Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Circulation and Medical Imaging

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# Prevalence and tracking of overweight and obesity in Norwegian children in an urban area

*- At what age should preventative actions be intensified?*

Master's thesis in Clinical Health Science, specialisation in obesity and health
Supervisor: Rønnaug Ødegård, Gudrun Bjørnelv and Vidar Halsteinli
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Kunnskap for en bedre verden

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# Abstract

**Background:** Obesity is a severe threat to health and wellbeing. Worldwide, overweight and obesity have almost tripled since 1975. In Norway, the prevalence of overweight and obesity have started to level off. However, the prevalence is still too high, and prevention and treatment are exceedingly important. High birth weight or high BMI early in life has been associated with overweight or obesity later in life. There is an urban-rural gradient in Norway, which indicates of a lower proportion in cities with high degree of centrality. However, there are limited studies of the prevalence and tracking in a Norwegian urban municipality. **Aim:** The aim of the study was to investigate how the prevalence of children with overweight and obesity (born between 2003 to 2010) changes between different ages (two, four and eight) in an urban municipality, and to analyse the odds for overweight or obesity at eight years of age according to weight categories (normal weight, overweight or obese) at the ages two and four. **Method:** The study was a descriptive and analytic retrospective registry study based on longitudinal data from health stations in Trondheim. A total of 7 643 children with observations at the ages two, four and eight were included. Iso-body max index (BMI), BMI-z-score, age, gender and year of birth were variables used in the study. Iso-BMI is adjusted for age and gender and defines overweight as iso-BMI ≥25-<30, obesity grade I as iso-BMI≥30-<35 and obesity grade II as iso-BMI≥35. Associations were measured with logistic regression and for proportions, margins were used. **Results:** The prevalence of overweight was 10% at two years of age, 8.4% at four years of age and 12.7% at eight years of age and obesity grade I was 1.2%, 1% and 2.6%. In boys, obesity grade II increased fourth fold from the age of two to eight. The majority with overweight or obesity at the age of eight were normal weight at two and four years of age. The chance for overweight or obesity at the age of eight were 51% higher if normal weight at two years of age and overweight or obese at the age of four compared to normal weight at both the ages two and four years. Also, being overweight or obese at the age two and normal weight at the age of four resulted in a 15% higher chance for overweight or obesity at the age of eight compared to normal weight at both the ages two and four. **Conclusion:** The results in this urban population-based study indicated that being overweight or obese at four years of age, the chance for overweight or obesity at eight years of age was high. But, an increased risk for overweight or obesity at the age of eight was also presented if overweight or obese at the age of two, even with normal weight at four. The prevalence of overweight and obesity was comparable with data on a national level. A gender difference was shown with a higher proportion of overweight in girls compared to boys. However, in obesity grade I and II, boys presented the highest proportions.


# Relevance

This study may contribute to a wider knowledge regarding what ages are critical for developing overweight and obesity during childhood. Thanks to this knowledge, a clear picture of when large primary- and secondary preventative actions should be intensified, can be formed. From a primary preventative angle, the chance for being overweight and obesity at eight years of age is high if overweight or obese at four years of age. At the same time a majority were normal weight at all ages. This supports an intensified primary prevention during childhood. Since overweight or obesity at the age of two is a risk for later overweight or obesity, even for children with normal weight at the age of four, this may also contribute to change in practice within the area of actions in childhood obesity for urban municipalities in Norway.

# Content

# *1. Background*

## *1.1 Introduction*

Worldwide, the amount of overweight and obesity among children under the age of five is around 41 million. Increasing proportions of overweight and obesity, 4% to 18%, are presenting in children and adolescents from 1975 (1). In Norway, the prevalence of overweight and obesity in boys and girls is showing relatively stable numbers from 2008 to 2015, around 15 to 20% (figure 1). The prevalence of obesity is stable around 3% for both genders during the time periods. In conclusion, the increase in prevalence of overweight and obesity is levelling off among third graders in Norway, but is still too high (2, 3). An urban-rural gradient in childhood overweight prevalence is shown in Norway, with a higher frequency in urban areas (2, 4).

