UNIVERSITY OF TROMSØ UIT

FACULTY OF HEALTH SCIENCES
DEPARTMENT OF COMMUNITY MEDICINE

Contribution of Risk Factors to Socioeconomic Variation in Blood Pressure: the Tromsø study

Sintayehu Asfaw

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Supervisor: Guri Skeie

Postdoctoral, Department of Community Medicine, University of Tromsø, Norway

Co-supervisor: Tonje Braaten

Associate professor, Department of Community Medicine, University of Tromsø, Norway

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Abstract

Objectives: Examine the degree to which BMI, heart rate, physical activity, alcohol intake, smoking and social participation may account for the association between socioeconomic status (SES) and systolic blood pressure (SBP), with main focus on measured SBP continuous variable.

Design: Cross-sectional study with data from the Tromsø study 6.

Setting: Tromsø

Participant: The sample included 6095 women and 5419 men, aged 30 – 87 at screening.

Results: High SBP was more prevalent for women and men with the lowest education compared with women and men with the highest education. After adjustment for heart rate the differences in SBP between the highest and the lowest educated groups reduced from 5.86 mmHg (95% confidence interval 4.32 to 7.40) to 5.61 mmHg (4.07 to 7.16) for women, and for men from 2.48 mmHg (0.92 to 4.04) to 1.96 mmHg (0.39 to 3.52) with further adjustment for BMI, physical activity, alcohol intake, smoking and social participation the variation in SBP decreased to 5.39 mmHg (3.78 to 6.99) for women and to 1.60 mmHg (– 0.04 to 3.25) for men.

Conclusions: High SBP is more predominant among the lowest educated compared with the highest educated women and men. When all documented risk factors were adjusted simultaneously in the models, the differences in SBP turned into nonsignificance in men and 8% of the variation in SBP was explained in women according to levels of education.

Abbreviations

BMI– Body Mass Index

BPT– Blood Pressure Treatment

CI – Confidence Interval

OR – Odds Ratio

NS – Non significant

RC – Regression Coefficient

S.D. – Standard Deviation

SBP – Systolic Blood Pressure

SES – Socioeconomic Status

SPSS – Statistical Package for the Social Sciences

WHO –World Health Organization

Definitions

Systolic blood pressure: the amount of pressure that blood exerts on vessels while the heart is beating.

Confounder: « confusion of two supposedly causal variables, so that part or all of the purported effect of one variable is actually due to the other.» (1, p. 383)

BMI: body mass index, weight divided by height squared (kg/m^2).

Social inequality in health: systematic difference in health among different social groups. (63)

Underweight: BMI< 18.5 kg/m^2. (75)

Normal: BMI 18.5–24.99 kg/m^2. (75)

Overweight: BMI 25–29.9 kg/m^2.(75)

Obesity: BMI ≥ 30 kg/m^2. (75)

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1. Introduction

1.1 General Introduction

As several epidemiological studies have reported, the association between lower Socioeconomic Status (SES) and high Blood Pressure (BP) is equivocal, with some studies showing a relationship of lower SES and high BP, (2-7) and others showing no association. (8-13) Difference in methodologies may explain the contradictory results.

However, there is little evidence that lower SES increases BP.(14) Moreover, there is another mechanism that may explain SES differences in BP. Perhaps, different risk factors may account for SES variation in BP. A Swedish clinical cardiovascular researcher, Peter Nilsson (15) emphasizes that identifying the different mechanisms underlying the association between SES and BP through known risk factors is useful knowledge for public health intervention. This knowledge may be important to address social inequality in BP. (16)

High BP varies related to gender and SES. Research from the United States has indicated that women with lower SES have an increased systolic BP. (17) The confounding effect of risk factors may account for the association between SES and BP. Also, in many European countries, similar association has been observed. Combined surveys (18) have reported that the association between lower SES and high BP are larger among women than men in eight European countries. It appears that more risk factors for BP may accumulate in women than men. Furthermore, two studies from Tromsø and Nord-Trøndelag, Norway have indicated that lower education is related with high Systolic BP in both men and women. (6, 19)

High BP affects around 1 billion individuals worldwide. (20) The prevalence of high BP has also increased. It has been predicted that the number of adults with high BP will increase by

60% to a total of 1.56 billion globally by 2025 (21); it is also estimated that high BP accounts for 13.5% of mortality globally. (22)

In Norway, Public health experts, Graff-Iversen et al (23) have found that the prevalence of systolic BP higher than 140 mmHg and/or a diastolic BP higher than 90 mmHg among men and women aged 30, was 17.4 % and 3.2 %, respectively, and among men and women aged 60, 40-50% had an elevated BP in combined surveys. This elevated high BP among women and men may cause kidney and cardiovascular disease if it is not treated since epidemiological studies have investigated the connection between high BP, kidney and cardiovascular disease. (24, 25)

There is a need for further documenting socioeconomic differential in BP with exploration of potential risk factors to reduce social inequality in BP. However, there have been few recent cross-sectional studies.

One study from US has showed the relationship between SES and Systolic BP mediated by risk factors. In this study the risk factors are: physical activity, alcohol consumption, smoking, body mass index, waist circumference, and resting heart rate, (26) and this study has reported that being married and having higher household income have been independently related with lower Systolic BP. Moreover, Greater waist circumference, higher body mass index, higher alcohol consumption and smoking have been each independently associated with higher Systolic BP. Apart from these, higher education level has been related with lower Systolic BP. Moreover, resting heart rate, body mass index and alcohol consumption have mediated between education level and SBP. However, this study has been limited by a young population with a relatively narrow age range.

Similarly, other two studies from France have reported the intermediate mechanisms of risk factors related to socioeconomic variables and BP. (27, 28) The first study has revealed that lower education level in both the individual and the neighborhood is significantly related with increased Systolic BP. In addition, body mass index/waist circumference and heart rate are the most important mediators. Furthermore, higher education have been related with higher alcohol use, lower odds of physical activity, lower odds of obesity, lower odds of smoking and lower resting heart rate.

Regarding the second study (28), decrease in neighborhood education and decrease in municipality population density have been associated with an increased Systolic BP independently. Furthermore, increased weight and higher central adiposity of people from poor neighborhood have explained the association between lower neighborhood education and higher BP.

It, however, appears that in both studies the participants have not been a representative to the whole population because all occupational categories have not been included in the recruitment of participants, and the subjects have been recruited without a priori sampling. (29) Thus, a meaningful association between SES and BP explained by different risk factors could not be conclusively determined.

Moreover, in these three studies the risk factors have been considered as mediators of the association between SES and BP. Nevertheless, in the present thesis the risk factors are considered as confounders, which may explain the relationship between SES and BP. Confounding is defined as «confusion of two supposedly causal variables, so that part or all of the purported effect of one variable is actually due to the other.» (1, p. 383) Further, as MacKinnon et al. (30) have described, there are two types of confounders: positive and negative confounders. If a direct effect is smaller than the total effect and the two parameters share the same sign, this indicates positive confounding, and if a direct effect is larger than the total effect, this indicates negative confounding.

An association, which is explained by confounders, may not be inevitably causal, but in mediation the association must be causal. In this sense, a US statistician in behavioral medicine, Michael Babyak (31) has showed as there is a conceptual difference in confounding and mediation. He has further demonstrated that the relationships among independent variable, the confounder variable and the dependent variable must not be causal in confounding, but in mediation the associations among the independent variable, the dependent variable and the mediating variable must be causal. The three US and French studies, however, have used cross-sectional design, which has a weakness to deal with causality.

The shortcomings in the above three studies certainly show a need for larger population-based studies on this issue. Consequently, larger community-based studies should be done, which investigate the known risk factors may explain socioeconomic gradients in BP to address social inequality in BP. This is the main focus of the present thesis.

1.2 Known risk Factors

1.2.1 Age and sex

Age and sex are associated with high BP. Wiinber and colleagues (32) have found that systolic BP is significantly lower in women than in men, and increases slightly with age. These findings have been based on a sample of randomly selected 352 healthy participants aged 20-79 years in Denmark. Furthermore, Burt and colleagues (33) have studied 9901 participants 18 years and older, and have found that the prevalence of hypertension is slightly lower among women than men, and aging is related with an increasing prevalence of hypertension. Moreover, girls have been less likely than boys to develop high systolic BP as they approach adulthood.(34) However, a review has revealed that the prevalence of hypertension has been about equal in white men and women, but it has been higher in black women than black men.(35) Methodological and population differences may explain the inconsistent findings.

1.2.2 Resting Heart rate

Resting heart rate is the risk factor for high BP. Studies have showed that resting heart rate is associated with socioeconomic differences in BP. (26, 28) It appears that unhealthy lifestyle may contribute to higher heart rate, and, in turn, higher heart rate may account for high BP.

1.2.3 Body mass index

Body mass index explains some of the relationship between lower SES and high BP. After adjustment for BMI alone or with other variables, the association has existed between SES and BP, (6, 7, 26, 28) whereas in other studies the socioeconomic gradient in BP has removed after adjustment for age and BMI in men or women. (36, 37) Residual confounding factors may account for the inconsistent results in these findings. Furthermore, there is independent and positive association between BMI and BP in younger subgroups. (38-40) Both BMI at baseline and BMI change are independently related with BP change for women. (41) Higher BMI is also associated with high BP for both men and women. (42)

1.2.4 Physical activity

Physical activity has a relationship with high BP. A meta-analysis of randomized, controlled trials has demonstrated that physical activity may reduce high BP. (43) Nevertheless, in other studies the relationship between physical activity and high BP have not been confirmed in adolescents.(44, 45) Methodology differences may clarify the contradictory results. In addition, there is an association between physical activity and SES. A study has shown that higher socioeconomic groups have a lower risk of being in the lower quartile of leisure-time physical activity. (46, 47) This may explain that individuals in the lower socioeconomic groups have lower participation in leisure-time physical activity.

