Title: The 8-year cumulative incidence of diabetes mellitus among Sami and non-Sami inhabitants of Northern Norway - The SAMINOR Study

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Abstract

Objectives: The aim of the study was to estimate and compare the 8-year cumulative incidence of diabetes mellitus (DM) among Sami and non-Sami inhabitants of rural districts in Northern Norway.

Design: Longitudinal study based on linkage of two cross-sectional surveys.

Methods: Ten municipalities in rural Northern Norway were included in the study. DM-free participants aged 30 and 36–71 years were followed from two years after the SAMINOR 1 Survey (2003–2004) to the SAMINOR 2 Clinical Survey (2012–2014). The average follow-up time was 8.1 years. Of 5875 subjects who had participated in SAMINOR 1 and could potentially be followed to SAMINOR 2, 3303 were included in the final analysis. Self-report and/or HbA1c $\geq$ 6.5% were used to identify incident cases of DM.

Results: At baseline, body mass index (BMI) and waist-to-height ratio (WHtR) were higher among Sami than among their non-Sami counterparts. After 8 years of follow-up, 201 (6.1%) incident cases of DM were identified. No statistically significant difference was observed in the sex-specific cumulative incidence of DM between the Sami and non-Sami.

Conclusions: No statistically significant difference in the 8-year cumulative incidence of DM among Sami and non-Sami was observed, although Sami men and women had higher baseline BMI and WHtR.

Key words: cumulative incidence, diabetes mellitus, indigenous, native, Norwegian, SAMINOR, HbA1c, Sami

INTRODUCTION

Type 2 diabetes mellitus (DM) is one of the most prevalent and disabling chronic diseases affecting millions of people worldwide [1]. Indigenous peoples throughout the world are facing an unprecedented epidemic of type 2 DM [2], but publications concerning the incidence of the disease among these groups are rather sparse. This could in part be due to the need for costly and cumbersome cohort studies or the lack of available robust data from national registries.

The Sami are an indigenous people, who have traditionally inhabited northern parts of Norway, Sweden, and Finland, and the Kola Peninsula of Russia. While no statistically significant difference was observed in the prevalence of DM between Sami and non-Sami in the SAMINOR 1 Survey (2003–2004), using self-report and/or non-fasting plasma glucose [3, 4], the prevalence of both pre-diabetes and type 2 DM was higher among Sami people in the SAMINOR 2 Clinical Survey (2012–2014), using self-report and/or HbA1c [5]. There is a lack of longitudinal studies estimating the incidence of DM among Sami and non-Sami inhabitants of rural municipalities in Northern Norway.

The aim of this study is to measure and compare the 8-year cumulative incidence of DM among Sami and non-Sami inhabitants of rural districts in Northern Norway.

METHODS

In 2003–2004, the Centre for Sami Health Research at UiT The Arctic University of Norway, in collaboration with the Norwegian Institute of Public Health, conducted the SAMINOR 1 Survey (hereafter referred to as SAMINOR 1) [6]. This survey included 24 mostly rural municipalities and districts in Northern and Central Norway with a considerable proportion of Sami inhabitants.

In 2012–2014, the Centre for Sami Health Research undertook a two-part second survey, the SAMINOR 2 Questionnaire Survey [7] and the SAMINOR 2 Clinical Survey. The present analyses are based on data from the SAMINOR 2 Clinical Survey (hereafter referred to as SAMINOR 2), which, similarly to SAMINOR 1, consisted of self-administered questionnaires, a clinical examination, and analysis of blood samples. The survey was conducted in 10 municipalities in Finnmark, Troms, and Nordland counties, all previously included in SAMINOR 1: Kautokeino, Karasjok, Tana, Nesseby, Porsanger, Lyngen, Storfjord, Kåfjord, Skånland, and Evenes (Figure 1).

Study sample

The present analyses are based on longitudinal data of those participating in both SAMINOR 1 and SAMINOR 2 from the above-mentioned ten municipalities. In SAMINOR 2, 12,455 subjects, aged 40–79 years, were invited to take part, and 6004 participated (48.2%). We lack information about those invited to SAMINOR 2, who had also participated in SAMINOR 1 but who failed to participate in SAMINOR 2, as a linkage is only allowed for those who participated in both surveys. Therefore, loss to follow-up is described based on SAMINOR 1 participants who would have been invited to SAMINOR 2, given that they had not died or moved from the 10 studied municipalities prior to invitation to SAMINOR 2. There were 11,558 invitees to SAMINOR 1, who, according to their birth year and municipality, would

have been invited to SAMINOR 2, given that they had not moved or died. Of these, 6450 (55.8%) participated in the SAMINOR 1 clinical examinations, of whom 6408 gave their consent to register linkages. The two data files were merged by Statistics Norway, using the unique 11-digit personal identification number assigned to all subjects residing in Norway.

