstetric anal sphincter injury. Our results support the importance of preventing obstetric anal sphincter injuries to reduce anal incontinence.

INTRODUCTION

Vaginal delivery (VD) is considered as a risk factor for injuries to the pelvic floor including tears of the anal sphincter and impaired pudendal nerve function.[1-3] This damage may have short and long term consequences such as anal incontinence (AI) including leakage of gas and /or unintentional loss of solid or liquid stool.[4-6] Whether elective cesarean section (CS) can prevent the potential impact of delivery on women's future health remains controversial.[1, 7]However, the belief that CS could prevent the development of AI may be one of the reasons for the increased requests for CS.[8]

Anal continence is a complex physiologic mechanism dependent on factors such as bowel disease, bowel habits, cortical awareness, integrity of the pelvic floor muscles and the anal sphincter muscles in particular, as well as a number of psychological factors.[9, 10] Fecal (FI) and AI are defined as the involuntary loss of solid or liquid stool, and loss of stool and/or gas, respectively. Fecal urgency is defined as having difficulty deferring a sudden or compelling desire to defecate.[11] Previous studies have reported that disturbance in bowel habits and pelvic floor disorders such as AI, fecal urgency, constipation and pelvic organ prolapse often co-occur, and quality of life in women experiencing more than one pelvic floor disorder is more affected than women with few or no pelvic floor disorders.[2, 12, 13] Furthermore, other studies have shown that AI in particular may have a devastating impact on social, emotional and physical activity as well as quality of life.[14, 15] AI is associated with increasing age, obesity, pregnancy, instrumental VD and obstetric anal sphincter injury (OASIS).[5, 14, 16-20] The role of planned CS in order to prevent OASIS, AI and the potential impact of delivery on women's future health remains unclear [1, 7, 21] A Cochrane review concluded that planned CS showed no benefit in preservation of AI in postpartum women.[7]

The aim of this study was to explore whether women who only had delivered vaginally were at greater risk of developing AI compared women who had undergone only caesarean sections or compared to women who had never undergone childbirth.

MATERIAL AND METHODS

Information on AI had been collected as part of the third round of a population-based health survey conducted in Nord-Trøndelag in the period October 2006-June 2008 (HUNT 3).[22] Data on AI from HUNT 3, was linked to information on mode of delivery, obtained from the Norwegian Medical Birth Registry (MBRN) (Figure 1). In HUNT 3, questions on AI were posed along with a broad range of health related topics for women aged 30 and above. Women were asked to indicate whether they experienced involuntary leakage never/rare, weekly or daily during the month prior to participation.[20] Information from all births in Norway has been registered in a common database, the MBRN, since 1967.[23]

Only women with deliveries before HUNT 3 were included. The following women were excluded; those who had deliveries prior to 1967 (n=3370), women who had delivered both vaginally and by CS (n=1274), women with multiple gestations (n=514) and women with more than four deliveries (n=299). In addition, we excluded women with missing information on AI (n=4662), who were pregnant at the time of participation in HUNT 3 (n=111) and women aged 80 years and older when participating in HUNT 3 (n=1003).

Anal incontinence was defined as involuntarily loss of feces and/or flatus weekly or more frequently during the last month. *Fecal incontinence* was defined as any involuntary loss of feces weekly or more frequently during the last month. *Flatal incontinence* was defined as any involuntarily loss of flatus (gas) weekly or more frequently during the last month. Women responding negative to the question "are you able to defer defecation and toilet visit for 15 minutes after first feeling the need to go?" were categorized as having fecal *urgency*. Any AI was defined as experiencing one or more AI symptoms.[11]

Women were categorized into four groups according to parity, mode of delivery and OASIS; Nulliparous women, women who had delivered by CSs only, women with one or more VDs with no OASIS, and women with one or more VD with OASIS. Age was categorized in 10-year groups (30-39, 40-49, 50-59, 60 and older). Body mass index (kg/m²) was calculated based on measures of weight and height from HUNT 3. Nulliparous women were identified by their response on questions on parity in HUNT 3. Information on women's age at first delivery and years since last delivery were divided into 5 year categories, and birth weight recorded in the first delivery was categorized as ≤2499 g, 2500 to 3999 g and ≥ 4000 g. Information on education was obtained from Norwegian National Education Database (NUDB), and classified according to the Norwegian Standard Classification of Education: Low level (≤10th class level), intermediate level (11-14th class level) and high educational level (>14th class level).