1.2.5 Alcohol consumption

Alcohol intake and high BP have an association. Alcohol consumption has been related with higher BP. (48, 49) Interventional short- term studies have demonstrated that cessation or reduction in alcohol consumption may reduce the elevated BP. (50, 51) Also, alcohol consumption is associated with socioeconomic gradient. For example, the higher income and increased education level are associated with higher alcohol consumption in women and men in Norway. (52, 53) Similarly, other study from Canada has showed that elevated odds of high-risk alcohol consumption is related with increased education and economic status. (54) These findings suggest that in Western countries increased education and higher income may be attributable for higher alcohol consumption. However, although higher SES is related with higher alcohol intake, it appears that individuals with higher SES have lower BP in these countries.

1.2.6 Smoking

Smoking has an association with BP. A study from England has showed that a relationship existed between smoking and high BP after adjustment for social class, age, BMI and alcohol consumption (55). This study has found that older men who were heavy and moderate smokers have significantly higher Systolic BP than nonsmokers. However, in another study smoking has been related with lower risk of high BP in younger subgroups. (40) Smoking cigarette for many years or few years may elucidate these different findings in the above studies. Moreover, smoking is associated with SES. For instance, a study in Europe has showed that smoking is related with lower SES among young adult men and women. (56, 57)

Besides this, in Norway lower SES is associated with smoking. (58, 59) Socioeconomic deprivation may lead to smoking or make quitting more difficult.

1.2.7 Salt intake

High salt intake is related with high BP. Francesco Cappuccio and colleagues (60) say high salt intake may cause high BP and cardiovascular outcomes. In this context, Finland has targeted to reduce the average salt intake (61) by one-third (6g per person per day) since 1970s, and followed by Systolic BP decreased by over 10 mmHg in the population average during the past 3 decades, and mortality from stroke and coronary heart disease has reduced 75-80%. But other review from Norway has sufficiently been documented that salt reduction could not reduce the prevalence of hypertension, morbidity and mortality associated with hypertension. (62)

Even though there are contradictory results concerning the association between high salt intake and high BP because of methodological difference, it is not the focus of this paper to examine the association between high salt intake and high BP.

To sum up, whilst there have been few studies have investigated to show SES differences in BP explained by risk factors, there should be more population-based studies that examine the degree to which risk factors may explain SES variation in BP.

1.3 Theoretical explanation to social inequality in health

There is no universally accepted definition for social inequality in health. The literal translation of ˝social inequality in health‟ can vary in health among different social groups in the population due social stratification. For instance, the following definition has been suggested by WHO/Europe: social inequality in health is defined as a systematic difference in health between different social groups.(63) According to this definition, the health difference is created by the society systematically through difference in income and education. This difference can partly be avoided through narrowing the income gap among different social groups, creating conducive working environment and providing equal access to health care services.(64)

The Black Report (65) which was published, in 1980 is perhaps the most authoritative to explain about the social class differences in health. The Black Report separates four possible explanation of social inequality in health: artefact; natural or social selection; materialist; and cultural/behavioral differences; and the other two-neo materialist and psychosocial environment interpretation are proposed by other scholars (Lynch et al. and Richard Wilkinson, respectively).

Artefact explanation: this approach suggests that the observed association between social class and health may be in the measures themselves. In other words, it implies that there is a relationship between social class and health, however, the association does not tell us about the causes of disease because there is no consensus how health and social class are measured.

The natural or social selection explanation: explanation of this type sees health as important for social class not the vice versa. Those in poor health than their class peers are more likely to be downwardly mobile on the social ladder, and those in better health upwardly mobile. This explanation thus emphasizes the causal relationship of health and social class, and recognizes health as an independent variable and social class as an outcome variable.

Cultural/ behavioral explanation: this explanation suggests that there is a relationship between social class and health, and the relationship is causal. This theory sees social class as independent variable and health dependent variable. According to this theory, social class differences in behavior such as (alcohol consumption, smoking, physical inactivity,) utilization of preventive health care can result in social gradient in health. This theory therefore accepts that health affecting behaviors stem from social class differences.

Materialist: this type of explanation sees the association between social class and health as causal, and social class as independent variable. This theory is also similar in cultural/ behavioral explanation because both consider health as dependent variable. But it differs from cultural/behavioral explanation in the sense that cultural/behavioral recognizes culture and behavior as autonomous while materialist sees the effects of social structure on health, and the most likely cause of social class differences in health are considered to be structurally determined differences in education and income.

Neo-materialist: explanation of this type sees the difference augmentation of experiences and exposures that result from the material world results in health inequality.(66) According to this explanation, for example, disparity in income distribution results from political-economic, historical, and cultural processes; and these processes also impact the public infrastructure — education, health care, food accessibility, transportation system, housing and occupational health regulations.(66)

Psychosocial environment interpretation: this interpretation suggests that psychosocial factors are important in understanding the income inequality on health effects (67). According to this interpretation, health is influenced by income inequality through negative emotions such as shame and distrust that are translated into stress induced behavior like smoking. The psychosocial conditions that influence health are social support (68, 69), social network (68, 69), job demand and control (68-70), social ties (71), perceived support (71), and hopelessness (72), stress and depression. (71) These psychosocial conditions can play a role on the health of different social groups along with other factors.

2. Objectives of the thesis

There is a need for larger population-based researches to investigate the degree to which the risk factors may account for the relationship between SES and BP. And in this study education level is used as a marker for socioeconomic gradient. Thus, the objectives of this study are to assess whether: (1) there is sex difference in the association between SES and the known risk factors, (2) there is an inverse association between SES and BP and if so, (3) established risk factors explain socioeconomic differences in BP, (4) some risk factors are more important explaining the association of SES and BP. More specifically, this thesis focuses on the following questions:

1. Is there sex difference in the association between SES and the known risk factors?
2. Is there an inverse association between SES and BP?
3. Are socioeconomic differences in BP accounted for by known risk factors?
4. Which risk factors are more important explaining the relationship of SES and BP?

3 Subjects

3.1 Study population

The participants included in this analysis were subjects in the 6th survey of the Tromsø Study. The Tromsø Study 6 survey was conducted in 2007-2008. Tromsø has a population of 70,000 and it is the largest city in the northern part of Norway. The majority of the dwellers live on the Tromsø Island. The Tromsø study is a population-based survey, which was started in 1974, and it has been carried out six times: Tromsø study 1, Tromsø study 2, Tromsø study 3, Tromsø study 4, Tromsø study 5 and Tromsø study 6 consecutively in the same population. In the Tromsø 6 study survey four groups were invited: a 10% random sample aged 30–39 years who took part in the special study in the Tromsø 4 survey, a 40% random sample of subjects aged 43–59 years, and all individuals in Tromsø 40–42 years or 60–87 years. Of

19762 invited persons, 12 984 men and women (65,7 %) attended the survey, and from 12984 study participants, 10797 men and women were included in this study (figure 1).

Flowchart of subjects in Tromsø 6 study

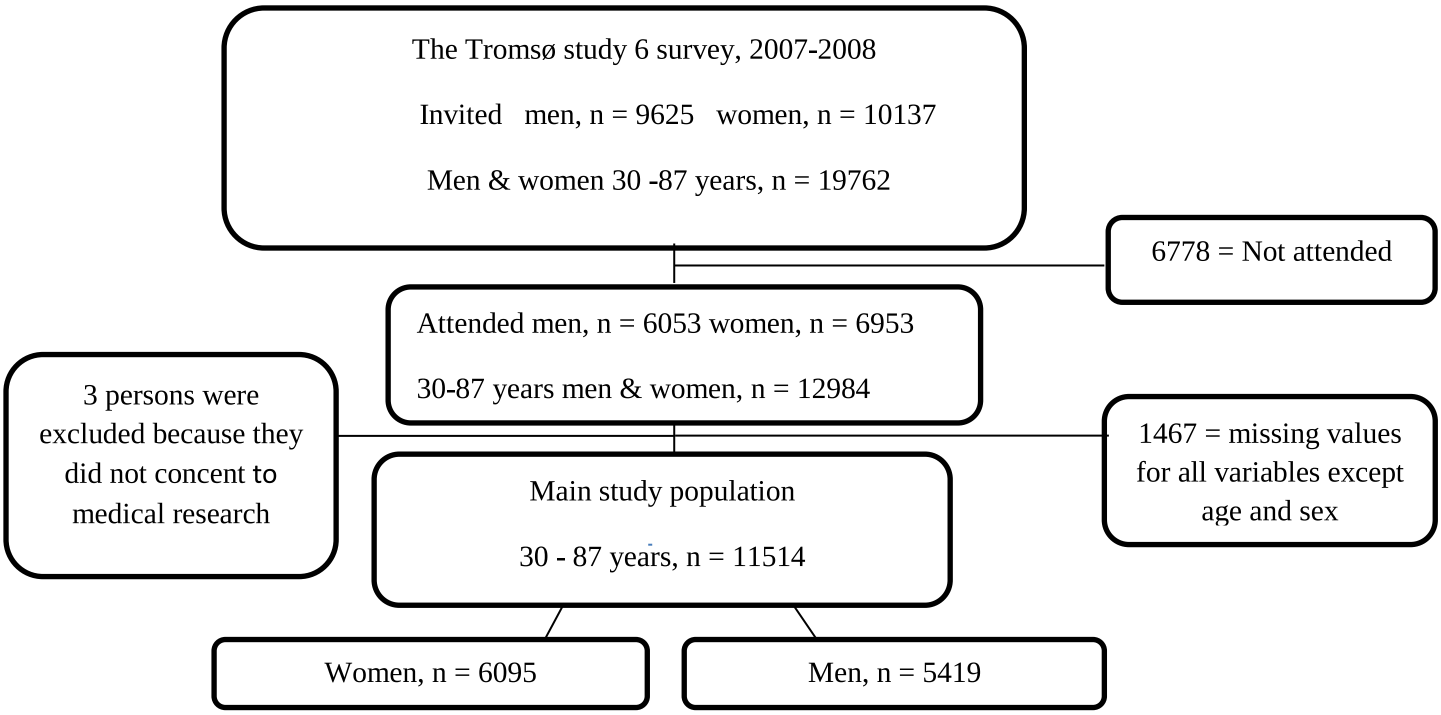

Figure 1. Flow chart of Tromsø 6 study

3.2 Ethics

All the participants gave written, informed consent prior to participation. The protocol was recommended by the Regional Health Research Ethics, and the study was approved by the Norwegian Data Inspectorate.

