Research Square

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Time trends in osteoporosis prevalence and cross-sectional associations with parental family history: The Tromsø Study

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Abstract

Background

Osteoporosis is a growing public health concern yet research on its epidemiology remains limited. This study aimed to examine trends in the prevalence of osteoporosis and the association between a parental family history of osteoporosis and osteoporosis.

Methods

Self-reported data from the population-based Tromsø Study, conducted in 1994–1995 (Tromsø4), 2001 (Tromsø5), and 2007–2008 (Tromsø6), were utilized in this cross-sectional study, with analyses performed using generalized estimating equations and logistic regression.

Results

The prevalences of osteoporosis increased over time in both women and men. Women had a higher prevalence of osteoporosis than men in both age groups (≤ 50 and > 50 years old). Among women, the highest prevalence of osteoporosis (9.9% [95% CI 9-10.8]) was found in Tromsø6 for the > 50 age group, while the lowest (0.1% [0.1–0.2]) was observed in the ≤ 50 age group in Tromsø4. Among men, the highest prevalence (1.2% [0.8–1.6]) was found in Tromsø5 for the > 50 age group, whereas the lowest (0.1% [0.05–0.2]) was observed in the ≤ 50 age group in Tromsø4. A parental history of osteoporosis independently increased the odds of osteoporosis with an odds ratio of 2.4 [95% CI 1.9–3.2]. The association remained independent, across both sexes and all levels of adjustment (age and osteoporosis-related factors).

Conclusion

Utilizing this knowledge to develop a more personalized approach may enhance osteoporosis prevention and control.

Background

Osteoporosis is a growing public health concern, significantly impacting morbidity, mortality, and healthcare costs[1–5]. With an aging population and various contributing risk factors, understanding the prevalence and determinants of osteoporosis is crucial for developing effective prevention strategies. Risk factors include advanced age, female sex, certain ethnic backgrounds, lifestyle habits, chronic conditions, and a family history of fractures[6] etc. Despite its widespread impact, osteoporosis often remains undiagnosed until fractures occur, leading to serious health consequences and substantial economic burdens.

Norway, like many other countries, faces an osteoporosis burden. The prevalence of osteoporosis globally is estimated at approximately 19%[7–8]. Norwegian data suggest that between 240,000 and 300,000 individuals are affected[9]. Considering that the total population of Norway in 2016 was 5,213,985[10], this corresponds to a prevalence between 4.6% and 5.7%. The Tromsø Study data demonstrated higher prevalences in men (10.8%) and women (20.9%)[11] compared to the national total estimates.

One well-established risk factor for developing osteoporosis is a family history of fractures, particularly on the maternal side[6]. However, whether a family history of osteoporosis itself increases the likelihood of developing the condition remains uncertain, as studies have reported conflicting findings[7,12–14].

This study aims to examine trends in osteoporosis prevalence in the Tromsø Study and assess the role of parental history of osteoporosis.

Methods

Study design

The Tromsø Study is a population-based longitudinal cohort study comprising seven consecutive surveys conducted in the municipality of Tromsø, Norway between 1974 and 2016. Both complete birth cohorts and random samples of women and men were invited to participate[15]. This cross-sectional study used data from three surveys—Tromsø4 (1994–1995), Tromsø5 (2001), and Tromsø6 (2007–2008) —all of which followed standardized protocols and collected relevant information on osteoporosis. Tromsø4 was the first survey to include osteoporosis data and enabled prevalence estimates over time. Tromsø6 was additionally used to examine associations with parental history of osteoporosis due to the availability of relevant covariates.

Study population

A total of 30,288 individuals who participated in at least one of the three surveys were included (Figure 1). For osteoporosis prevalence analyses, participants were required to have complete data on osteoporosis status, age, and sex, resulting in inclusion rates of 83.1% (Tromsø4), 96.7% (Tromsø5), and 97.3% (Tromsø6). Analyses of parental history and osteoporosis were restricted to Tromsø6 participants with complete data on family history, osteoporosis status, and covariates (Figure 2); 91.2% met the inclusion criteria after excluding outliers.