Statistical analyses

Comparison of means between two groups was analyzed using the Independent samples t-test for continuous data, Chi-square test (linear-by-linear) was used when comparing graded categorical data and the Mann-Whitney U test for categorical data. The association between the primary

outcome measures any AI and fecal urgency as the dependent variables, and the various independent variables such as age, education, parity, mode of delivery, diarrhea and constipation were assessed using multivariable logistic regression analyses. Variables with a p-value <.10 in the univariable analyses were included in the multivariable analyses. Results are presented as odds ratio (OR) with 95% confidence intervals (CI). Due to multicollinearity between age, years since last delivery and menopausal status, the latter two variables were not included in the final multivariable models. Level of significance was set to $p < 0.05$ (two-sided). Prevalence calculations with 95% CI were used to test differences between proportions within groups. Data was analysed using SPSS version 23 (IBM, Armonk, NY, USA) and Microsoft Excel for Windows® 2010 (Microsoft Corp., Redmond WA, USA).

Ethical approval

The study was approved by the Regional Committee for Medical and Health Research Ethic Central Norway (No. 2009/1214) and followed the Declaration of Helsinki.

RESULTS

After exclusion, a total of 12 567 women were included (Figure 1). Table 1 shows the characteristics of the study population. More than 80% (10.340) of the included women had one or more VD without OASIS, whereas 2.2% (276) had one or more VD with OASIS. Nulliparous women and the women with VD but no OASIS were significantly older and had a higher education level compared to the women who had delivered exclusively by CS. Women with VD with or without OASIS had significantly more deliveries compared to women with CS only. There were no statistically significant differences in any AI symptoms between the nulliparous women, those with CS only (p=.448) or women with VD and no OASIS (p=.210). Among women with VD and OASIS 72% were continent, compared to more than 82% in the other parous and nulliparous women. Overall few women reported experiencing FI alone. Approximately 15% reported flatus incontinence alone amongst the nulliparous women and women with CS alone and VD with no OASIS. Amongst the women in the group with VD and OASIS, however, more than 20% reported flatus incontinence alone, and 5.8% reported experiencing AI, the combination of FI and flatus incontinence compared to only 0.3% in the CS group (p<.001).

No association was found between AI or fecal urgency and mode of delivery when VD was not categorized into VD with no OASIS and VD with OASIS in any statistical model (Data not shown). Table 2, 3 and 4 show crude and adjusted OR for AI and fecal urgency. Variables included in the multivariable models with any AI as the dependent variable were age, body mass index, diarrhea, education, fecal urgency, constipation, mode of delivery, parity including nulliparous women and birthweight.

Experiencing any AI was associated with increasing age, and symptom severity of diarrhea and constipation. Women with higher education and those who delivered an infant with a birthweight ≥ 4000g at first delivery, had 60% higher odds of experiencing any AI compared to women with primary or intermediate level education or women with infants with birthweight lower than 4000g. The only significant association between any AI and mode of delivery including being nulliparous was found amongst women with VD and OASIS who had more than twice the risk of any AI (95%CI: 1.5, 3.2). The odds ratio of also reporting fecal urgency was 2.6 in women experiencing any AI (95%CI 2.3, 3.1) (Table 2). In the separate multivariable logistic regression analyses including parous women only, similar results were seen for any AI, however, women with 4 deliveries had twice the risk of any AI compared to women with fewer deliveries (Table 3). The same pattern was also observed when only primiparous women were included, however, education and birthweight was not associated with increased risk of AI in this group (Table 4).

Increasing age, increasing symptoms severity in diarrhea and experiencing any AI increased the odds of experiencing fecal urgency in the analyses including both nulliparous and parous women, as well as in the separate analyses including parous women only. Interestingly, higher educational level reduced the risk of fecal urgency (Tables 2 and 3).

DISCUSSION

In this large population-based cohort study, we found no association between AI or fecal urgency and mode of delivery when women with CS were compared to the total group of women with VD. However, more women with VD complicated by OASIS reported AI compared to nulliparous and other parous women. Women aged 40 years and older were at increased risk of AI and fecal urgency when all participating women or all parous women were included in the analyses. Amongst

primiparous women, only women aged 50 or over were at increased risk of AI. No association was found between age and fecal urgency in this group. Other non-delivery-related factors associated with reporting any AI was educational level, fecal urgency and reporting diarrhea or constipation during the last year. OASIS and macrosomia (birthweight ≥4000g of the first infant) increased the risk of any AI in all the participating women, whereas parity was significantly associated with an increased risk of any AI amongst all parous women only. No delivery-related factors were found to be associated with fecal urgency. Diarrhea and reporting AI increased the risk of fecal urgency, whereas women who had achieved a higher educational level had a reduced risk of reporting fecal urgency.