Figure 2 displays the population and exclusions applied. Among the 6408 individuals, the following were excluded: 169 due to missing initial questionnaire; 2 due to missing main questionnaire (containing diabetes information); and 27 due to missing ethnicity information in SAMINOR 1. Based on self-report and random (non-fasting) plasma glucose (RPG) ≥11.1 mmol/L measurement in SAMINOR 1, 260 prevalent cases of DM were excluded. To ensure exclusion of prevalent cases, in total 75 participants were excluded, as, in SAMINOR 2, they reported the date at the time of DM diagnosis as prior to (n=52), at the same time as (n=6) or during the first two years after participating in SAMINOR 1 (n=17, two years wash-out period. Of the remaining 5875 persons, 11 were not included in the final analysis due to missing main questionnaire (n=10) or HbA1c measurement (n=1) in SAMINOR 2. A total of 2561 did not participate in SAMINOR 2 as they had died, moved out of the included municipalities during the follow-up period, or were not willing or able to participate in SAMINOR 2. Hence, 3303 individuals (participation rate: 56.2%) were included in the analysis (Figure 2).

The data collection for SAMINOR 1 took place over two calendar years and over three calendar years for SAMINOR 2, and the municipalities were not visited in the same order in the two surveys. Thus, the time span between the two examinations varied from eight to eleven years, with a mean of 10.1 years. The merged file contains individuals born in the period 1933–1968 and in 1973, who were aged 30 and 36–71 years in SAMINOR 1 and 40–41 and 44–79 years in SAMINOR 2.

Blood sampling

In both SAMINOR 1 and 2, blood samples were taken by venipuncture at normal venous pressure with the participant in a seated position. In SAMINOR 1, blood samples were mailed directly to the laboratory for analysis. Among the included analyses was RPG. The applied methods and procedures in SAMINOR 1 are described in detail elsewhere [6]. In SAMINOR 2, glycated haemoglobin (HbA1c) was measured immediately on site from whole blood, using DCA Vantage™ (Siemens Medical Solutions Diagnostics, Tarrytown, NY, USA). In SAMINOR 1, HbA1c was not measured.

Ethnicity

Ethnic information was collected through self-report in SAMINOR 1. The questions were: "What language(s) do/did you, your parents and your grandparents use at home?", "What is your, your father's and your mother's ethnic background?", and "What do you consider yourself to be?" For all items, the response options were: "Norwegian", "Sami", "Kven", and "Other". The questions were to be answered separately for each relative, and multiple answers were allowed. Sami ethnicity was defined based on two criteria: 1) self-identification as a Sami, and 2) a Sami language connection. Sami self-identification was regarded as fulfilled if the respondent considered him/herself to be Sami or reported having a Sami ethnic background. Sami language connection was defined if at least one grandparent, parent, or the participant him/herself spoke a Sami language at home. Participants who fulfilled both criteria were categorised as Sami. All other participants were categorised as non-Sami.

Diabetes mellitus

In SAMINOR 1, both questionnaire information and RPG levels were used to categorise participants as having DM. The question concerning diabetes was: "Do you have, or have you had, diabetes? (yes/no)". Those who answered "yes", or who had RPG levels of 11.1 mmol/L or higher, were considered prevalent cases of DM.

In SAMINOR 2, the question was: “Have you ever been diagnosed with diabetes (elevated blood sugar levels)? (yes/no)”. Missing self-report of DM was classified as “no”. Participants who answered “yes” or had HbA1c ≥ 6.5% were categorised as incident cases.

Risk factors for type 2 DM

All potential risk factors for DM included in the present study were measured at the start of the study, i.e., in SAMINOR 1.

Height (cm) and weight (kg) were measured using an electronic height and weight scale, with participants wearing light clothing without shoes. Body mass index (BMI) was calculated as weight in kilogrammes, divided by the square of the height in metres (kg/m^2). Waist circumference (WC) was measured in centimetres at the umbilicus, with the participant standing and breathing normally. Waist-to-height ratio (WHtR) was calculated as waist circumference divided by height.

Those who reported in the questionnaire that at least one of their parents, siblings or offspring had DM were regarded as having a positive family history of DM. Marital status (married vs single, widowed/widower, divorced or separated), education (highly educated with more than 12 years of education vs lower education), cigarette smoking (current smoker vs ex-smoker or never-smoker), alcohol drinking (drinking at least once a week vs drinking less often), annual family gross income (lower than 451,000 Norwegian Kroner vs higher income) were also assessed.