3.3 Self-administered Questionnaire

In Tromsø 6 study survey self-reported questionnaires were used to collect information about education level, alcohol consumption, smoking, having blood pressure, physical activity and other variables. There were two kinds of questionnaires. The first questionnaire, including the invitation letter sent by mail to all participants, and completed at home and collected at the research center. Concerning the second questionnaire, it was completed when the participants admitted and returned by mail in envelope with pre-paid stamp.

3.4 Physical examination

Height was measured to the nearest 0.5 centimeter. Weight was measured participants wearing light clothe and no footwear to the nearst 0.1 kg on an automatic electronic scale Jenix DS 102 stadiometer (Dong Sahn Jenix Co.,Ltd,Seol, Korea). Body mass index (was calculated as a measure of body mass relative to height (kg/m^2)). Heart rates (pulse rate) were monitored with a Polar S 610 I(Finland) wrist watch with trained assistants. Blood pressure was measured using automated device Dinamap Pro care 300 Monotor at the research center by health professionals when the individuals were sitting.   The mean of the two latest systolic blood pressure readings was employed in the present thesis.

4. Methods

4.1.1 Outcome Variables

Systolic BP (SBP) is defined as the amount of pressure that blood exerts on vessels while the heart is beating. For example, in BP reading (such as 120/80), the number on the top is SBP, and the bottom number represents diastolic BP. Nevertheless, there is no universally accepted threshold level of BP. For instance, the suggestion of WHO and the European Society of Cardiology (ESC) and European Society of Hypertension (ESH), (73, 74) SBP $\geq$ 140-mmHg is considered as high based on high or low risk groups. This threshold level of SBP is applied to define SBP in this thesis.

SBP – was considered as continuous variable, and a dichotomous variable indicating high BP or not, where a SBP ≥ 140-mmHg was considered as hypertension.

Self-reported high BP – was considered as dichotomous variable: yes or no.

4.1.2 Independent Variable

Education – was categorized into four levels: Primary/ secondary school and modern secondary school as I; technical school, vocational school, 1-2 years senior high school and high school diploma as II; College/ University less than 4 years as III; and College/University 4 years or more as IV.

4.1.3 Other variables

Age – was categorized into six levels: 30-39; 40-49; 50-59; 60-69; 70-79; 80-87.

Blood pressure treatment (Blood pressure lowering drugs) – was coded as current; former; and never.

Sex – was considered as man and woman.

Body mass index – was considered as categorical variable. BMI (kg/m^2) < 18.5 ; 18.5-24.99; 25-29.99 ; and ≥ 30 defined by WHO (75). However, because there were few BMI < 18.5 kg/m^2 in this study, BMI (<18.5 kg/m^2) was combined with BMI (18.5-24.99 kg/m^2) together and considered as normal.

Resting heart rate – was derived from the median pulse- to-pulse interval, and was categorized into quartiles: first; second; third; and fourth.

Physical activity – was coded into 5 classes: never; less than once a week; once a week; 2-3 times a week; and approximately every day.

Alcohol intake – was categorized into: never; monthly or less frequently; 2-4 times a month; 2-3 times a week; and ≥ 4 times a week.

Smoking status – was coded into three levels: current; former; and never.

Association (Social participation) – Participating in organized gathering, e.g. sport clubs, political meetings, religious or other associations was categorized into four level: never or just few times a year; 1-3 times a month; approximately once a week; and more than once a week.

4.2 Statistical method

To describe the baseline characteristics of SBP (as continuously distributed variable), hypertension and self-reported high BP and other variables, mean, standard deviation and proportion (%) were used as required in sex-specific analysis. Statistical Package for Social Sciences (SPSS), version 19 was employed for statistical analysis. Linear regression was applied for continuous SBP, and two sided P-value <0.05 were considered significant statistically. Also, with 95 % confidence intervals, odds ratio (OR) point estimates were reported for hypertension and self-reported BP.

The analysis was sex-stratified. Moreover, In this study education IV(highest) was a reference; age group 30-39 was reference; BMI ($\geq$24.99 kg/m^2) was a reference; first quartile for resting heart rate was a reference; never was a reference for smoking; never was a reference for physical activity; never was a reference for association; and never was a reference for alcohol intake. To assess the impact of risk factor adjustment on the age-adjusted regression coefficient and odds ratio, it was calculated the percentage change for the effect estimate change as:

$RC_{\text{(age-adjusted)}} - RC_{\text{(adjusted for age plus risk factor or risk factors)}} / RC_{\text{(age-adjusted)}} \text{ x } 100$ and

$OR_{(age\text{-}adjusted)} – OR_{(adjusted\ for\ age\ plus\ risk\ factor\ or\ risk\ factors)} / OR_{(age\text{-}adjusted)}$ x 100

4.3 Confounding

Some propose a 10% thumb of rule for effect estimate change. When all the risk factors are included in the model simultaneously, the effect estimate change must be at least 10% or more. Otherwise, the risk factors are not considered as confounders. This rule applied in this study. The remained part about confounding has been mentioned in detail in introductory section. In this study except education, SBP continuous variable, Hypertension and self-reported high BP, the other variables were included as confounders in linear and logistic regression.

5 Results

The response rate was 65.7% (68.4 for women and 62.9% for men). Because of missing information for the variables such as BMI, heart rate, SBP, self-reported high BP, BP treatment, social participation, physical activity, alcohol intake and smoking, only 6095 (46.9%) women and 5419 (41.7%) men were included in the analysis from a total of 12981 subjects. About 21.5% of women and 21.5% of men participants were taking blood pressure treatment.

Table 1 shows the basic characteristics. 61.4 % of women and 59.1% men were in the lower educational groups. Lower education was positively associated with higher SBP continuous, hypertension and self-reported high BP in women and men (Table 1).

Regarding educational level and risk factors, lower education was associated with older age, lower social participation, greater heart rate, greater BMI, lower physical activity, lower alcohol intake and higher rate of cigarette smoking compared with higher education for women. For men lower education was related with older age, lower social participation, higher heart rate, greater BMI, lower physical activity, lower alcohol intake and higher rate of smoking compared with higher education. (Table 1) Also, lower education was related with older age, higher social participation, greater heart rate, lower BMI, higher physical activity, lower alcohol intake and higher rate of smoking in women than men (Table 1).

Furthermore, education level and SBP are presented for women and men separately with age-adjusted analysis (Table 2 and Table 3). Education I had 5.86-mmHg (95 % CI 4.32-7.40), education II had 3.70-mmHg (95% CI 2.28-5.13), education III had 1.70-mmHg (95 % CI 0.01-3.39) of increased SBP, respectively compared with the reference group – education IV (highest) for women. For men education I had 2.48-mmHg (95% CI 0.92-4.04**)**, education II had 1.66-mmHg (95% CI 0.25-3.07), education III had 1.52-mmHg (95% CI -0.04-3.09) elevated SBP, respectively compared with the reference group - education IV (highest).

Similarly, education levels and Hypertension with age adjustment in men and women are presented (table 4 and table 5). The odds of having Hypertension (measured high BP) for education I was 1.74 (95% CI 1.45-2.09), for education II was 1.50 (95% CI 1.26-1.79), for education III was 1.20 (95% CI 0.97-1.50) times that of the reference group - education IV (highest) for women. For men the odds of having Hypertension for education I was 1.26 (95% CI 1.05-1.51**)** times that of the reference group-education IV; the odds of having SBP ≥140-mmHg for education II was 1.20 (95% CI 1.01-1.41) times that of the reference group-education IV; and for education III was 1.18 (95% CI 0.99-1.42) times that of the reference group - education IV (highest) for men.

Table 6 and Table 7 present education level and self-reported high BP with age adjustment in women and men. The odds of having self-reported high BP for education I was 1.85 (95% CI 1.54-2.23) times that of the reference group - education IV; the odds of having self-reported high BP for education II was 1.68 (95% CI 1.40-2.01) times that of the reference group-education IV; and the odds of having self-reported high BP for education III was 1.18 (95% CI 0.99-1.42) times that of the reference group-education IV in women. For men the odds of having self-reported high BP for education I was 1.39 (95% CI 1.13-1.71) times that of the reference group- education IV; the odds of having self-reported high BP for education II was 1.42 (95% CI 1.17-1.72) times that of the reference group - education IV; and the odds of having self-reported high BP for education III was 1.35 (95% CI 1.10-1.67) times that of the reference group - education IV.