There is conflicting evidence of the benefit of CS in prevention of postpartum AI.[7] Some studies suggest that the timing of a CS, and CS in late labour in particular, may have an impact on the continence mechanism.[24] In a recent review, CS was shown to have a protective effect on postpartum AI in the short-term. However, from six months postpartum, no significant association between mode of delivery and AI was found.[3] Guise and co-workers (2009) explored the risk of FI in the postpartum period and among the included 6152 primiparous women, VD was associated with a greater risk of FI compared to CS. However, when assessing a subgroup of women with VD and no perineal laceration or instrumental assistance, no significant difference between VD and CS was found.[25] Similarly, MacArthur and co-workers (2013) demonstrated persistence of FI 12 years after delivery,[17] but found no association between mode of delivery and long term FI when comparing women with CS only and women who had at least one VD.[26] In the present study, we found no association between AI or fecal urgency when mode of delivery was categorized into nulliparous, CS or VD. However, when VD with or without OASIS was included in the adjusted statistical analyses, a two-fold increase in risk of AI was found in women with VD complicated by OASIS only. Further, amongst primiparous women with VD complicated by OASIS, the risk of AI was three-fold. These results are in concurrence with Evers and co-workers (2012) who found that OASIS was associated with an increased risk of AI more than five years after first delivery, and the prevalence of postpartum AI was similar in women who had delivered by CS exclusively and those who had VD with no OASIS.[27] An American population based survey, found that females were more likely to have fecal urgency before an episode of leakage than males, indicating a deficit in the external anal sphincter muscle.[13] Moreover, some studies suggest that grade of OASIS is associated with increasing risk of AI both in the short-term[4] and in the long-term.[5, 6] We did not have information about grade of OASIS in our data, and were thus unable to explore this association further. Previous

studies have shown that delivery-related factors such as parity, birthweight and instrumental delivery increase the risk of OASIS and postpartum AI in the long term.[2, 5, 17, 28] In the present study, only women with four deliveries were at increased risk of AI, and in contrast to other studies, we found no association between forceps delivery and AI or fecal urgency. MacLennan and co-workers (2000) showed that increasing parity was associated with an increased risk of pelvic floor disorders, including AI. However, neither parity nor VD with suturing (OASIS not specified) was found to be associated with symptom severity in the Australian cross-sectional study.[2] Our results indicate that a normal VD, not complicated by OASIS, does not increase the risk of AI in the long term. However, part of the complex physiological mechanism of continence may be compromised by injury to the anal sphincter muscles, and in the event of one or more risk factor occurring during labor, the combination of these delivery-related risk factors may potentially result in a synergistic impact on the development of AI symptoms after delivery and in the long term.[3, 27]

Increasing age and diarrhea were among the most consistent factors associated with an increase in risk of AI in recent systematic reviews.[3, 29] The effect of aging includes reduced rectal compliance, reduced rectal sensation and perineal laxity.[13, 30] In the present study, the risk of AI and fecal urgency was increased amongst women aged 50 years and over. However, the mean age of the present study population (49.9 years) was relatively low, and women who had delivered by CS exclusively or had one or more VDs complicated by OASIS were five to ten years younger than the other participating women. Subsequently, only one third were postmenopausal in these groups compared to more than 50% of the women who were nulliparous or those with VD and no OASIS. Compulsory notification to the MBRN was initiated in 1967, and the oldest female participants in HUNT3 who did not have their delivery-related data registered in MBRN were excluded from further analyses as we had no other available source of information on delivery-related variables. This selection bias may have had an impact on our results.

In concurrence with our findings, previous studies have shown strong associations between AI and gastrointestinal factors such as diarrhea and constipation, as well as stool consistency and irritable bowel syndrome (IBS).[12, 13, 20] Donnelly and co-workers (1998) found that women with IBS were at increased risk of postpartum fecal urgency and flatus incontinence, but not OASIS when compared to primiparous women with no IBS.[31] Others have concluded that amongst women with IBS, VD is an acceptable mode of delivery except for women with IBS who are at high risk of OASIS.[21] The