Hopkins Symptom Checklist (SCL-10) was used for measuring mental distress [8]. Ten items relevant for mental health are included in the SCL-10: experiencing fear, frightened/ anxiousness, faintness/dizziness, tenseness/upset, insomnia/sleeplessness, easily blaming yourself, being dejected/melancholia, being useless or of little value, experiencing everything as a struggle, being hopeless regarding the future. Each question was answered on a four-

point scale ranging from 1 = “Not affected” to 4 = “Extremely affected”. In total, 418 participants had at least one missing answer to one of the mentioned ten questions. Imputation was performed for those with one (n=130) or two (n=31) missing answers, by assigning the mean values of the respective questions to them, as described by Strand et al. [9]. For records with three or more missing responses, the SCL-10 score was not calculated. The mean of the ten scores was then calculated for each participant, by dividing the sum of the scores by ten. A SCL-10 score over 1.85 is considered indicative of mental distress [8, 9].

Participants scored their leisure-time physical activity during the past year on a four-point scale: 1) “reading, watching TV, or other sedentary activities”; 2) “walking, cycling, or similar forms of exercise at least four hours a week”; 3) “at least four hours a week of recreational sports, heavy gardening, etc.”; and 4) “hard training or sports competitions regularly and several times a week” [10]. Those who reported reading, watching TV, or other sedentary activities were regarded as inactive.

Statistical analysis

Data management and statistical analysis were performed using Stata version 15.0 (Stata Corp., College Station, TX, USA). All tests were two-sided with a 5% significance level and were performed separately for men and women.

Those who were included in the analysis were compared with those we would wish to follow up but were not able to include (due to death, emigration, or lack of participation or insufficient information in SAMINOR 2) with regard to the available baseline characteristics and risk factors for DM (Table 1). Differences in mean age, BMI, WC, and WHtR were tested by two-sample *t*-tests. For the categorical variables, Sami ethnicity, having positive family history of DM, marital status, being highly educated, SCL-10 score > 1.85 (mental distress), smoking, drinking alcohol, having low income, and being inactive in leisure-time, the groups

were compared using Pearson's χ^2 tests. The same variables were compared for Sami vs non-Sami subjects included in the analyses (Table 2).

Those who were categorised as having DM in SAMINOR 2, but not in SAMINOR 1 or the first two years after it, were regarded as incident cases of DM, and, by dividing the number of incident cases by the number of DM-free participants in SAMINOR 1 (at-risk individuals), the approximately 8-year cumulative incidence of DM was estimated. Participants were divided into two age groups: 30 or 36–52-year-old participants, and 53–71-year-old participants in SAMINOR 1. The 8-year cumulative incidence of DM was estimated for and compared between Sami and non-Sami participants from the same sex and age group, using Pearson's χ^2 tests (Table 3).

Multiple logistic regression analysis was used to assess the effect of ethnicity (Sami vs non-Sami), as well as various risk factors, on the development of DM in men and women (Table 4). The first model included ethnicity and age. Then, in addition to age and ethnicity, each of the potential risk factors was included in separate models. Finally, the effect of age, ethnicity, WHtR and education on the cumulative incidence of DM was assessed.

Ethics

The SAMINOR Study was approved by the Norwegian Data Inspectorate and by the Regional Committees for Medical and Health Research Ethics North (REC North). The committee also approved the present study, with approval number 2016/173. All participants gave written informed consent for medical research and to have their data linked to other registers or surveys. The study was also approved by the SAMINOR Project Board.

Table 1. Characteristics of individuals we were able to follow-up, compared to those who were not followed up, among those who participated in SAMINOR 1 (2003–2004) and were eligible[1] for SAMINOR 2 (2012–2014), by sex (N=5875). Numbers are mean (standard deviation) for continuous variables and percent (number of subjects) for categorical variables.