Data Collection

The Tromsø Study surveys have followed the same general design and have been described in detail previously[15-16]. In Tromsø4–6, osteoporosis status (yes/no) was assessed through self-administered questionnaires. In Tromsø6, we additionally used questionnaire data on family history of osteoporosis (parents, children, siblings; yes/no), use of osteoporosis medication (yes/no), education level (primary school/ vocational school/ upper secondary school/ university < 4 years/ university ≥ 4 years), physical activity frequency (never/ less than once a week/ once a week/ 2-3 times a week/ approximately every

day), alcohol consumption frequency (never/ monthly or less frequently/ 2-4 times a month/ 2-3 times a week/ 4 or more times a week), daily smoking (current/ previous/ never), daily coffee and tea consumption (cups per day). Further details on the questionnaires are available on the Tromsø Study website (https://uit.no/research/tromsostudy).

Body height and weight were measured with participants wearing light clothing and no shoes. Height was recorded to the nearest 0.1 cm and weight to the nearest 100 g. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2). According to the WHO classification, BMI was categorized as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obesity (≥30.0 kg/m^2).

Statistical Analysis

Osteoporosis prevalence was estimated with 95% confidence intervals (CIs) and stratified by survey, sex, and age group (≤50 vs. >50 years). Prevalence across surveys was compared using generalized estimating equations (GEE) to account for repeated participation. Odds ratios (ORs), CIs, and p-values are reported.

Associations between parental history of osteoporosis and osteoporosis prevalence were examined using binomial logistic regression. Potential confounders were identified using directed acyclic graphs (DAGs) and included sex, age, education, smoking, alcohol use, tea and coffee consumption, physical activity, and BMI. Interaction between sex and family history was assessed but was not statistically significant; nevertheless, sex-stratified analyses were presented due to clinical relevance. The interaction between age and family history was not tested, as genetic risk factors remain constant over life.

Results

The total prevalences suggest an increase in osteoporosis over time, with the most significant jump observed from Tromsø4 to Tromsø5 (Table 1). This trend was more pronounced in women. Men displayed the highest total prevalence in Tromsø5. In both women and men regardless of the age, the proportion of individuals with osteoporosis significantly differed in Tromsø5 and Tromsø6 compared to Tromsø4. Specifically, in Tromsø5, the odds of developing osteoporosis were higher compared to Tromsø4, with an OR of 1.9 [95% CI 1.7-2.2] in women and 3.8 [95% CI 2.3-6.2] in men. Similarly, in Tromsø6, the OR were 3.0 [95% CI 2.7-3.3] in women and 4.1 [95% CI 2.7-6.5] in men.

In women, the prevalence of osteoporosis increased with age. In women aged ≤50 years, the prevalence of osteoporosis remained low in Tromsø4 (0.1%) and Tromsø5 (0.2%), with an increase in Tromsø6 (1.0%) (Table 1). Compared to Tromsø4, the prevalence in Tromsø5 was stable [p = 0.95, OR = 1.1, 95% CI (0.2–5.0)], while in Tromsø6, the odds of having osteoporosis were higher [OR = 6.8, 95% CI (3.4–13.6)]. Among women aged >50 years, the prevalence of osteoporosis gradually increased over time, reaching its highest level in Tromsø6 (9.9%). Compared to Tromsø4, the odds of osteoporosis were elevated in both Tromsø5 [OR = 1.3, 95% CI (1.1–1.4)] and Tromsø6 [OR = 1.7, 95% CI (1.5–2.0)].

In men, the prevalence of osteoporosis was lower compared to women in the older age group and was the same in the younger age group, except in Tromsø6. In men aged ≤50 years, the prevalence of osteoporosis was relatively low across all three surveys—0.1% in Tromsø4, 0.2% in Tromsø5, and 0.4% in Tromsø6. Compared to Tromsø4, the prevalence in Tromsø5 remained stable [OR = 1.3, 95% CI (0.3–6.1)], while in Tromsø6, the odds of developing osteoporosis were higher [OR = 2.8, 95% CI (1.2–6.7)]. Among men aged >50 years, the prevalence increased from 0.4% in Tromsø4 to 1.2% in Tromsø5, followed by a slight decrease to 1.1% in Tromsø6. The odds of developing osteoporosis were higher in both Tromsø5 [OR = 3.1, 95% CI (1.7–5.7)] and Tromsø6 [OR = 3.3, 95% CI (1.9–5.9)] compared to Tromsø4.