associations between diarrhea and constipation was strong both in the analyses including nulliparaous women as well as amongst primiparas only, supporting the knowledge base that AIlater in life is associated with factors independent of mode of delivery. Furthermore, our results show a strong association between any AI and fecal urgency in all statistical models. This is in concurrence with previous findings indicating that women with one pelvic floor disorder are more likely to also experience other pelvic floor disorders.[12] Moreover, previous studies have shown that women who experience incontinence symptoms prior to pregnancy and delivery are at increased risk of postpartum AI.[28, 32, 33] A Danish population-based cohort study, concluded that women who had an OASIS at their first delivery and experienced AI symptoms prior to their second pregnancy, were at increased risk of long term AI regardless of mode of second delivery. However, women who had a second VD were at higher risk of deteriorating AI symptoms compared to women with a planned CS at their second delivery.[28] Unfortunately we did not have information about AI symptoms prior to participation in HUNT 3 and we were thus unable to include this in our analyses.

Reports on the prevalence of postpartum AI in the short and long term vary depending on the population, definition, measuring tool used. In order to fit the questionnaire in the HUNT study, the main outcome measures, AI, and fecal urgency were based on a modified version of the St. Mark's incontinence score including the response alternatives never/rarely, weekly or daily.[20] Consequently, women with symptoms occurring less frequently than weekly were included in the continent category, and a conservative estimate of FI, leakage of stool or flatus weekly or more often was applied. In addition, HUNT 3 did not include any questions about use of pad or plug, and use of stopping medication, and we were unable to calculate a total St. Mark's incontinence score. In a large American population based study, 14% reported FI in the past, and 33% reported FI during the last week. Similar to the prevalence of AI reported by nulliparous and parous women with no OASIS in the present study, one in five amongst nearly 400 women with two VD and no OASIS reported AI and / or fecal urgency ten years after their first delivery.[14] Forty and fifty percent of women with OASIS after first delivery reported AI symptoms after a second vaginal and caesarean delivery, respectively, and one in three reported fecal urgency.[28] This is higher than the 27% reporting any AI and 10 to 15% reporting fecal urgency in the present study.

The strength of the present study is that it is population based and includes a large number of nulliparous as well as parous women. Furthermore, the delivery-related data was collected from the MBRN. Notification to the MBRN is compulsory and all deliveries are recorded by the attending midwife and/or obstetrician. Previous studies have suggested that maternal recall about OASIS is poor.[27] However, others indicate that reported data on pregnancy, first deliveries and onset of AI symptoms are associated with such significant events in life that it is unlikely that the collected data are affected by recall bias.[34] Data on OASIS collected from MBRN is reputed to be of high quality,[23] thus reducing the risk of bias in the present study.

The response rate in HUNT 3 amongst women aged 30 to 80 years was relatively high (61%). However, a recent study revealed that when compared to non-participants, participants in HUNT 3 had a significantly higher socioeconomic status, lower mortality and prevalence of several chronic diseases.[35] This selection bias may be considered one of the main limitations in our study that may have influenced our prevalence rates, but it is unlikely to have influenced the association between AI and mode of delivery. Furthermore, the compulsory notification to the MBRN was initiated in 1967, and we had no other available source of information on delivery-related variables. Therefore, the oldest female participants in HUNT3 with no delivery-related data registered in MBRN were excluded from our data analyses. This selection bias, in combination with the significant differences in educational level, parity and birthweight between the groups may have had an impact on our findings, and thus our results must be interpreted with caution.

CONCLUSION

This large population-based study of parous and nulliparous women has shown that CS does not seem to protect the development of AI, neither in the short term nor in the long-term. However, when the VDs had been complicated by OASIS we found a significantly increased risk of AI. Our findings also indicate that AI later in life are caused by factors independent of mode of delivery.

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Legends of Tables and Figures

Figure 1. Flow chart of the recruiting and inclusion process through each stage of the present study. HUNT 3, large population-based health survey in Norway; MBRN, Norwegian Medical Birth Registry; AI, anal incontinence.

Table 1. Demographic and delivery-related characteristics of participants according to parity and mode of delivery (n=12.567).

Table 2. Risk factors for anal incontinence after delivery among both nulliparous and parous women (n=12-567). Results from multivariable logistic regression analyses and backwards selection.

Table 3. Risk factors for anal incontinence among parous women only (n=11.279). Results from multivariable logistic regression analyses and backwards selection.

Table 4. Risk factors for anal incontinence after delivery among primiparous women (n=1330). Results from multivariable logistic regression analyses and backwards selection.