	Included in the follow-up analysis	Not followed up	p-value
Men	N=1447	N=1307	
Age (year)	52.4 (8.7)	51.2 (9.8)	<0.01
Body mass index (kg/m^2)	27.5 (3.5)	27.6 (4.2)	0.42
Waist circumference (cm)	92.3 (9.3)	93.0 (10.9)	0.07
Waist-to-height ratio	0.534 (0.054)	0.537 (0.064)	0.10
Sami ethnicity (%)	40.2 (581)	32.7 (866)	<0.01
Family history of DM[2] (%)	19.4 (280)	18.2 (238)	0.44
Married[3] (%)	64.5 (933)	52.8 (690)	<0.01
Education>12 years (%)	32.8 (458)	30.7 (381)	0.26
SCL-10 score >1.85 (%)	5.3 (72)	9.5 (114)	<0.01
Current smoker[4] (%)	28.8 (416)	39.5 (516)	<0.01
Alcohol[5] (%)	30.7 (444)	31.1 (407)	0.80
Low-income[6] (%)	57.0 (825)	61.5 (804)	0.02
Inactive[7] (%)	18.8 (272)	23.1 (302)	0.01
Women	N=1856	N=1265	
Age (year)	51.6 (9.0)	50.7 (10.1)	<0.01
Body mass index (kg/m^2)	27.4 (4.6)	27.6 (4.9)	0.38
Waist circumference (cm)	84.0 (11.2)	84.2 (11.8)	0.08
Waist-to-height ratio	0.526 (0.074)	0.527 (0.076)	0.40
Sami ethnicity (%)	39.5 (733)	29.4 (372)	<0.01
Family history of DM[2] (%)	23.2 (430)	21.8 (276)	0.38
Married[3] (%)	66.0 (1225)	58.2 (736)	<0.01
Education>12 years (%)	38.0 (674)	36.3 (428)	0.34
SCL-10 score >1.85 (%)	8.4 (141)	11.5 (130)	<0.01
Current smoker[4] (%)	30.6 (568)	40.9 (517)	<0.01
Alcohol[5] (%)	19.7 (365)	20.5 (259)	0.58
Low-income[6] (%)	58.7 (1090)	62.7 (793)	0.03
Inactive[7] (%)	19.1 (355)	22.9 (289)	0.01

1) Living in the 10 SAMINOR 2 municipalities at time of SAMINOR 1 with relevant year of birth
2) Those who had at least one with DM among father, mother, siblings or children
3) Married vs single, widow/widower, divorced, or separated
4) Current smokers vs former smokers or never-smokers
5) Drinking alcohol at least once a week
6) Yearly gross income of the household less than 451,000 Norwegian Kroner
7) Leisure-time activities include reading, watching TV or other sedentary activities

Table 2. Baseline characteristics of diabetes-free participants in SAMINOR 1 (2003–2004) followed-up to SAMINOR 2 (2012–2014), N=3303. Numbers are mean (standard deviation) for continuous variables (age, body mass index, waist circumference, and waist-to-height ratio) and percent (number of subjects) for categorical variables (family history of DM, married, education>12 years, SCL-10 score>1.85, alcohol, low-income, and inactive).

	Sami	Non-Sami	p-value
Men	N=581	N=866	
Age (year)	51.8 (8.8)	52.8 (8.7)	0.04
Body mass index (kg/m^2)	27.8 (3.8)	27.3 (3.3)	0.02
Waist circumference (cm)	91.7 (9.8)	92.8 (9.0)	0.03
Waist-to-height ratio	0.540 (0.060)	0.529 (0.050)	<0.01
Family history of DM[1] (%)	20.5 (119)	18.6 (161)	0.37
Married[2] (%)	59.2 (344)	68.0 (589)	<0.01
Education>12 years (%)	32.6 (184)	32.9 (274)	0.89
SCL-10 score >1.85 (%)	6.3 (34)	4.6 (38)	0.17
Current smoker[3] (%)	29.6 (172)	28.2 (244)	0.55
Alcohol[4] (%)	27.4 (159)	32.9 (285)	0.02
Low-income[5] (%)	60.2 (350)	54.8 (475)	0.04
Inactive[6] (%)	20.3 (118)	17.8 (154)	0.23
Women	N=733	N=1123	
Age (year)	50.7 (8.9)	52.1 (8.9)	<0.01
Body mass index (kg/m^2)	28.0 (4.8)	27.0 (4.5)	<0.01
Waist circumference (cm)	84.5 (11.3)	83.6 (11.2)	0.11
Waist-to-height ratio	0.539 (0.075)	0.516 (0.072)	<0.01
Family history of DM[1] (%)	24.6 (180)	22.3 (250)	0.25
Married[2] (%)	60.3 (442)	69.7 (783)	<0.01
Education>12 years (%)	42.7 (298)	35.0 (376)	<0.01
SCL-10 score >1.85 (%)	9.0 (60)	8.0 (81)	0.47
Current smoker[3] (%)	31.6 (232)	29.9 (336)	0.43
Alcohol[4] (%)	14.3 (105)	23.1 (260)	<0.01
Low-income[5] (%)	61.0 (447)	57.3 (643)	0.11
Inactive[6] (%)	25.0 (183)	15.3 (172)	<0.01

1) Those who had at least one with DM among father, mother, siblings or children
2) Married vs single, widow/widower, divorced, or separated
3) Current smokers vs former smokers or never-smokers
4) Drinking alcohol at least once a week
5) Yearly gross income of the household less than 451,000 Norwegian Kroner
6) Leisure-time activities include reading, watching TV or other sedentary activities

RESULTS

Compared to subjects who took part in SAMINOR 1, but were not followed up, subjects who participated in both surveys were on average older, and more likely to be married and report Sami ethnicity. Furthermore, those included in the follow-up analyses were more physically active and less likely to be current smokers, reporting mental disorders, and having low income (Table 1).