Table 1 Prevalence of osteoporosis stratified by sex and age group in Tromsø4, Tromsø5, and Tromsø6

		Women (n=22,894)			Men (n=20,179)		
Age (years)		Tromsø4	Tromsø5	Tromsø6	Tromsø4	Tromsø5	Tromsø6
≤50	cases/total	11/7938	2/1164	22/2306	10/7108	2/891	7/1956
	% (95% CI)	0.1 (0.1-0.2)	0.2 (0.02-0.6)	1. (0.6-1.4)	0.1 (0.05-0.2)	0.2 (0.03-0.8)	0.4 (0.1-0.6)
	OR (95% CI)	-	1.1 (0.2-5.0)	6.8 (3.4-13.6)	-	1.3 (0.3-6.1)	2.8 (1.2-6.7)
	p-value	-	0.95	<0.001	-	0.07	0.02
>50	cases/total	313/3805	292/3265	437/4416	15/3729	31/2541	45/3954
	% (95% CI)	8.2 (7.4-9.1)	8.9 (8.0-9.9)	9.9 (9.0-10.8)	0.4 (0.2-0.6)	1.2 (0.8-1.6)	1.1 (0.8-1.5)
	OR (95% CI)	-	1.3 (1.1-1.4)	1.7 (1.5-2.0)	-	3.1 (1.7-5.7)	3.3 (1.9-5.9)
	p-value	-	0.001	<0.001	-	<0.001	<0.001
Total	cases/total	324/11743	294/4429	459/6722	25/10837	33/3432	52/5910
	% (95% CI)	2.8 (2.5-3.1)	6.6 (5.9-7.4)	6.8 (6.2-7.4)	0.2 (0.1-0.3)	1.0 (0.6-1.3)	0.9 (0.6-1.1)
	OR (95% CI)	-	1.9 (1.7-2.2)	3.0 (2.7-3.3)	-	3.8 (2.3-6.2)	4.1 (2.7-6.5)
	p-value	-	<0.001	<0.001	-	<0.001	<0.001

OR = Odds Ratio, CI = Confidence Interval.

Descriptive characteristics of participants in Tromsø6 are presented in Table 2. Most participants were over 50 years of age. Across sexes and family history groups, vocational education, physical activity 2–3

times per week, overweight, and alcohol consumption 2–4 times per month were most common. Coffee/tea intake was lowest among women without a family history of osteoporosis and highest among men with a positive family history, while former smoking predominated, particularly among men.

Table 2 Descriptive characteristics of women and men with and without family history of osteoporosis; Tromsø6

		Women		Men	
		Family history of osteoporosis	No family history of osteoporosis	Family history of osteoporosis	No family history of osteoporosis
Age, years		55.35 (10.64)	56.78 (12.84)	54.85 (9.36)	57.02 (12.25)
Age, groups	≤50 years	267 (36%)	1967 (36%)	134 (35%)	1788 (34%)
	>50 years	474 (64%)	3521 (64%)	254 (65%)	3442 (66%)
Education	Primary school	170 (23%)	1688 (31%)	93 (24%)	1245 (24%)
	Vocational school	194 (26%)	1326 (24%)	97 (25%)	1490 (28%)
	Upper secondary school	53 (7%)	435 (8%)	29 (7%)	383 (7%)
	University < 4 years	133 (18%)	841 (15%)	77 (20%)	1102 (21%)
	University ≥ 4 years	191 (26%)	1198 (22%)	92 (24%)	1010 (19%)
Physical activity	Never	29 (4%)	270 (5%)	25 (6%)	335 (6%)
	Less than once a week	85 (11%)	734 (13%)	77 (20%)	1047 (20%)
	Once a week	140 (19%)	1010 (18%)	90 (23%)	1115 (21%)
	2-3 times a week	328 (44%)	2238 (41%)	139 (36%)	1914 (37%)
	Approximately every day	159 (21%)	1236 (23%)	57 (15%)	819 (16%)
BMI	Underweight	5 (1%)	44 (1%)	0 (0%)	13 (0%)
	Normal weight	326 (44 %)	2229 (41%)	128 (33%)	1416 (27%)
	Overweight	272 (37%)	2122 (39%)	190 (49%)	2714 (52%)
	Obesity	138 (19%)	1093 (20%)	70 (18%)	1087 (21%)
	Never	75 (10%)	7373 (13%)	22 (6%)	383 (7%)
	Monthly or less frequently	203 (27%)	1723 (31%)	92 (24%)	1334 (26%)
Alcohol	2-4 times a month	272 (37%)	1956 (36%)	88 (23%)	994 (19%)
	2-3 times a week	148 (20%)	835 (15%)	88 (23%)	994 (19%)

	4 or more times a week	43 (6%)	237 (4%)	26 (7%)	300 (6%)
Coffee/tea	Cups per day	5.12 (2.65)	5.00 (2.51)	6.04 (3.08)	5.61 (3.11)
Daily smoking	Current	147 (20%)	1176 (21%)	68 (18%)	1002 (19%)
	Previous	313 (42%)	2083 (38%)	169 (44%)	2444 (47%)
	Never	281 (38%)	2229 (41%)	151 (39%)	1784 (34%)

BMI=body mass index. Data in the table presented as absolute number (%) or mean (standard deviation).