Table 1. Demographic and delivery-related characteristics of participants according to parity and mode of delivery (n=12.567)

	Nulliparous women	**Parous women**		
		Cesarean section	Vaginal delivery	
			No OASIS	With OASIS
	(n=1.288)	(n=663)	(n=10.340)	(n=276)
Age years, mean (SD)[range] [a]	**52.2(14.1)[30,79]**	45.3(8.8)[30,79]	**50.0(9.4)[30,79]**	43.7(8.6)[30,73]
30-39 years[b]	**25.2 (325)**	29.6 (196)	**17.7 (1834)**	**40.2 (111)**
40-49 years	**22.0 (283)**	43.0 (285)	**28.9 (2986)**	**35.9 (99)**
50-59 years	**20.3 (262)**	21.4 (142)	**37.7 (3903)**	**18.5 (51)**
60 years and over	**32.5 (418)**	6.0 (40)	**1617 (15.6)**	**5.4 (15)**
Education[c]				
Primary education level	**60.6 (781)**	76.2 (505)	**61.2 (6332)**	78.6 (217)
Intermediate education level	**30.2 (389)**	19.2 (127)	**33.9 (3501)**	18.1 (50)
Higher education level	**1.9 (24)**	3.5 (23)	**4.7 (490)**	2.2 (6)
Body mass index, kg/m² mean (SD) [a]	27.2 (5.6)	28.0 (5.3)	**26.8 (4.6)**	26.6 (4.9)
Years since last delivery, mean (SD) [a]	-	14.2 (8.9)	**20.6 (10.4)**	12.4 (8.8)
Postmenopausal[c]	**50.9 (656)**	30.0 (199)	**53.4 (5524)**	28.6 (79)
Parity, mean (SD) [a]	-	1.9 (0.8)	**2.4 (0.8)**	**2.3 (0.8)**
1 delivery [b]	-	229 (34.5)	**1054 (10.2)**	**47 (17.0)**
2 deliveries	-	279 (42.1)	**5009 (48.4)**	**117 (42.4)**
3 deliveries	-	136 (20.5)	**3515 (34.0)**	**92 (33.3)**

4 deliveries	-	16 (2.4)	**762 (7.4)**	**20 (7.2)**
Birthweight, mean (SD) [a]				
1st delivery[a]	-	3392 (781)	**3462 (525)**	**3690 (501)**
2nd delivery[a]	-	3467 (712)	**3629 (528)**	**3792 (497)**
3rd delivery[a]	-	3486 (584)	3691 (540)	3928 (489)
4th delivery[a]	-	3310 (446)	3740 (524)	**3821 (829)**
Diarrhea, previous year[c]				
No	48.2 (621)	52.9 (351)	52.8 (5458)	48.2 (133)
Some	37.7 (485)	36.0 (239)	34.0 (3520)	42.4 (117)
A lot of	4.0 (52)	4.2 (28)	4.3 (447)	4.3 (12)
Constipation, previous year[c]				
No	45.6 (587)	47.4 (314)	46.5 (4808)	48.6 (134)
Some	38.1 (491)	35.3 (236)	37.1 (3832)	38.8 (107)
A lot of	7.8 (101)	10.4 (69)	8.1 (838)	6.9 (19)
Any anal incontinence [c]	16.8 (217)	15.8 (105)	17.8 (1836)	**27.9 (77)**
Fecal incontinence alone	0.5 (7)	0.3 (2)	0.5 (48)	**1.8 (5)**
Flatus incontinence alone	14.1 (182)	14.3 (95)	15.8 (1637)	**20.3 (56)**
Anal incontinence (fecal & flatus combined)	2.2 (28)	1.2 (8)	1.5 (151)	**5.8 (16)**
Continent[c]	82.5 (1063)	83.9 (556)	81.9 (8472)	**71.7 (198)**
Fecal urgency[c]	11.6 (149)	11.0 (73)	10.7 (1105)	15.2 (42)

Values are presented as % (n) unless otherwise stated. Bold indicates statistically significant difference ($p<.05$) from cesarean section group.

[a] independent samples t-test.

[b] Chi-squared test, linear by linear.

[c] Mann Whitney U test.

OASIS, obstetric anal sphincter injuries.

Table 2. Risk factors for anal incontinence (AI) after delivery among both nulliparous and parous women.

Results from multivariable logistic regression analyses and backwards selection.