Table 2 shows some baseline characteristics of DM-free individuals in SAMINOR 1 who were followed up until SAMINOR 2. In both sexes, Sami had higher mean WHtR and BMI compared to non-Sami. Mean WC was higher among non-Sami men, while no statistically significant difference was observed in the mean WC between Sami and non-Sami women. Among women, more Sami than non-Sami were considered inactive (Table 2).

A total of 201 incident cases of DM were identified in SAMINOR 2, based on self-report (n=138) or HbA1c ≥ 6.5% (without self-report) (n=63). We noted that all the self-reported cases had HbA1c ≥ 6.5% (results not shown). This number corresponds to a 6.1% (95% confidence interval: 5.3–6.9) 8-year cumulative incidence of DM. No statistically significant difference in the 8-year cumulative incidence of DM was found between Sami and non-Sami of the same sex and age group (Table 3).

Table 3. Estimated 8-year cumulative incidence of diabetes mellitus in % (number of cases) among Sami and non-Sami subjects, according to self-report and/or HbA1c≥6.5%, by sex and age at baseline. SAMINOR 1 (2003–2004) and SAMINOR 2 (2012–2014), N=3303.

	Age groups	Total % (n)	Non-Sami % (n)	Sami % (n)	p-value*
Men	30, 36–52 years	5.5 (38)	5.3 (21)	5.8 (17)	0.79
	53–71 years	7.8 (59)	7.5 (35)	8.4 (24)	0.65
	Total	6.7 (97)	6.5 (56)	7.1 (41)	0.66
Women	30, 36–52 years	3.8 (37)	3.2 (18)	4.5 (19)	0.32
	53–71 years	7.7 (67)	8.3 (47)	6.5 (20)	0.35
	Total	5.6 (104)	5.8 (65)	5.3 (39)	0.67

* p-values are from Pearson's χ^2- test

We found a positive relationship between age and the odds of DM during follow-up. This relationship was statistically significant in women ($p<0.01$) but not in men ($p=0.29$). The age-adjusted logistic regression analysis showed no statistically significant difference between Sami and non-Sami in the odds for DM in men or women. Further adjustments for other risk factors of DM confirmed that there were no ethnic differences in the odds of contracting DM (Table 4). BMI, WC and WHtR were statistically significant risk factors for DM in both sexes (adjusted for age and ethnicity).

Table 4. Adjusted odds ratios (OR) with 95% confidence interval (95% CI) for incident cases of diabetes mellitus (DM) for Sami compared to non-Sami subjects, and various risk factors for DM, stratified by sex. SAMINOR 1 (2003–2004) and SAMINOR 2 (2012–2014), N=3303.

Models	Adjusted OR (95% CI) for Sami vs non-Sami	p-value	Adjusted OR (95% CI) for respective risk factors (apart from age and ethnicity)	p-value
Men (n=1447)				
Age+ethnicity	1.11 (0.73–1.69)	0.62	-	-
Age+ethnicity+BMI[1]	0.91 (0.59–1.41)	0.68	1.27 (1.20–1.34)	<0.01
Age+ethnicity+WC[2]	1.15 (0.75–1.78)	0.51	1.08 (1.06–1.10)	<0.01
Age+ethnicity+WHtR[3]	0.84 (0.54–1.32)	0.46	1.16 (1.12–1.20)	<0.01
Age+ethnicity+education	1.09 (0.71–1.66)	0.70	0.95 (0.89–1.01)	0.11
Age+ethnicity+inactivity[4]	1.10 (0.72–1.67)	0.65	1.49 (0.92–2.42)	0.10
Age+ethnicity+alcohol[5]	1.09 (0.72–1.65)	0.68	0.67 (0.42–1.11)	0.12
Age+ethnicity+smoking[6]	1.10 (0.72–1.68)	0.64	0.97 (0.61–1.54)	0.90
Age+ethnicity+mental distress[7]	1.15 (0.74–1.78)	0.53	0.40 (0.10–1.64)	0.20
Age+ethnicity+WHtR+education	0.85 (0.54–1.33)	0.47	WHtR: 1.17 (1.12–1.21) education: 0.98 (0.92–1.04)	<0.01 0.55
Women (n=1856)				
Age+ethnicity	0.97 (0.64–1.47)	0.89	-	-
Age+ethnicity+BMI[1]	0.82 (0.53–1.25)	0.35	1.14 (1.10–1.18)	<0.01
Age+ethnicity+WC[2]	0.91 (0.59–1.39)	0.66	1.07 (1.05–1.09)	<0.01
Age+ethnicity+WHtR[3]	0.72 (0.47–1.11)	0.14	1.11 (1.08–1.13)	<0.01
Age+ethnicity+education	1.02 (0.66–1.57)	0.92	0.93 (0.87–0.99)	0.02
Age+ethnicity+inactivity[4]	0.95 (0.63–1.43)	0.80	1.28 (0.79–2.08)	0.31
Age+ethnicity+alcohol[5]	0.95 (0.63–1.43)	0.80	0.72 (0.41–1.24)	0.23
Age+ethnicity+smoking[6]	0.97 (0.64–1.46)	0.90	1.08 (0.70–1.66)	0.73
Age+ethnicity+mental distress[7]	1.10 (0.71–1.71)	0.66	0.94 (0.43–2.07)	0.88
Age+ethnicity+WHtR+education	0.78 (0.50–1.22)	0.28	WHtR: 1.10 (1.08–1.13) education: 0.96 (0.90–1.02)	<0.01 0.20