Having a parental family history of osteoporosis independently increased the odds of having osteoporosis (Table 3). For the overall population the crude OR was 2.5 [95% CI 2.0-3.2], the age-adjusted OR was 2.6 [95% CI 2.0-3.3], and the fully-adjusted OR was 2.4 [95% CI 1.9-3.2]. Individuals with a parental history of osteoporosis were more than twice as likely to be diagnosed with the condition themselves compared to those without a family history of osteoporosis. The increase in risk remained consistent across different levels of adjustment, reinforcing the robustness of the association. When stratifying by sex the association was stronger in men. However, the interaction term was not statistically significant (p=0.2).

Table 3 Odds ratios with 95% confidence intervals, for developing a family history of osteoporosis, at different levels of adjustment in the overall population, and separately for women and men

	Crude OR (95% CI) p-value	Age-adjusted OR (95% CI) p-value	Fully-adjusted OR[a] (95% CI) p-value
Parental family history of osteoporosis	2.5 (2.0-3.2) <0.001	2.6 (2.0-3-3) <0.001	2.4 (1.9-3.2) <0.001
Parental family history of osteoporosis in women	1.97 (1.5-2.6) <0.001	2 (1.5-2.6) <0.001	2.3 (1.7-3.0) <0.001
Parental family history of osteoporosis in men	3.2 (1.6-6.8) 0.002	3.3 (1.6-6.8) 0.002	3.9 (1.8-8.2) <0.001

OR= Odds Ratio, CI= Confidence Interval.

[a]Adjusted for age, sex (for non-sex-specific models), education, physical activity, body mass index, alcohol consumption, coffee/tea consumption, daily smoking.

Discussion

Summary of main findings

Overall, osteoporosis prevalence is increasing over time in both sexes. Women showed higher osteoporosis prevalence than men in the older age group, while rates were similar between sexes in the younger group. Among women, the highest prevalence was observed in Tromsø6 and the lowest in Tromsø4. Among men, the highest prevalences occurred in Tromsø5 and Tromsø6 for those over 50 years, and in Tromsø6 for those aged 50 years or younger.

An independent association between parental family history of osteoporosis and increased odds of developing the condition was found, with an OR of 2.63 [95% CI 2.02-3.43]. The association remains significant when stratified by sex and across different levels of adjustment.

Scientific discussion

Osteoporosis prevalence data from Norway are scarce, and this study provides novel population-based estimates from Tromsø using self-reported data. Compared with earlier DXA-based studies[11], this study shows slightly different osteoporosis prevalence estimates. Prior DXA research suggests[17] higher prevalence in Tromsø4 than Tromsø5, with no available comparisons for Tromsø6.

Research results on trends in osteoporosis prevalence over time in a population are inconsistent. While some studies report fluctuations[18-19], others suggest stability[20-22].

The upward trend may reflect aging and other characteristic variations[23] of the population, changes in diagnostic practices[24] and awareness, lifestyle changes such as diet, exercise and smoking, and advances in medical care. The decline in bone mineral density (BMD) from Tromsø5 to Tromsø6[25] further supports the increasing prevalence observed in this study. Consistent with existing literature, osteoporosis prevalence was higher in women[6].

Earlier research and classic orthopedic texts[14-15,26] highlight a family history of osteoporosis as a risk factor, while more recent studies and WHO guidelines[6,27] focus on family history of fractures. In this study, parental history of osteoporosis remained a relevant risk factor, potentially more predictive in men, highlighting the importance of familial, genetic[28] environmental and epigenetic[29] contributions to osteoporosis risk.

Strengths and limitations

The main strengths of this study include its large, population-based sample, high participation, and comprehensive data collection, which enhance statistical power, representativeness, and the ability to adjust for key confounders.