	Anal incontinence (AI)		**Fecal urgency**	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Mode of Delivery				
Nulliparous	1.1 (0.8 to 1.4)	1.1 (0.3 to 3.6)	1.1 (0.8 to 1.4)	
Cesarean section only	1	1	1	
Vaginal delivery, no OASIS	1.2 (0.9 to 1.4)	1.1 (0.9 to 1.4)	1.0 (0.8 to 1.3)	
Vaginal delivery, OASIS	**2.1 (1.5 to 2.9)***	**2.2 (1.5 to 3.2)***	1.5 (0.9 to 2.2)	
Age				
30-39 years	1	1	1	1
40-49 years	**1.2 (1.0 to 1.4)**	**1.2 (1.1 to 1.5)**	1.2 (0.9 to 1.5)	**1.2 (1.0 to 1.5)**
50-59 years	**1.4 (1.2 to 1,6)**	**1.4 (1.1 to 1.6)**	**1.8 (1.5 to 2.1)**	**2.1 (1.7 to 2.6)**
60 years and over	**1.6 (1.4 to 1.9)**	**1.4 (1.1 to 1.8)**	**2.1 (1.7 to 2.5)**	**2.8 (2.2 to 3.5)**
Body Mass Index, kg/m^2	**1.0 (1.0 to 1.0)**	-	**1.1 (1.1 to 1.1)**	**1.0 (1.0 to 1.0)**
Education				
Primary education level	1	1	1	1
Intermediate education level	**1.2 (1.1 to 1.4)**	1.1 (0.9 to 1.3)	**1.3 (1.2 to 1.5)**	**0.8 (0.7 to 0.9)**
Higher education level	**1.5 (1.2 to 1.8)**	**1.6 (1.2 to 2.1)**	0.9 (0.7 to 1.2)	**0.5 (0.4 to 0.7)**
Parity				
Nulliparous	1		1	

1 delivery	0.9 (0.8 to 1.2)		0.9 (0.8 to 1.2)	
2 deliveries	1.1 (0.9 to 1.2)		0.9 (0.8 to 1.2)	
3 deliveries	1.1 (0.9 to 1.3)		0.9 (0.7 to 1.1)	
4 deliveries	1.3 (0.9 to 1.6)		0.8 (0.6 to 1.1)	
Birthweight first delivery				
Up to 2499 gram	1	1	1	
2500 to 3999 gram	1.1 (0.9 to 1.4)	1.3 (0.9 to 1.7)	0.9 (0.7 to 1.2)	
4000 gram and over	**1.3 (1.0 to 1.8)**	**1.6 (1.1 to 2.1)**	0.9 (0.7 to 1.3)	
Diarrhea previous year				
No	1	1	1	1
Some	**1.8 (1.6 to 2.0)**	**1.7 (1.5 to 1.9)**	**2.0 (1.8 to 2.3)**	**2.0 (1.8 to 2.3)**
A lot of	**5.0 (4.2 to 6.0)**	**4.3 (3.4 to 5.3)**	**7.3 (6.0 to 9.0)**	**7.6 (6.2 to 9.3)**
Constipation previous year				
No	1	1	1	
Some	**1.5 (1.4 to 1.7)**	**1.5 (1.3 to 1.7)**		
A lot of	**3.1 (2.7 to 3.6)**	**3.4 (2.9 to 4.1)**		
Fecal urgency	**3.1 (2.8 to 3.5)**	**2.6 (2.3 to 3.1)**	**X**	**X**
Any AI	**X**	**X**	**3.1 (2.1 to 3.5)**	**2.5 (2.2 to 2.9)**

Bold indicates statistically significant risk factor of any AI or fecal urgency (p<.05); OR:Odds ratio; CI: confidence interval; OASIS: Obstetric anal sphincter injury

-: Variable removed after backwards selection due to non-significant association with the independent variables.

Table 3. Risk factors for anal incontinence (AI) among parous women only (n=11.279).

Results from multivariable logistic regression analyses and backwards selection.