1) BMI: body mass index (kg/m^2)
2) WC: waist circumference (cm)
3) WHtR: waist-to-height ratio. For the OR to be more understandable, this variable is multiplied by 100
4) Leisure-time physical activity includes reading, watching TV or other sedentary activities
5) Drinking alcohol at least once a week vs drinking alcohol less often
6) Current smokers vs ex-smokers and never-smokers
7) SCL-10 score >1.85

DISCUSSION

The present study is the first to estimate the cumulative incidence of DM among Sami and non-Sami inhabitants of Northern Norway. After eight years of follow-up, 201 (6.1%) incident cases of DM were identified, based on self-report and/or HbA1c $\geq$ 6.5%. The 8-year cumulative incidence of DM was not statistically significantly different between Sami and non-Sami counterparts of the same sex.

Of 5875 SAMINOR 1 participants who were eligible to participate in SAMINOR 2, 3303 were included in the follow-up analysis. To assess the risk of selection bias, we compared some relevant and available risk factors for DM between those who were included in the analysis and those who were not. Although those who were not included in the final analysis were on average younger, the age discrepancy was only around one year, which may not have affected the estimated cumulative incidence of DM. Not being married, being a smoker, having a higher SCL-10 score (mental distress indicator), having lower income and having lower level of leisure-time physical activity, were some attributes of those who were not included in the analysis. In the second survey of the Tromsø Study, it was found that non-participants were over-represented among young and unmarried men [11]. Results from the Tromsø Study indicate lower mortality in subjects who attended several surveys rather than only one [12]. Results from similar studies in Norway indicate that non-participants have higher levels of chronic diseases, higher mortality rates, higher prevalence of disability pension and belong to lower socioeconomic groups [13, 14]. On the other hand, BMI, WC, WHtR (indicators of obesity) and having a positive family history of DM (an indicator of genetic predisposition to DM) were not statistically significantly different between those included in our analysis and those not, making it less likely that the two groups were systematically different with regard to the risk of DM.

If loss to follow-up is due to the outcome (DM), its complications or diseases with shared risk factors (e.g. cardiovascular diseases), the cumulative risk is underestimated (competing risk effect) [15]. Our dataset was not linked to the Cause of Death Registry, so we do not have direct information about the number and causes of death of those who died during the follow-up period. It is unlikely that a participant contracted DM during the follow-up period and died of the disease itself or its late complications. On the other hand, deaths due to competing risks (like cardiovascular diseases) inevitably lead to underestimation of the cumulative incidence of DM. Based on numbers from Statistics Norway, one can expect there to have been around 330 deaths from 2001 to 2011 (10 years) in a group of 5875 persons with similar age span and age distribution to those of our participants (calculations not shown) [16].

According to the Norwegian Institute of Public Health, cancers are the leading cause of death in people with a similar age span to those of our participants, followed by cardiovascular diseases (mutual risk factors for DM) [17]. Competing risks become more important with the increasing age of the population under study (increased risk of multimorbidity). As the mean baseline age of both groups, those that were followed up and those that were not, was around 52 years, and there were relatively few expected deaths (330 deaths totally), it is not thought that competing risks have substantially affected our estimate of the cumulative incidence of DM. Furthermore, studies have shown minimal or no difference between Sami and non-Sami individuals in the distribution of risk factors for cardiovascular diseases and/or the risk of acute myocardial infarction or cerebral stroke [18, 19]. We do not have information on the participants in SAMINOR 1, who, due to emigration, were not included in the final analysis, but they were few, and it is unlikely that they had any impact on the conclusions.

At the end of the follow-up period (SAMINOR 2), self-reported DM and/or HbA1c $\geq$ 6.5% was used to identify incident cases of DM. This HbA1c cut-off is suggested by the American Diabetes Association, as well as the Norwegian Directorate of Health [20, 21], and is being

largely applied in practice. According to the Tromsø OGTT study, an HbA1c cut-off ≥ 6.5% provides sensitivity and specificity of around 35% and 97%, respectively [22]. The low performance of the test leads to substantial misclassification of DM, but it must be assumed to be unrelated to categorisation as a Sami or not.