Among the risk factors, higher heart rate and higher BMI were independently associated with Hypertension for women and men, while smoking was independently, negatively related with Hypertension for women and men (Table 8). However, physical activity, alcohol intake and association were insignificant (The result was not shown). In addition, higher heart rate, higher BMI were independently, positively related with self-reported High BP for women and men, whereas physical activity, alcohol intake were negatively associated with self-reported high BP for women, and for men higher social participation was negatively related with self-reported high BP. But physical activity and alcohol intake were insignificant for men (The result was not shown). Smoking was negatively related with self-reported high BP for women and men (Table 9).

The regression coefficient in measured SBP continuous, and odds ratio for the risk of Hypertension and Self-reported high BP according to educational level was adjusted for age, for age and heart rate, BMI, physical activity, alcohol intake, smoking and social participation one by one (Table 2,3,4,5,6,and7). All the variables were included simultaneously in the final model.

SES and SBP (as continuously distributed variable)

Age-adjusted difference in SBP for the lowest compared with the highest educated women was 5.86 mmHg (4.32 to 7.40) for women (Table 2). When heart rate, BMI, alcohol intake and social participation were adjusted separately in the model, the reduction in SBP differences was 4.3% to 5.61 mmHg (4.07 to 7.16), 20.8% to 4.64 mmHg (3.12 to 6.17), 1.2% to 5.79 mmHg (4.22 to 7.35) and 2.2% to 5.73 mmHg (4.17 to 7.29), respectively, while physical activity and smoking were adjusted separately, the increment in SBP differences was 2.6% to 6.01 mmHg (4.46 to 7.57) and 18.4% to 6.94 mmHg (5.37to 8.50), respectively for women. When all the risk factors were included, the reduction in SBP differences was 8% to 5.39 mmHg (3.78 to 6.99) for women (Table 2).

Age-adjusted difference in SBP for the lowest compared with the highest educated men was 2.48-mmHg (0.92 to 4.04) (Table 3). When heart rate, BMI, alcohol intake and social participation were adjusted separately in the model, the reduction in SBP difference was 20.9% to 1.96 mmHg (0.39 to 3.52), 31.8% to 1.69 mmHg (0.14 to 3.24), 13.3% to 2.15 mmHg (0.56 to 3.74) and 9.3% to 2.25 mmHg (0.66 to 3.84), respectively, whereas physical activity and smoking were adjusted separately, the increment in SBP differences was 1.6% to 2.52 mmHg (0.94 to 4.11) and 16.9% to 2.90 mmHg (1.30 to 4.51), respectively.

When all the risk factors were included simultaneously in the model, the reduction in SBP difference was 35.5% to 1.60 mmHg (– 0.04 to 3.25), and turned into non significance (indicating no significant difference in SBP between the lowest and the highest education in men).

Table 1. Basic Characteristics by level of Education, the Tromsø study. Values are means (SDs) or numbers (percentages).

	Women					Men				
Level of Education[a]		I	II	III	IV		I	II	III	IV
	N	%	%	%	%	N	%	%	%	%
Total	6095	29.1	32.3	15.8	22.8	5419	23.5	35.6	21.3	19.6
Age at enrollment										
30-39		1.4	3.6	7.3	7.8		1.5	3.0	3.6	7.8
40-49		11.1	31.3	43.1	42.4		19.5	30.8	30.1	36.0
50-59		15.2	22.6	19.9	22.6		19.1	19.4	22.3	19.1
60-69		41.4	31.1	22.4	22.9		35.8	33.5	32.5	30.2
70-79		23.7	9.3	6.1	3.9		19.9	10.9	10.2	6.5
80-87		7.2	3.1	1.2	0.4		4.2	2.4	1.3	0.4
Mean age (SD) in years at enrollment		63.7(0.27)	54.2(0.41)	51.6(0.38)	50.8(0.29)		60.5(0.34)	55.3(0.46)	51.6(0.38)	50.8(0.29)
Mean Systolic BP(mmHg)		142.7(0.63)	130.8(0.81)	126.1(0.72)	123.9(0.58)		140.6(0.61)	136.5(0.75)	137.0(0.60)	133.9(0.61)
Systolic BP ≥140mmHg										
Yes		53.3	35.8	24.6	21.3		48.1	42.4	41.4	34.8
No		46.7	64.2	75.4	78.7		51.9	57.6	58.6	65.5
Self-reported high BP										
Yes		38.3	28.0	20.5	16.1		29.3	26.1	24.9	18.1
No		61.7	72.0	79.5	83.9		70.7	73.9	75.1	81.9
BP treatment										
Current		33.9	21.4	14.1	10.0		27.4	21.8	20.8	14.0
Ex–user		2.0	1.8	1.3	2.8		1.8	1.7	1.6	1.0
Never		64.1	76.8	84.6	87.2		70.8	76.5	77.6	85.0

[a] Education (I-IV) represent: primary/secondary school, modern secondary school; technical school, vocational school, 1-2 years senior high school and high school diploma; College/university less than 4 years; college/university 4 years or more.

Table 1. Continued.

	Women				Men			
Level of Education[a]	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Total	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Heart rate(beat/min) quartiles								
First	**17.1**	**18.6**	**23.2**	**25.8**	**26.3**	**27.0**	**25.8**	**35.4**
Second	**20.3**	**21.7**	**23.7**	**24.2**	**22.3**	**21.4**	**24.2**	**25.8**
Third	**31.3**	**31.0**	**29.5**	**30.7**	**25.7**	**27.3**	**30.7**	**21.0**
Fourth	**31.3**	**28.7**	**23.6**	**19.3**	**25.7**	**24.3**	**19.3**	**17.8**
Mean heart rate[b] (beat/min)	**67.2(0.25)**	**66.4(0.37)**	**64.8(0.32)**	**63.8(0.27)**	**64.9(0.33)**	**64.7(0.43)**	**64.8(0.32)**	**63.8(0.27)**
BMI(kg/m^2)								
<= 24.99	**32.8**	**40.6**	**45.3**	**53.6**	**27.3**	**24.5**	**26.2**	**35.9**
25.00-29.99	**42.5**	**39.8**	**37.7**	**30.8**	**50.0**	**53.3**	**52.3**	**51.2**
>= 30	**24.7**	**19.6**	**17.0**	**15.6**	**22.7**	**22.2**	**21.5**	**12.9**
Mean BMI (kg/m^2)	**27.3(0.11)**	**26.5(0.17)**	**26.1(0.15)**	**25.5(0.12)**	**27.3(0.11)**	**27.5(0.58)**	**27.4(0.11)**	**26.4(0.10)**
Social participation								
Never	**53.2**	**50.4**	**42.6**	**41.6**	**73.1**	**58.5**	**51.8**	**45.0**
1-3 times a month	**30.0**	**29.0**	**32.2**	**30.2**	**14.4**	**19.2**	**21.3**	**20.3**
Approximately once a week	**11.3**	**13.9**	**15.5**	**17.8**	**8.1**	**12.3**	**15.0**	**20.4**
More than once a week	**5.5**	**6.7**	**9.7**	**10.4**	**4.5**	**10.0**	**11.9**	**14.3**

[a] Education (I-IV) represent: primary/secondary school, modern secondary school; technical school, vocational school, 1-2 years senior high school and high school diploma; College/university less than 4 years; college/university 4 years or more.

[b] Resting heart rate quartile for women: first(34-58); second(59-64); third(65-71);fourth(72-125). Resting heart rate for men: first (33-56); second (57-61); third (62-69); fourth (70-148).

Table 1. Continued.

	Women				Men			
Level of Education[a]	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Total	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Physical activity								
Never	**9.6**	**3.5**	**1.4**	**1.4**	**11.3**	**6.7**	**3.7**	**2.2**
Less than once a week	**15.4**	**12.4**	**14.6**	**10.6**	**22.2**	**22.6**	**19.4**	**13.8**
Once a week	**18.5**	**18.6**	**17.8**	**19.9**	**20.3**	**22.9**	**22.8**	**22.1**
2-3 times a week	**36.5**	**43.5**	**44.5**	**42.5**	**32.1**	**34.8**	**37.4**	**42.9**
Approximately every day	**20.0**	**22.0**	**21.7**	**25.6**	**14.1**	**13.0**	**16.7**	**19.0**
Alcohol intake								
Never	**22.4**	**10.0**	**9.2**	**5.4**	**11.2**	**6.3**	**4.0**	**5.5**
Monthly or less frequently	**39.0**	**32.1**	**25.3**	**22.0**	**32.0**	**27.0**	**22.0**	**15.3**
2-4 times a month	**29.0**	**38.5**	**41.5**	**38.1**	**42.3**	**45.5**	**44.0**	**36.2**
2-3 times a week	**7.6**	**15.4**	**20.2**	**25.8**	**11.7**	**16.8**	**24.0**	**30.8**
4 or more times a week	**2.0**	**4.0**	**3.8**	**8.7**	**2.8**	**4.4**	**6.0**	**12.2**
Smoking status								
Current	**26.7**	**25.1**	**17.1**	**11.9**	**27.5**	**21.4**	**15.6**	**8.5**
Former	**38.0**	**39.5**	**38.3**	**38.3**	**53.2**	**46.8**	**47.1**	**36.8**
Never	**35.3**	**35.4**	**44.6**	**49.8**	**19.3**	**31.8**	**37.3**	**54.7**

[a] Education (I-IV) represent: primary/secondary school, modern secondary school; technical school, vocational school, 1-2 years senior high school and high school diploma; College/university less than 4 years; college/university 4 years or more.