However, limitations include reliance on self-reported data and potential selection and information bias related to healthy participant effect and recall bias. However, studies have found only minor differences between participants and non-participants in the Tromsø Study surveys, supporting the overall

generalizability of the results in the general population[30]. Risk of residual confounding from unmeasured factors such as race cannot be excluded. Some variables, like smoking, may be affected by measurement errors inherent in self-reported data.

Conclusions

The findings indicate a rising trend in osteoporosis prevalence over time. Tromsø4 recorded the lowest rates for both men and women across all age groups. Among women and younger men, Tromsø6 showed the highest prevalence, while older men had the highest rates in Tromsø5.

A parental family history of osteoporosis independently increased the odds of developing the condition in both the overall population and sex-specific groups across all levels of adjustment.

This study enhances the epidemiological understanding of osteoporosis and underscores the importance of personalized prevention and management strategies based on individual risk factors.

Declarations

Ethics approval and consent to participate

The Tromsø Study has been performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. All participants provided prior voluntary informed consent before participating in the Tromsø Study surveys. This study has been approved by Regional committees for medical and health research ethics (REC, reference 696648).

Consent for publication

Not applicable.

Availability of data and materials

Upon request, data may be made available to researchers who have obtained approval from the Data and Publication Committee of the Tromsø Study. Information for applicants is available at: https://uit.no/research/tromsostudy

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MA, ML, and ES conceptualized the study and formulated the research questions. MA conducted all statistical analyses and drafted the manuscript. ML and ES revised the manuscript. All authors read and approved the final version of the paper.

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Authors' information (optional)

Not applicable.