	Anal incontinence		**Fecal urgency**	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Mode of Delivery				
Cesarean section only	1	1	1	
Vaginal delivery, no OASIS	1.2 (0.9 to 1.4)	1.1 (0.8 to 1.4)	0.9 (0.8 to 1.3)	
Vaginal delivery, OASIS	**2.1 (1.5 to 2.9)**	**2.1 (1.5 to 3.1)**	1.5 (1.0 to 2.2)	
Age				
30-39 years	1	1	1	1
40-49 years	1.2 (0.9 to 1.4)	**1.2 (1.1 to 1.5)**	1.2 (0.9 to 1.4)	1.1 (0.9 to 1.4)
50-59 years	**1.4 (1.2 to 1.6)**	**1.4 (1.1 to 1.6)**	**1.8 (1.5 to 2.2)**	**1.9 (1.5 to 2.4)**
60 years and over	**1.6 (1.3 to 1.9)**	**1.4 (1.1 to 1.8)**	**2.0 (1.7 to 2.5)**	**2.4 (1.9 to 3.3)**
Body Mass Index, kg/m^2	**1.0 (1.0 to 1.0)**	-	**1.0 (1.0 to 1.1)**	-
Education				
Primary education level	1	1	1	1
Intermediate education level	**1.3 (1.1 to 1.4)**	1.1 (0.9 to 1.3)	**1.4 (1.2 to 1.6)**	0.9 (0.7 to 1.1)
Higher education level	**1.5 (1.2 to 1.8)**	**1.6 (1.2 to 2.1)**	0.9 (0.6 to 1.2)	**0.5 (0.3 to 0.7)**
Parity				
1 delivery	1	1		

2 deliveries	1.1 (0.9 to 1.2)	1.1 (0.9 to 1.3)		
3 deliveries	1.1 (0.9 to 1.3)	1.2 (0.9 to 1.4)		
4 deliveries	**1.3 (1.0 to 1.6)**	**1.4 (1.1 to 1.8)**		
Birthweight first delivery				
Up to 2499 gram	1	1	1	
2500 to 3999 gram	1.1 (0.9 to 1.4)	1.3 (0.9 to 1.7)	0.9 (0.7 to 1.2)	
4000 gram and over	**1.3 (1.0 to 1.8)**	**1.6 (1.2 to 2.2)**	0.9 (0.7 to 1.3)	
Diarrhea last year				
No	1	**1**	1	1
Some	**1.8 (1.7 to 2.0)**	**1.7 (1.5 to 1.9)**	**2.0 (1.8 to 2.3)**	**1.8 (1.6 to 2.1)**
A lot of	**5.2 (4.2 to 6.3)**	**4.3 (3.5 to 5.4)**	**7.5 (6.1 to 9.4)**	**5.8 (4.7 to 7.3)**
Constipation last year				
No	1	1	1	
Some	**1.5 (1.3 to 1.7)**	**1.5 (1.3 to 1.7)**	0.9 (0.8 to 1.0)	
A lot of	**3.1 (2.7 to 3.6)**	**3.5 (2.9 to 4.1)**	1.1 (0.9 to 1.3)	
Fecal urgency	**3.2 (2.8 to 3.6)**	**2.6 (2.3 to 3.1)**	**X**	**X**
Any AI	**X**	**X**	**3.1 (2.8 to 3.6)**	**2.6 (2.2 to 3.0)**

Bold indicates statistically significant risk factor of any AI or fecal urgency (p<.05); OR:Odds ratio; CI: confidence interval; OASIS: Obstetric anal sphincter injury

-: Variable removed after backwards selection due to non-significant association with the independent variable.

Table 4. Risk factors for anal incontinence (AI) after delivery among primiparous women (n=1330).

Results from multivariable logistic regression analyses and backwards selection.

	Anal incontinence (AI)		**Fecal urgency**	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Mode of Delivery				
Cesarean section only	1	1	1	
Vaginal delivery, no OASIS	1.1 (0.7 to 1.6)	1.1 (0.7 to 1.6)	0.8 (0.5 to 1.3)	
Vaginal delivery, OASIS	**3.2 (1.6 to 6.3)**	**3.2 (1.5 to 6.9)**	1.5 (0.6 to 3.5)	
Age				
30-39 years	1	1	1	
40-49 years	1.3 (0.8 to 1.9)	1.4 (0.9 to 2.2)	1.2 (0.7 to 2.0)	
50-59 years	1.3 (0.8 to 1.9)	**1.6 (1.0 to 2.6)**	1.4 (0.8 to 2.2)	
60 years and over	1.6 (1.0 to 2.6)	**1.8 (1.1 to 3.2)**	1.5 (0.8 to 2.6)	
Body Mass Index, kg/m²	1.0 (0.9 to 1.0)		**1.0 (1.0 to 1.1)**	**1.0 (1.0 to 1,1)**
Education				
Primary education level	1		1	
Intermediate education level	1.3 (0.9 to 1.7)		0.9 (0.6 to 1.3)	
Higher education level	1.2 (0.6 to 2.4)		0.9 (0.4 to 2.1)	
Birthweight first delivery				
Up to 2499 gram	1		1	-