BMI was the largest contributor for the reduction of SES variation for women, followed by smoking, which increased the SES variation. For men BMI was the largest contributor for the reduction of SES differences and followed by heart rate. Smoking was the third contributor, which increased the SES variation. Alcohol intake was also the fourth contributor to the reduction of SES variation.

When individuals who were taking BP treatment were excluded from the analysis, age-adjusted education I had 5.04 mmHg (2.54 to 6.00), and 2.14 mmHg (0.43 to 3.85) SBP for women and men respectively, and when all risk factors adjusted simultaneously, Education I had 4.27 mmHg (2.54 to 6.00) SBP for women and 1.07 mmHg (-0.73-2.87) SBP for men and there was no significant difference between the lowest and highest education in men. For women the reduction in SBP difference was 15.3% from 5.04 mmHg (2.54 to 6.00) to 4.27 mmHg (2.54 to 6.00), and for men the reduction in SBP difference was 50% from 2.14 mmHg (0.43 to 3.85) to 1.07 mmHg (-0.73-2.87) and there was no significant difference between the highest and the lowest education (the data was not shown).

SES and Hypertension

Age adjusted odds ratio for hypertension for the lowest compared with the highest educated respondents was 1.74 (1.45 to 2.09) for women (Table 4), and 1.26 (1.05 to 1.51) for men (Table 5). When heart rate, BMI, alcohol intake and social participation were adjusted separately in the model, the differences in hypertension were reduced by 1.7% to 1.71 (1.43 to 2.05), 12.6% to 1.58 (1.32 to 1.90), 1.1% to 1.72 (1.42 to 2.07), and 1.6% to 1.24 (1.03 to 1.49) respectively, while physical activity and smoking were adjusted separately, the variation in hypertension were increased by 1.1% to 1.76 (1.47 to 2.11) and 7.5% to 1.87 (1.55 to 2.24), respectively for women. When all the risk factors were included in the final model, the differences in hypertension was reduced by 2.3% to1.70 (1.39 to 2.06) for women (Table 4).

The adjustment of heart rate, BMI and social participation separately in the model, the variation in hypertension were decreased by 4.8% to 1.20 (1.00 to 1.44), by 7.1% to 1.17 (0.98 to 1.41) and 1.6% to 1.24 (1.03 to 1.49), respectively for men. When physical activity, alcohol intake and smoking were adjusted separately, the increment in hypertension were by 0.8% to 1.27 (1.06 to 1.53), 2.4% to 1.29 (1.07 to 1.55) and 5.6% to 1.33 (1.11 to 1.60), respectively for men. After adjustment of all risk factors simultaneously, the differences in hypertension was reduced by 1.6% to 1.70 (1.39 to 2.06) for men (Table5). BMI was also the main contributor for the reduction in SES differences for both women and men.

SES and self-reported high BP

Age-adjusted odds ratio for self-reported high BP for the lowest compared with the highest educated respondents was 1.85 (1.54 to 2.23) for women (Table 6), and 1.39 (1.13 to 1.71) for men (Table 7). When heart rate, BMI, physical activity, alcohol intake and social participation were adjusted separately in the model, the differences in self-reported high BP were reduced by 1.1% to 1.83 (1.51 to 2.20), 11.4% to 1.64 (1.36 to 1.99), 1.6% to 1.82 (1.51 to 2.20), 9.7% to 1.67 (1.38 to 2.02) and 0.5% to1.84 (1.53 to 2.23), respectively for women (Table 6). When smoking was adjusted, the variation in self-reported high BP was increased by 8.6% to 2.01 (1.67 to 2.43). When all the risk factors were included at the same time in the model, the differences in self-reported high BP was decreased by 12.4% to 1.62 (1.32 to 1.98).

For men when heart rate, BMI, physical activity and social participation were adjusted separately, the reduction of the differences in self-reported high BP were by 5.0% to 1.32 (1.08 to 1.63), 10.8% to 1.24 (1.01 to 1.53), 2.2% to 1.36 (1.11 to 1.68) and 5.8% to 1.31 (1.06 to 1.61). After adjustment of alcohol intake and smoking separately, the variation in self-reported high BP were increased by 1.4% to 1.41 (1.14 to 1.75) and 2.2% to 1.42 (1.15 to 1.76), respectively. After adjustment of all risk factors simultaneously, the differences in self-reported high BP was decreased by 13% to 1.21 (0.97 to 1.52) for men and it was insignificant (no significant difference in self-reported high BP between the highest and the lowest educated men).

BMI was the largest contributor for the reduction of the variation in self-reported high BP between the lowest and the highest educated women and men. However, alcohol intake was the second contributor only for women.

6. Discussion

6.1 Summary of the findings

The present study found that lower education was independently associated with measured higher SBP, hypertension and self-reported high BP in both women and men. The associations were also stronger among women than men.

This study found that less education was associated with older age, lower level of social participation, higher heart rate, greater BMI, lower physical activity, lower alcohol intake and larger proportion of smoking compared with higher education for both women and men. The present study also revealed that lower education was related with older age, more social participation, higher heart rate; lower BMI, higher level of physical activity, less alcohol intake and larger proportion of smoking in women than men.

To my knowledge, no study has assessed whether the association of SES variation in BP explained by the risk factors in separate analysis for women and men. This study revealed that when all the document risk factors were adjusted simultaneously in the final model, the differences in SBP according to levels of education turned into statistically nonsignificance, and that showed socioeconomic variation in SBP may be explained by known risk factors, which supported the hypothesis of this study fully.

For women, however, only 8% variation in SBP according to educational levels was accounted for when all the risk factors were adjusted at the same time, and that supported the hypothesis of this study partially because the SES variation persisted after the adjustment of the risk factors.

Regarding hypertension when all the risk factors were included simultaneously in the final models, 2.3% and 1.6% of the differences in hypertension risk according to educational levels were explained in women and men, respectively, which supported the hypothesis of this study in part because the SES difference continued after the adjustment of the risk factors.

When the risk factors were adjusted simultaneously in the final model, 12.4% of the differences in self-reported high BP was explained according to levels of education for women, and the variation in SBP according to educational levels declined into nonsignificance only for men, which supported the hypothesis of this study fully for men, and partially for women.

In addition, this study disclosed that BMI was the most important variable contributing to the association between SES and SBP, Hypertension and self-reported high BP for women, and BMI and heart rate for men.

6.2 Socioeconomic variation in Blood pressure

In line with earlier studies, (2-7) the present study has showed that there was an association between lower SES and high BP, whereas other studies have documented no association between lower SES and high BP.(8-13) The inconsistency reporting in the above studies may be due to sociocultural differences.

Table 2. Difference in SBP between the highest educated groups and the lowest educated groups in women. Results and contribution from different adjusted models.

	Women				
		Education[a]			
	Relative contribution[b] (%)	**I**	**II**	**III**	**IV**
SBP					
Adjusted for age only		**5.86 (4.32-7.40)**	**3.70 (2.28-5.13)**	**1.70 (0.01-3.39)**	**1.00 (Reference)**
Adjusted for age and heart rate	**4.3**	**5.61 (4.07-7.16)**	**3.50 (2.07-4.92)**	**1.60 (-0.08-3.28)**	**1.00 (Reference)**
Adjusted for age and BMI	**20.8**	**4.64 (3.12-6.17)**	**2.92 (1.51-4.32)**	**1.21 (-0.45-2.85)**	**1.00 (Reference)**
Adjusted for age and physical activity	**2.6**	**6.01 (4.46-7.57)**	**3.71 (2.28-5.13)**	**1.67 (-0.01-3.36)**	**1.00 (Reference)**
Adjusted for age and alcohol intake	**1.2**	**5.79 (4.22-7.35)**	**3.68 (2.25-5.12)**	**1.71 (0.01-3.42)**	**1.00 (Reference)**
Adjusted for age and smoking	**18.4**	**6.94 (5.37-8.50)**	**4.49 (3.06-5.93)**	**1.98 (0.30-3.67)**	**1.00 (Reference)**
Adjusted for age and social participation	**2.2**	**5.73 (4.17-7.29)**	**3.63 (2.20-5.06)**	**1.67 (-0.01-3.36)**	**1.00 (Reference)**
Adjusted fully[c]	**8**	**5.39 (3.78-6.99)**	**3.38 (1.94-4.82)**	**1.41 (-0.26-3.09)**	**1.00 (Reference)**

[a] Education **I** represents primary/secondary school, modern secondary school; education **II** represents technical school, vocational school, 1-2 years senior high school and high school diploma; education **III** represents college/university less than 4 years; education **IV** represents college/university 4 years or more.

[b] Relative contribution: the relative effect estimate change as the risk factor was adjusted or the risk factors were adjusted.

[c] Adjusted fully includes: age, BMI groups, heart rate quartiles, physical activity, alcohol intake, smoking and social participation.

Table 3. Difference in SBP between the highest educated groups and the lowest educated groups in men. Results and contribution from different adjusted models.