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Figures

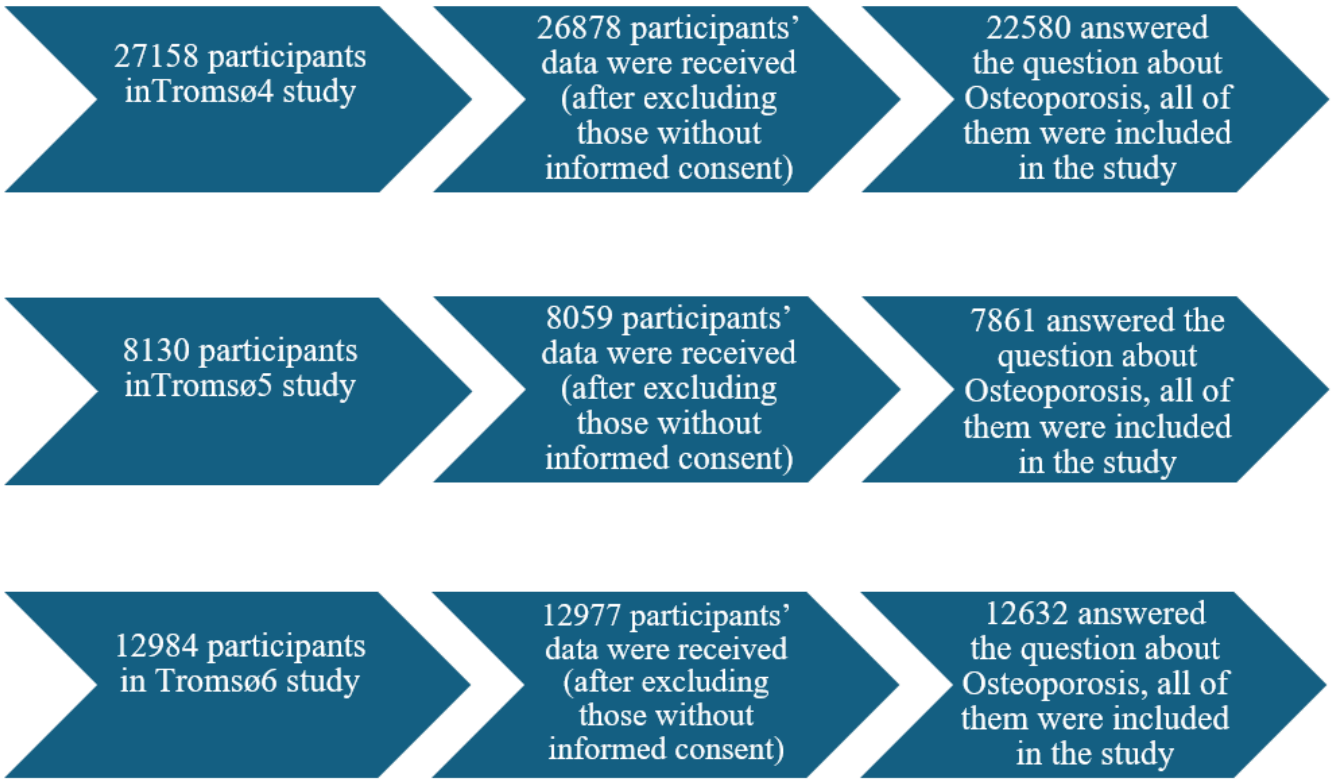


Figure 1

Flowchart of study participants – Tromsø osteoporosis prevalence trends

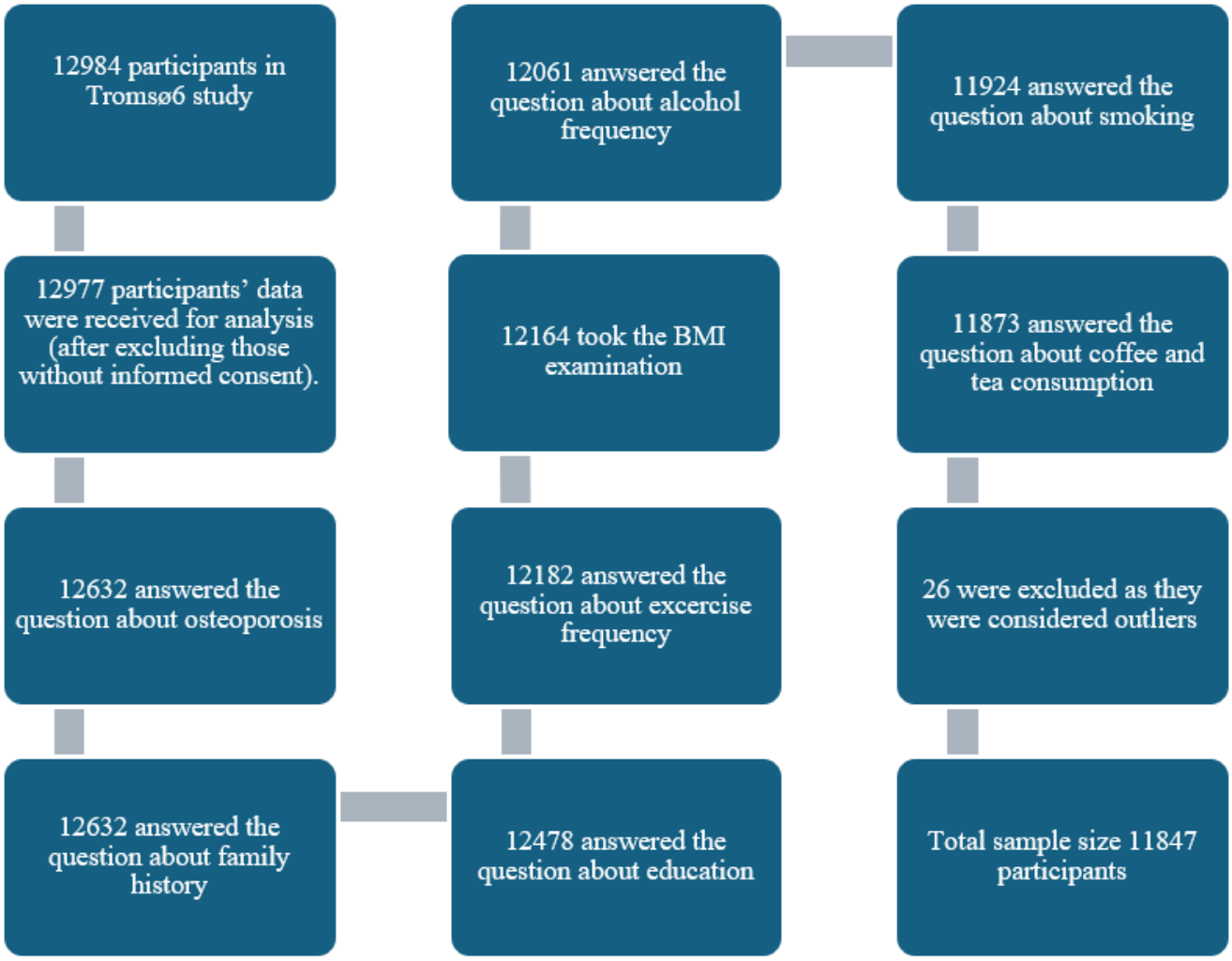


Figure 2

Flowchart of study participants – parental history and its role in osteoporosis development