The HbA1c reflects average plasma glucose concentration during the preceding two to three months [23]. The test has high levels of pre-analytical stability and reproducibility, fewer day-to-day perturbations during periods of stress and illness, and convenience (no need for fasting state or glucose overload) [20]. These attributes might, to some extent, offset the low performance of the test [23].

The questionnaire applied in the present study was not validated. However, the sensitivity and positive predictive value of self-reported DM were reported as 86.7% and 73.4%, respectively, in the CADEUS study in France, using medical records as standard [24]. The validity of self-reported DM in the HUNT 1 Survey was reported to be excellent by comparison with the general practitioners' records, with positive and negative predictive values of 96% and 99.7%, respectively [25].

Categorisation of the participants into Sami and non-Sami was based on the information provided from the SAMINOR 1 questionnaires. It is extremely unlikely that a non-Sami individual would report their ethnicity as Sami, while, due to decades of the governmental assimilation policy (Norwegianisation) and the stigmatisation of Sami people, it is quite likely that some Sami people might report their ethnicity as non-Sami.

These misclassifications must be expected to be unrelated to the DM diagnosis, and have most likely substantially attenuated the measure of association (the possible ethnic difference in DM risk) [26, 27]. The lack of statistically significant difference in the 8-year cumulative incidence of DM between Sami and non-Sami might be explained by the misclassifications or

the relatively small study sample size. Similar standards of living, high awareness about lifestyle diseases like type 2 DM and fair access to healthcare services for both ethnic groups in the study municipalities are other possible explanations.

According to a newly published cohort study, the estimated prevalence of diagnosed type 2 DM for all residents in Norway aged 30 to 89 years increased from 4.9% in year 2009 to 6.1% in 2014 [28]. Nevertheless, the incidence rate of type 2 DM decreased significantly from 609 cases per 100,000 person-years in 2009 to 398 cases per 100,000 in 2014, an annual reduction of 10.1%. Our estimated cumulative incidence of DM (6.1% in 8 years or around 762 cases in 100,000 participants in a year) is comparable to the reported 609 cases per 100,000 person-years in year 2009. It should be kept in mind that our estimate included all types of DM, while the mentioned study reported known cases of type 2 DM. However, due to the age of the new cases, they must be expected to be mainly type 2 DM. In the HUNT Study (from 1995–1997 to 2006–2008), the 11-year cumulative incidence of any diabetes was around 4.5% among adults ($20 \leq age < 70$) using self-report, RPG $\geq$ 11.1 mmol/L, fasting plasma glucose $\geq$ 7 mmol/L, HbAc1 $\geq$ 6.5% or 2-hour 75g OGTT $\geq$ 11.1 mmol/L [25]. The different age span of participants in the HUNT Study is the most likely explanation for the difference between our results and those from the HUNT Study.

While incidence rates of type 2 DM have been reported to be on the rise worldwide in the last 30 years, the disease disproportionally affects indigenous populations [29, 30]. Higher incidence and prevalence of type 2 DM among indigenous peoples, in comparison to the benchmark populations, seems to be a shared phenomenon worldwide [2]. For example, the age-standardised incidence of type 2 DM of 1814 Australian Aboriginal and Torres Strait Islander adults from 1999 to 2007 was reported to be 30.5 in 1000 person-years. The estimated incidence rate is nearly four times higher than that for the non-Indigenous

population and 50% higher than the incidence reported 10 years ago in Australian Aboriginals [31].

Results from the present study, as well as results from our previous studies, which found either no or not a marked ethnic difference in the incidence or prevalence of DM between Sami and non-Sami people in Norway [3-5], imply substantial better conditions for Sami people in Norway, compared with those of other indigenous peoples throughout the world. This is probably due to the Sami enjoying quite similar living and healthcare standards to those of other Norwegian citizens.

Strengths and limitations

Some of the strengths of the present study lie in the application of a comprehensive questionnaire and the use of trained personnel, enabling us to obtain copious amounts of information on several aspects of living and health-related conditions, as well as the use of HbA1c, in addition to self-report, to ascertain DM. The present study is the first longitudinal study to measure the cumulative incidence of DM in Sami-inhabited regions in Norway.

A conventional participation rate, relatively small sample size, limited number of included municipalities, lack of sufficient dietary information, no differentiation between types of DM, lack of linkage to national health registers such as prescription databases, the Cause of Death Register, or discharge register, are some of the limitations of the present study. It is also a limitation that we lack information about which of the SAMINOR 1 participants were actually invited to SAMINOR 2.