	Men				
	Education[a]				
	Relative contribution[b] (%)	I	II	III	IV
SBP					
Adjusted for age only		**2.48 (0.92 - 4.04)**	**1.66(0.25 - 3.07)**	**1.52 (-0.04 - 3.09)**	**1.00 (Reference)**
Adjusted for age and heart rate	**20.9**	**1.96 (0.39 - 3.52)**	**1.23(-0.17 - 2.64)**	**1.31 (-0.25 - 2.87)**	**1.00 (Reference)**
Adjusted for age and BMI	**31.8**	**1.69 (0.14 - 3.24)**	**0.77(-0.62 - 2.18)**	**0.79 (-0.76 - 2.35)**	**1.00 (Reference)**
Adjusted for age and physical activity	**1.6**	**2.52 (0.94 - 4.11)**	**1.64(0.21 - 3.06)**	**1.48 (-0.08 - 3.05)**	**1.00 (Reference)**
Adjusted for age and alcohol intake	**13.3**	**2.15 (0.56 - 3.74)**	**1.42(-0.00 - 2.85)**	**1.28 (-0.29 - 2.87)**	**1.00 (Reference)**
Adjusted for age and smoking	**16.9**	**2.90 (1.30 - 4.51)**	**1.92 (0.48 - 3.35)**	**1.65 (0.07 - 3.23)**	**1.00 (Reference)**
Adjusted for age and social participation	**9.3**	**2.25 (0.66 - 3.84)**	**1.52 (0.10 - 2.95)**	**1.44 (-0.12 - 3.02)**	**1.00 (Reference)**
Adjusted fully[c]	**35.5**	**1.60(-0.04 - 3.25)**	**0.63 (-0.81- 2.08)**	**0.61 (-0.96 - 2.18)**	**1.00 (Reference)**

[a] Education **I** represents primary/secondary school, modern secondary school; education **II** represents technical school, vocational school, 1-2 years senior high school and high school diploma; education **III** represents college/university less than 4 years; education **IV** represents College/university 4 years or more.

[b] Relative contribution: the relative effect estimate change as the risk factor was adjusted or the risk factors were adjusted.

[c] Adjusted fully includes: age, BMI groups, heart rate quartiles, physical activity, alcohol intake, smoking and social participation.

Table 4. Age-adjusted odds ratio (95% confidence interval) of Hypertension in relation to level of education for women

	Women				
	Education[a]				
	Relative contribution[b] (%)	I	II	III	IV
Hypertension					
Adjusted for age only		**1.74 (1.45-2.09)**	**1.50 (1.26-1.79)**	**1.20 (0.97-1.50)**	**1.00 (Reference)**
Adjusted for age and heart rate	**1.7**	**1.71 (1.43-2.05)**	**1.48 (1.24-1.76)**	**1.20 (0.96-1.49)**	**1.00 (Reference)**
Adjusted for age and BMI	**12.6**	**1.58 (1.32-1.90)**	**1.41 (1.18-1.69)**	**1.16 (0.93-1.44)**	**1.00 (Reference)**
Adjusted for age and physical activity	**1.1**	**1.76 (1.47-2.11)**	**1.50 (1.26-1.79)**	**1.20 (0.96-1.49)**	**1.00 (Reference)**
Adjusted for age and alcohol intake	**1.1**	**1.72 (1.42-2.07)**	**1.49 (1.25-1.79)**	**1.20 (0.96-1.49)**	**1.00 (Reference)**
Adjusted for age and smoking	**7.5**	**1.87 (1.55-2.24)**	**1.58 (1.32-1.88)**	**1.22 (0.98-1.52)**	**1.00 (Reference)**
Adjusted for age and social participation	**1.1**	**1.72 (1.43-2.06)**	**1.49 (1.25-1.78)**	**1.20 (0.97-1.49)**	**1.00 (Reference)**
Adjusted fully[c]	**2.3**	**1.70 (1.39-2.06)**	**1.47 (1.22-1.77)**	**1.18 (0.94-1.47)**	**1.00 (Reference)**

[a] Education **I** represents primary/secondary school, modern secondary school; education **II** represents technical school, vocational school, 1-2 years senior high school and high school diploma; education **III** represents college/university less than 4 years; education **IV** represents college/university 4 years or more.

[b] Relative contribution: the relative effect estimate change as the risk factor was adjusted or the risk factors were adjusted.

[c] Adjusted fully includes: age, BMI groups, heart rate quartiles, physical activity, alcohol intake, smoking and social participation.

Table 5. Age-adjusted odds ratio (95% confidence interval) of Hypertension in relation to level of education for men

	Men				
	Education[a]				
	Relative contribution[b] (%)	I	II	III	IV
Hypertension					
Adjusted for age only		**1.26 (1.05-1.51)**	**1.20 (1.01-1.41)**	**1.18 (0.99-1.42)**	**1.00 (Reference)**
Adjusted for age and heart rate	**4.8**	**1.20 (1.00-1.44)**	**1.14 (0.97-1.35)**	**1.16 (0.96-1.40)**	**1.00 (Reference)**
Adjusted for age and BMI	**7.1**	**1.17 (0.98-1.41)**	**1.10 (0.93-1.30)**	**1.10 (0.92-1.33)**	**1.00 (Reference)**
Adjusted for age and physical activity	**0.8**	**1.27 (1.06-1.53)**	**1.20 (1.01-1.42)**	**1.18 (0.98-1.42)**	**1.00 (Reference)**
Adjusted for age and alcohol intake	**2.4**	**1.29 (1.07-1.55)**	**1.21(1.02-1.44)**	**1.19 (0.99-1.44)**	**1.00 (Reference)**
Adjusted for age and smoking	**5.6**	**1.33 (1.11-1.60)**	**1.24 (1.04-1.46)**	**1.21 (1.00-1.45)**	**1.00 (Reference)**
Adjusted for age and social participation	**1.6**	**1.24 (1.03-1.49)**	**1.19 (1.00-1.40)**	**1.18 (0.98-1.42)**	**1.00 (Reference)**
Adjusted fully[c]	**1.6**	**1.24 (1.02-1.51)**	**1.13 (0.95-1.35)**	**1.13 (0.93-1.36)**	**1.00 (Reference)**

[a] Education **I** represents primary/secondary school, modern secondary school; education **II** represents technical school, vocational school, 1-2 years senior high school and high school diploma; education **III** represents college/university less than 4 years; education **IV** represents college/university 4 years or more.

[b] Relative contribution: the relative effect estimate change as the risk factor was adjusted or the risk factors were adjusted.

[c] Adjusted fully includes: age, BMI groups, heart rate quartiles, physical activity, alcohol intake, smoking and social participation.

Table 6. Age-adjusted odds ratio (95% confidence interval) of Self-reported high BP in relation to level of education for women

	Women				
	Education[a]				
	Relative contribution[b] (%)	I	II	III	IV
Self-reported high BP					
Adjusted for age only		**1.85 (1.54-2.23)**	**1.68 (1.40-2.01)**	**1.30 (1.04-1.62)**	**1.00 (Reference)**
Adjusted for age and heart rate	**1.1**	**1.83 (1.51-2.20)**	**1.65 (1.30-1.98)**	**1.29 (1.03-1.60)**	**1.00 (Reference)**
Adjusted for age and BMI	**11.4**	**1.64 (1.36-1.99)**	**1.57 (1.31-1.89)**	**1.25 (1.00-1.56)**	**1.00 (Reference)**
Adjusted for age and physical activity	**1.6**	**1.82 (1.51-2.20)**	**1.66 (1.39-1.99)**	**1.30 (1.04-1.62)**	**1.00 (Reference)**
Adjusted for age and alcohol intake	**9.7**	**1.67 (1.38-2.02)**	**1.59 (1.32-1.91)**	**1.25 (1.00-1.56)**	**1.00 (Reference)**
Adjusted for age and smoking	**8.6**	**2.01 (1.67-2.43)**	**1.78 (1.48-2.14)**	**1.32 (1.06-1.65)**	**1.00 (Reference)**
Adjusted for age and social participation	**0.5**	**1.84 (1.53-2.23)**	**1.67 (1.40-2.00)**	**1.30 (1.04-1.62)**	**1.00 (Reference)**
Adjusted fully[c]	**12.4**	**1.62 (1.32-1.98)**	**1.56 (1.29-1.89)**	**1.23 (0.98-1.54)**	**1.00 (Reference)**

[a] Education **I** represents primary/secondary school, modern secondary school; education **II** represents technical school, vocational school, 1-2 years senior high school and high school diploma; education **III** represents college/university less than 4 years; education **IV** represents college/university 4 years or more.

[b] Relative contribution: the relative effect estimate change as the risk factor was adjusted or the risk factors were adjusted.

[c] Adjusted fully includes: age, BMI groups, heart rate quartiles, physical activity, alcohol intake, smoking and social participation.

Table 7. Age-adjusted odds ratio (95% confidence interval) of Self-reported high BP in relation to level of education for men

	Men				
	Education[a]				
	Relative contribution[b] (%)	I	II	III	IV
Self-reported high BP					
Adjusted for age only		**1.39 (1.13-1.71)**	**1.42 (1.17-1.72)**	**1.35 (1.10-1.67)**	**1.00 (Reference)**
Adjusted for age and heart rate	**5.0**	**1.32 (1.08-1.63)**	**1.36 (1.12-1.65)**	**1.33 (1.07-1.64)**	**1.00 (Reference)**
Adjusted for age and BMI	**10.8**	**1.24 (1.01-1.53)**	**1.26 (1.03-1.53)**	**1.21 (0.98-1.51)**	**1.00 (Reference)**
Adjusted for age and physical activity	**2.2**	**1.36 (1.11-1.68)**	**1.40 (1.15-1.70)**	**1.34 (1.09-1.66)**	**1.00 (Reference)**
Adjusted for age and alcohol intake	**1.4**	**1.41 (1.14-1.75)**	**1.44 (1.18-1.75)**	**1.37 (1.10-1.69)**	**1.00 (Reference)**
Adjusted for age and smoking	**2.2**	**1.42 (1.15-1.76)**	**1.44 (1.19-1.75)**	**1.36 (1.10-1.68)**	**1.00 (Reference)**
Adjusted for age and social participation	**5.8**	**1.31 (1.06-1.61)**	**1.38 (1.14-1.67)**	**1.33 (1.08-1.65)**	**1.00 (Reference)**
Adjusted fully[c]	**13.0**	**1.21 (0.97-1.52)**	**1.24 (1.01-1.52)**	**1.22 (0.98-1.52)**	**1.00 (Reference)**

[a] Education **I** denotes primary/secondary school, modern secondary school; education **II** represents technical school, vocational school, 1-2 years senior high school and high school diploma; education **III** represents college/university less than 4 years; education **IV** represents college/university 4 years or more.