2500 to 3999 gram	1.1 (0.6 to 1.9)		0.6 (0.3 to 1.1)	-
4000 gram and over	1.2 (0.6 to 2.3)		0.9 (0.5 to 2.1)	-
Diarrhea previous year				
No	1	1	1	1
Some	**2.0 (1.4 to 2.7)**	**1.8 (1.3 to 2.6)**	**2.0 (1.3 to 2,9)**	**1.7 (1.2 to 2.6)**
A lot of	**7.4 (4.3 to 12.5)**	**6.5 (3.6 to 12.0)**	**6.5 (3.6 to 11.7**	**4.7 (2.5 to 8.8)**
Constipation previous year				
No	1	1	1	
Some	**1.9 (1.3 to 2.6)**	**1.7 (1.2 to 2.5)**	1.0 (0.6 to 1.5)	
A lot of	**3.1 (1.9 to 5.0)**	**3.3 (2.0 to 5.5)**	0.9 (0.5 to 1.7)	
Fecal urgency	**2.8 (1.9 to 4.1)**	**2.2 (1.4 to 3.0)**	**X**	**X**
Any AI	**X**	**X**	**2.7 (1.9 to 4.1)**	**2.2 (1.4 to 3.4)**

Bold indicates statistically significant risk factor of any AI or fecal urgency ($p<.05$); OR: Odds ratio; CI: confidence interval; OASIS: Obstetric anal sphincter injury

-: Variable removed after backwards selection due to non-significant association with the independent variables.

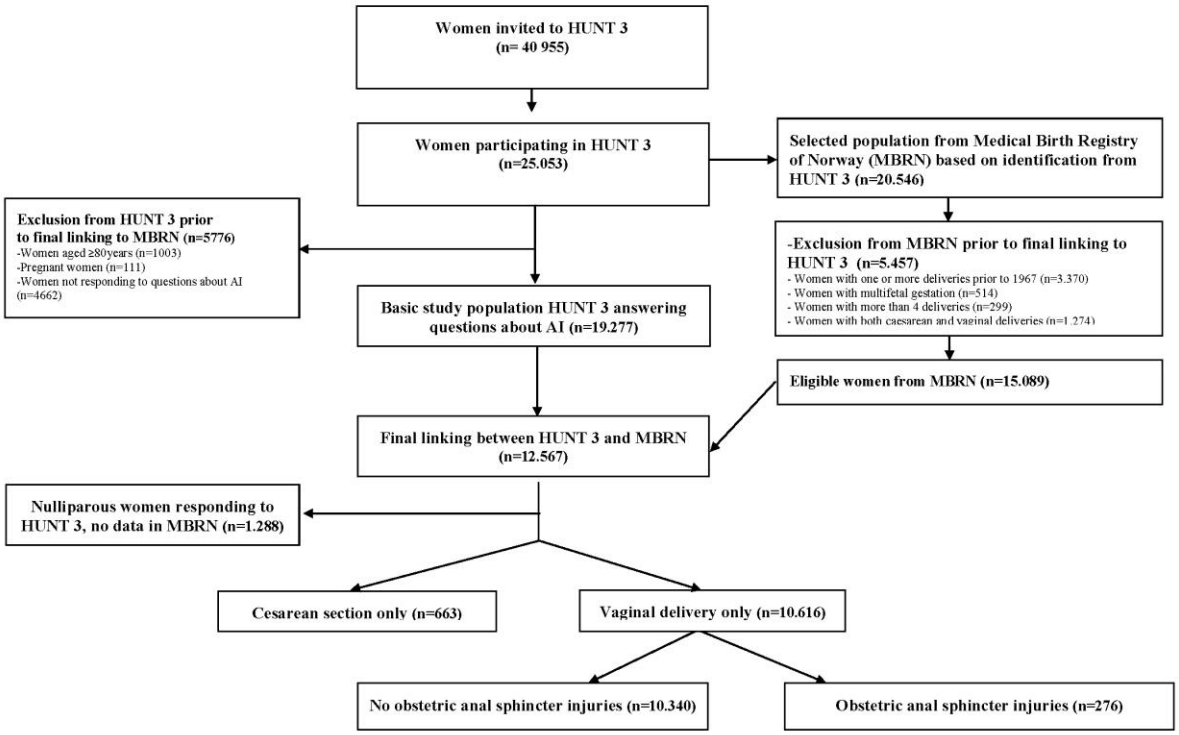

Figure 1. Flow chart of the recruiting and inclusion process through each stage of the present study