We did not have reliable data on the exact time of diagnosis/occurrence of the disease, which made calculation of the incidence rate of DM impossible.

CONCLUSIONS

We observed no ethnic difference in the 8-year cumulative incidence of DM, although mean WHtR and BMI were higher among Sami than non-Sami participants of both sexes. There may be a need for larger studies in the future, to track and elucidate any ethnic difference in the cumulative incidence or incidence rate of DM.

List of abbreviations:

BMI: body mass index

DM: diabetes mellitus

HbA1c: glycated hemoglobin

RPG: random plasma glucose

TV: television

WC: waist circumference

WHtR: waist-to-height ratio

DECLARARTION

Acknowledgment: We are indebted to the participants of the SAMINOR Study, without whom our research would be impossible.

Competing interests*:* The authors declare that they have no competing interests.

Ethics approval and consent to participate: The SAMINOR Study was approved by the Norwegian Data Inspectorate and by the Regional Committees for Medical and Health Research Ethics North (REC North). The committee also approved the present study with the approval number 2016/173. All participants gave written informed consent for medical research and to have their data linked to other registers or surveys.

Consent for publication: Not applicable

Funding: The Norwegian Ministry of Health and Care Services provided funding for The SAMINOR 1 Survey. The SAMINOR 2 Clinical Survey was financed by the Norwegian Ministry of Health and Care Services; the Northern Norway Regional Health Authority; the Regional Research Fund of Northern Norway; the Sami Parliament; the Sami Norwegian National Advisory Unit on Mental Health and Substance Use; Finnmark, Troms, and Nordland County Councils. UiT The Arctic University of Norway funded Naseribafrouei's PhD scholarship. The funding organs had no role in the analysis or preparation of the manuscript. The publication charges for this article have been funded by a grant from the publication fund of UiT The Arctic University of Norway.

Contributors' contributions: ARB conceptualised and initiated the study. AN as the corresponding author analyzed the data and wrote the article. MM assisted in statistical analyses as well as material and methods' descriptions. BME, MM, JS and ARB contributed to the interpretation of the results and drafting of the manuscript. All authors read and approved the final manuscript.

Availability of data and materials: The data that support the findings of this study were used under licence for the current study and are therefore not publicly available. Data are available from the SAMINOR Study upon reasonable request (www.saminor.no), but restrictions apply to the availability of these data, due to Norwegian privacy regulations.

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Figure 1. Map of Northern Norway, Sápmi, and the included municipalities in the SAMINOR 2 Clinical Survey (2012–2014).

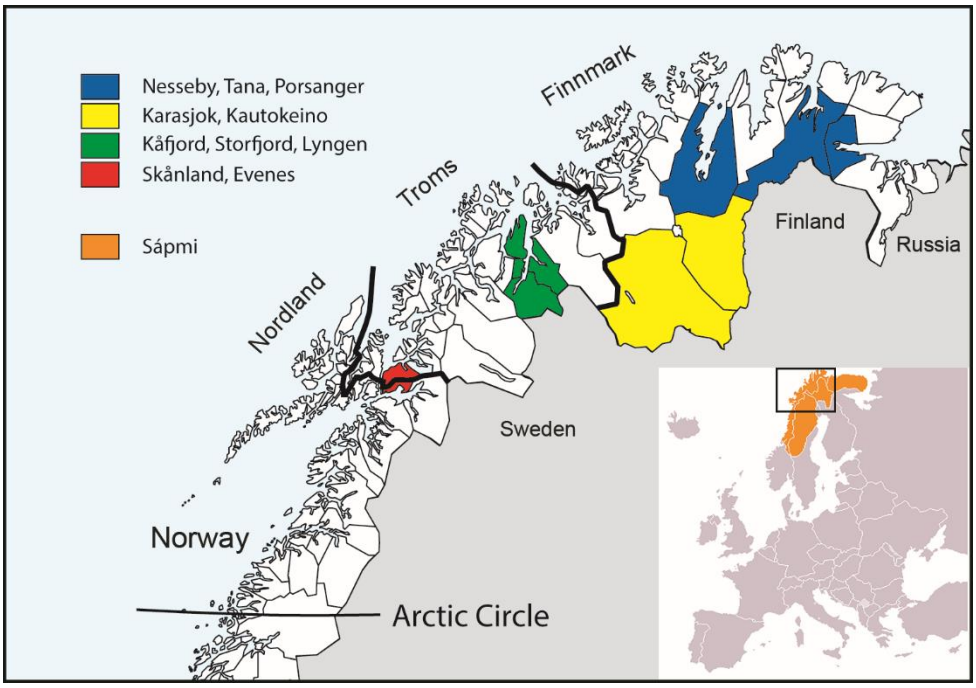

Figure 2. Flow chart demonstrating persons included for final analysis.