[b] Relative contribution: the relative effect estimate change as the risk factor was adjusted or the risk factors were adjusted.

[c] Adjusted fully includes: age, BMI groups, heart rate quartiles, physical activity, alcohol intake, smoking and social participation.

Table 8[a]. Age-adjusted odds ratio of Hypertension in relation to Each Risk Factor

	Women		Men	
Risk factor	**OR**	**P Value**	**OR**	**P value**
Heart rate (beat/ min) quartile		**= 0.001**		**< 0.001**
First (Reference)	**1.00**		**1.00**	
Second	**0.85**	**= ns[b]**	**0.96**	**= ns**
Third	**0.95**	**= ns**	**1.27**	**= 0.003**
Fourth	**1.20**	**= 0.03**	**1.61**	**< 0.001**
BMI (kg/m^2)		**< 0.001**		**< 0.001**
≥24.99 (Reference)	**1.00**		**1.00**	
25.00-29.99	**1.69**	**< 0.001**	**1.60**	**< 0.001**
≥30	**2.35**	**< 0.001**	**2.32**	**< 0.001**
Smoking		**= 0.005**		**< 0.001**
Non-smoker (Reference)	**1.00**		**1.00**	
Current	**0.77**	**= 0.003**	**0.78**	**= 0.006**
Former	**0.85**	**= 0.019**	**1.10**	**= ns**

[a] Only significant variables are displayed in the table.
[b] NS - Non-significant.

Nevertheless, the association between education and health is well established: the higher an individual's education, the better her or his health. Education contributes to find out how to access information, collecting facts, learning concepts that may influence health.(76) In this context, education impacts health positively by broadening understanding of individuals to choose healthy life style. Besides, education and income is linked,(77) in a sense that those with more education may have higher income. In that respect, it seems that income may also influence the health of the individuals. For instance, there is a close association between incomes of the individuals and their life expectancy and mortality. (78)

This study demonstrated that women with lower SES had an increased BP than men. This is consistent with studies in U.S. and eight European countries. (17, 18) The explanation could be, for example, in Norway the majority of women have worked in nursing care and service sectors,(79) where there is a lower payment, and thus women have earned less than men. (80)

Table 9[a]. Age-adjusted odds ratio of Self-reported high BP in relation to Each Risk Factor

	Women		Men	
Risk factor	**OR**	**P Value**	**OR**	**P value**
Heart rate (beat/ min) quartile		**< 0.001**		**< 0.001**
First (Reference)	**1.00**	**Reference**	**1.00**	**Reference**
Second	**0.85**	**= ns[b]**	**1.01**	**= ns**
Third	**0.86**	**= ns**	**1.44**	**< 0.001**
Fourth	**1.22**	**= 0.02**	**1.61**	**< 0.001**
BMI (kg/m^2)				**< 0.001**
≥24.99	**1.00**	**Reference**	**1.00**	**Reference**
25.00-29.99	**1.71**	**< 0.001**	**2.11**	**< 0.001**
≥30	**3.69**	**< 0.001**	**3.85**	**< 0.001**
Physical activity		**= 0.007**		
Never	**1.00**	**Reference**		
Less than once a week	**0.87**	**= ns**		
Once a week	**0.95**	**= ns**		
2-3 times a week	**0.88**	**= ns**		
Approximately every day	**0.70**	**= 0.01**		
Alcohol intake		**< 0.001**		
Never	**1.00**	**Reference**		
Monthly or less frequently	**0.86**	**= ns**		
2-4 times a month	**0.73**	**= 0.001**		
2-3 times a week	**0.62**	**< 0.001**		
4 or more times a week	**0.42**	**< 0.001**		
Smoking		**= 0.003**		**< 0.001**
Non-smoker	**1.00**	**Reference**	**1.00**	**Reference**
Current	**0.74**	**= 0.001**	**0.86**	**= ns**
Former	**0.93**	**= ns**	**1.24**	**= 0.004**
Association				**= 0.002**
Never			**1.00**	**Reference**
1-3 times a month			**0.82**	**= 0.02**
Approximately once a week			**0.74**	**= 0.004**
More than once a week			**0.75**	**= 0.02**

[a] Only significant variables are displayed in the table.
[b] NS - Non-significant.

However, in the present study SES did not fully influence BP directly, but it affected BP through risk factors as well, which is in agreement with the results of other study. (14)

6.3 The role of risk factors in the association between Socioeconomic Status and Blood pressure

BMI

In the present study BMI showed the largest confounding effect on the association between education and BP, as a lower BMI among the well-educated reduced their high BP risk. This is in accordance with findings from other population-based studies.(14,26-28) The findings of this study also suggest that obesity is an important risk factor for measured high SBP and self-reported high BP independent of SES, which is consistent with other studies.(26,38-40) Possible factor that relates lower SES to an elevated high BP may include diet. (81) For instance a diet without fruits and vegetables because of lack of financial and socio-environmental resources may predispose an increased BP for person with lower SES.(81) It could also be assumed that less educated women and men may not have better knowledge of health risks related with overweight and obesity, and they may have no motivation to reduce their weight.

Heart rate

Differences in heart rate contributed to 20.9% and 4.3% of the variation in SBP between the lowest and the highest educational groups in men and women, respectively. However, the confounding effect of heart rate on socioeconomic differences in hypertension and in self-reported high BP was minor in women and men. This study also showed that higher heart rate was independently related with hypertension and self-reported high BP in women and men. This is in line with data of other author who found that higher heart rate was associated with high SBP. (26) In addition, epidemiological studies have shown that resting heart rate in women is higher than in men.(82, 83)

McGrath and colleagues (84) have interpreted those chronic stressors, such as unemployment, violence, crime, noise, pollution and crowding are associated with lower SES and higher heart rate, which may result in higher BP. Another possible explanation would be unhealthy life style that may contribute to higher heart rate among lower educated women and men, which may result in higher BP.

Smoking

This study found that differences in smoking habit increased the variation in SBP, in Hypertension and in self-reported high BP in the lowest educated women and men compared with the highest educated, which has been unexpected. When smoking was adjusted in the models, it was assumed that the differences in BP according to educational groups either reduced or turned into nonsignificance, but the present study showed the opposite. In other studies, however, smoking neither increased nor decreased the SES differences in BP. (26,28) This study also showed that smoking was independently, negatively associated with Hypertension in women and men, and with self-reported high BP only in women, which is in line with other previous studies, (85-87) and the reduction in SBP is about 2.6 mmHg to 4.6 mmHg in current smokers compared with nonsmokers.(85, 88) Other studies, however, found that smoking increased BP, (55, 89, 90) which is contradictory with the present study.

There are possible explanations why smokers had lower BP in the present study. One suggestion is smokers have lower body weight than nonsmokers. Associated loss of weight in current smokers contributes to lowering BP since smoking is related with a decrease in body weight, (91-94) and smoking cessation leads to a weight gain.(95) However, in the present study, even after adjusted BMI, the negative association between smoking and BP persisted, and for ex-smokers it was insignificant (the data was not shown).

Another possible explanation for the difference in BP between non-smokers and smokers could be BP drops during abstinence and rises during the act of smoking.(85, 96) In several epidemiological surveys the participants have refrained from tobacco smoking the last few hours before their BP is measured,(85) and that is why smokers have lower BP than non-smokers. This suggestion, however, does not fully explain the difference in BP in smokers and non-smokers because in the present study women smokers had lower BP in self-report, and self-report does not require the individuals to abstain from tobacco smoking for some time to participate in the survey.

A further possible explanation for the difference in BP between smokers and non-smokers could be a decreased left ventricular performance with preexisting coronary artery disease and a reduced myocardial contractility in smokers, (97) which may partly explain a lower BP (85). In addition, smoking is associated with cardiomyopathy and ventricular wall abnormalities, and the abnormalities in cardiomyopathy and ventricular wall may partially account for the reduction in BP seen in smokers. (98) Another suggestion would be the result of a decreased stroke volume, (97, 99) because smokers tend to have higher heart rates than non-smokers and smoking also seems to create increased peripheral resistance. (100) Furthermore, airway-specific vasopressin release may explain the acute effect of smoking on lower BP.(101)

Another possible suggestion for the difference in BP between nonsmokers and smokers could be larger proportion of current smokers were taking BP lowering drugs in the present study. For example, 21.4% of women and 18.9% of men were current smokers, and 15.9% of women and 15.3% of men who were current smokers were taking BP treatment (the data was not shown).

In Norway, although smoking rate decreases among highly educated, it increases among the less educated. (102) In present study, larger proportions of smokers were women than men with lower education. This is consistent with the survey of the Central Bureau of Statistics of Norway. (103)

Other risk factors

Physical activity

Physical activity did show contrary effects between measured SBP and Self-reported high BP. Physical activity increased SES variation in measured SBP in women and men, and it decreased SES differences in self-reported high BP for both women and men. Physical activity, nevertheless, contributed a slight confounding effect on the relationship between education and measured SBP and self-reported high BP. However, other studies did not find the mediating effect of physical activity on the relationship between education and SBP.(26,28) In the present study, however, physical activity was statistically insignificant in hypertension and in self-reported high BP independent of SES, which is in accordance with other study. (26) Furthermore, previous studies have shown individuals with lower SES participated less in physical activity than highly educated women and men. (46, 47)

Alcohol intake

Alcohol intake reduced SES variation in measured SBP continuous variable in women and men, which is consistent with another studies (26, 28). Nevertheless, alcohol intake seemed to have contrary effects on hypertension and self-reported high BP in women and men. Alcohol intake reduced SES differences in hypertension and in self-reported high BP for women, while it also increased SES differences in hypertension and in self-reported high BP for men. In the present study alcohol intake, however, was independently, statistically insignificant in hypertension and in self-reported high BP for men. In addition, epidemiological studies have shown that in other Western countries alcohol intake is related with higher SES among women and men. (53-54)

Social participation

The present study showed that differences in social participation reduced the variation in measured SBP and self-reported high BP slightly, in supporting of higher educated women and men. In accordance with other study,(104) the present study found that social participation was independently associated with lower BP. Apart from this, research has indicated that involvements in voluntary associations may have positive relationship with health, and SES is antecedent to this association. (105) Furthermore, Michael Marmot (78) recognizes if the social participation is high, people with relatively low SES may have good health. According to Marmot, when people participate in organized gatherings like in politics, sport clubs, religious activities and other associations, the activities may help them reduce stress and depression, and may activate physiological system which may directly influence their health.

6.4 Socioeconomic Status and the known risk factors

Among women a clearly smaller proportion of the association between education and measured SBP is associated with the known risk factors. In a sense that the substantial proportion may be educationally linked or some other factors that were not included in the present study might influence the association. Nevertheless, for men the relation between education and measured SBP continuous variable and self-reported high BP may be explained through the known risk factors.

6.5 Measured Systolic Blood Pressure and self-reported high BP

In the present study the results of measured SBP and self-report are not similar. The possible explanation could be when SBP measured and self-reported high BP were compared, 39.9% of men and 24% of women were not diagnosed due to possibly they were in low risk or in some other reasons. In the present study self-reported high BP was underestimated in women and men. This is consistent with other study.(106) Thus, the underestimation of self-reported may explain the different results in measured SBP and in self-report.

6.6 Contribution of Blood Pressure Treatment

In this study those individuals who were taking BP treatment were included in the analysis when the risk factors were adjusted simultaneously, 8% difference in SBP was explained between the lowest educated and the highest educated women, but those individuals who were taking BP lowering drugs were excluded from the analysis, 15% difference in SBP was explained between the lowest and the highest educated women. And for men the difference in SBP between the highest education and the lowest education declined into nonsignificance in both cases — when including and excluding individuals who were taking BP treatment. Thus, medication of high BP may help to reduce the SES difference little for both women and men in measured SBP because it may be a lot of individuals were not diagnosed.

However, in self-reported high BP there was no significant difference between the highest and the lowest education in women and men, and therefore, BP treatment may remove SES variation in BP because 95.3% of women and 91.3% of men participants, who were diagnosed with high BP, were taking BP treatment (the data was not shown).

6.7 Inclusion of participants taking Blood pressure treatment in the analysis

In this study participants who were taking BP treatment were included in the analysis of measured SBP and in self-reported high BP because 95.3% of women and 91.3% of men, who were diagnosed with high BP, were taking high BP lowering drugs, and if the individuals who were taking medication for high BP were excluded, only few individuals could be included in the analysis in self-reported high BP. Hence, to include several participants as possible and compare the results in measured SBP and self-reported high BP, those taking BP treatment were included in measured SBP and self-reported high BP analysis.

6.8 Strengths and limitations

This study has strengths. One of the strengths of this study is the use of data from Tromsø study. The Tromsø 6 study is a population-based study, and the attendance rate is 65.7%, which has an overall high attendance rate compared to other community-based studies, and it has external validity. As external validity is defined, it is the ability to generalize the conclusions to other groups in the population. (1) Therefore, the conclusions from this study may apply to other similar population. Second, in this study the objective measurements of anthropometric and SBP were assessed by trained persons. The other strength of this study is that an attempt has been made to include important confounding factors because of the high quality of the questionnaire information and comprehensive information on the risk factors for high BP. The other strength is also measured SBP and self-reported high BP have been compared.

However, this study is not without limitation. First, this study used cross-sectional design that deterred us from conclusions about the causality of the associations. Second, although high salt intake is the risk factor for high BP, this study did not include it. Third, this study used self-reported education, which might be different from official recorded statistic. Fourth, there may be slight difference between attendees and non-attendees. Regarding the non-attendees in Tromsø 6 study, only age and sex were mentioned. The mean age of non-participants for women was generally little higher than the participants included. Besides, for men non-attendees were younger than the participants included in the study sample. In addition, more women than men relatively had missing values for all variables in Tromsø 6 study. Thus, difference in attendees and non-attendees may reduce the strength of the observed association between SES and BP, which has been explained by established risk factors.

7. Conclusions and implication

7.1 Conclusions

This study found that lower SES is independently associated with higher BP in both women and men, and the association is also stronger in women than men.

This study suggests that the observed differences in BP associated with SES may result from exposure to established risk factors for men, but for women only smaller proportion.

For women BMI is the largest contributors to the differences in BP between the lowest educated and the highest educated, and for men BMI and heart rate.

This study also shows that lower education is associated with greater BMI in men than women. Lower education is also related with older age, higher heart rate, higher percentage of physical activity and larger proportion of current smoking in women than men. Furthermore, higher education is associated with higher proportion of alcohol intake in men than women. Higher education is also related with more social participation in women compared to men.

These results have implication to focus on SES variation in BP and the most important risk factors in particular:

7.2 Public health implication

The established risk factors may explain the association between SES and BP for men. For women, however, the largest proportion of the variation in BP may be linked with education or may be related with some other factors that are not included in the present study. Therefore, it may be possible to reduce SES variation partly through narrowing income gap in women and men.

7.3 Research implication

This study is cross-sectional and causal mechanisms cannot be explored. Therefore, longitudinal studies are needed to examine in what extent the known risk factors can explain SES variation in BP.

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Appendix

Questionnaire

<u>GENERAL INFORMATION</u> - **<u>GENERAL INFORMATION</u>**

AGE_T6 - Age per 31.12.2007

SEX_T6 - Sex

1 : Male

0 : Female

<u>PHYSICAL EXAMINATION</u> - **<u>PHYSICAL EXAMINATION</u>**

HEIGHT_T6 - Body height in cm measured at screening

WEIGHT_T6 - Body weight in kg measured at screening

PULSE1_T6 - Pulse (first measurement)

PULSE2_T6 - Pulse (second measurement)

PULSE3_T6 - Pulse (third measurement)

MEAN_SYSBP_T6 - Systolic blood-pressure (mmHg) (mean of reading 2 and 3)

SYSBP1_T6 - Systolic blood-pressure (mmHg) (first measurement)

SYSBP2_T6 - Systolic blood-pressure (mmHg) (second measurement)

SYSBP3_T6 - Systolic blood-pressure (mmHg) (third measurement)

<u>HEALTH AND DISEASES</u> - **<u>HEALTH AND DISEASES</u>**

HIGH_BLOOD_PRESSURE_T6 - Have you ever had, or do you have high blood pressure?

1 : Yes

0 : No

USE OF MEDICINE - **USE OF MEDICINE**

BP_TREATMENT_T6 - Do you use, or have you used blood pressure lowering drugs?

3 : Never used

1 : Currently

2 : Previously, but not now

FAMILY AND FRIENDS - **FAMILY AND FRIENDS**

ASSOCIATION_T6 (social participation) - How often do you normally take part in organized gatherings, e.g. sports clubs, political meetings, religious or other associations?

1 : Never, or just a few times a year

2 : 1-3 times a month

3 : Approximately once a week

4 : More than once a week

WORK, SOCIAL SECURITY PAYMENTS AND INCOME - **WORK, SOCIAL SECURITY PAYMENTS AND INCOME**

EDUCATION_T6 - What is the highest levels of education you have completed?

1 : Primary/secondary school, modern secondary school

2 : Technical school, vocational school, 1-2 years senior high school

3 : High school diploma

4 : College/university less than 4 years

5 : College/university 4 years or more

PHYSICAL ACTIVITY - **PHYSICAL ACTIVITY**

EXERCISE_T6 - How often do you exercise (i.e walking, skiing, swimming or training/sports)?

1 : Never

2 : Less than once a week

3 : Once a week

4 : 2-3 times a week

5 : Approximately every day

ALCOHOL AND TOBACCO - **ALCOHOL AND TOBACCO**

ALCOHOL_FREQUENCY_T6 - How often do you usually drink alcohol?

1 : Never

2 : Monthly or less frequently

3 : 2-4 times a month

4 : 2-3 times a week

5 : 4 or more times a week

SMOKE_DAILY_T6 - Do you/did you smoke daily?

1 : Yes, now

2 : Yes, previously

3 : Never