For children, weight and height varies with gender and age, therefore cut-offs from the International obesity task force (IOTF) is being used for thinness, overweight and obesity for children and adolescents, called iso-BMI. These cut-offs enable a global comparison of prevalence. When using iso-BMI, overweight is defined as iso-BMI ≥25-<30, obesity grade I as iso-BMI≥30-<35 and obesity grade II as iso-BMI≥35. BMI is calculated for the child or adolescent followed by age and gender specific numbers (appendix 1). Iso-BMI can be applied on children and adolescents at 2 to 18 years of age. For children younger than two years, weight-for-height percentiles are applied (5).

Despite the reaching plateau, overweight and obesity among children continues to be a major public health problem. Overweight and obesity during childhood and adolescence is a high risk for multiple complications and comorbidities, both long- and short term. Children and adolescents with overweight and obesity is showing a higher risk for development of cardiovascular- and metabolic diseases. Other comorbidities due to overweight and obesity are pulmonary- and endocrine diseases, gastrointestinal disorders, cancer and psychological problems (6). In addition to comorbidities, children with overweight and obesity, independent of weight in adulthood, are having an increased risk for mortality and diseases in adulthood (7). From a societal angle, stigmatisation is a common concept within overweight and obesity. Stigmatization refers to negative opinions about a person or a group because of a characterises (8). The society often defines individuals with overweight or obesity as lazy, irresponsible and lack of self-control. Individuals with overweight or obesity are reporting being discriminated through bulling, ignoring and alienation. Economic disadvantages later in life because of denied opportunities, reduced education and success are also consequences from

stigmatization (9). Overweight and obesity are more common in individuals with low socioeconomic status (10). Also, overweight and obesity are mostly common in low- and middle income countries (1).

Because of the negative impact on health, quality of life in childhood and the high risk of health complications in adulthood, it is of importance to identify and prevent this condition early (11). In Norway, specific guidelines are being used to prevent the presence of overweight and obesity. Prenatal clinics, health centre- and school health services and general practitioners are authorities where preventive work is being carried out in Norway (12). Child health centre- and school health services are being recommended to do routine measurements on weight and length on children to identify children of risk at an early stage. If children are in the overweight or obesity category, interventions are applied. At health centre services, children are measured frequently up to school age. At school health services, children's weight and length are being measured at school start, at third- and eighth grade (11).

Tracking is being performed to explore the risk of obesity later in life for a given child based on the current weight and age (13). Results is showing that 80% of adolescents who are overweight or obese continue to be this in adulthood (14). In northern Norway, a small retrospective cohort is being made to evaluate the presence and degree of overweight and obesity from childhood to adolescence. When being overweight or obese in the age group two to four, the chance to become overweight or obese at the age of eight is 52.5% (15). The Child growth study of Norway is an observational study on a national level based on a randomized data collection on municipalities in Norway. The study is examining if overweight or obese children at eight years of age is associated with high birth weight. The study is showing that 20.4% of the children is overweight or obese at 8 years of age. An association between being overweight (OR: 1.80, 95%CI: 1.60, 2.00) or obese (OR: 1.80, 95%CI: 1.40, 2.30) at eight years of age and high birth weight is also discovered. This indicates that children with high birth weight has a tendency to stay in this condition at eight years of age (16).

The prevalence of overweight and obesity in eight-year olds in Norway is stable. However, the prevalence is still too high even if preventive work is prioritized (12). Urban-rural differences are presented in Norway, with a lower degree of overweight and obesity in urban areas. In northern Norway, being overweight or obese at the age of five to seven are showing a high risk for overweight or obesity at the age of 17 (15). In order to improve the health care that is provided to these groups, additional knowledge about early BMI-development is needed. Even if earlier studies (15, 16) show that the presence of overweight and obesity in

early childhood is associated with this at later ages, more knowledge within this area should be provided that in practice can be useful for employees at health care- and school health services. Therefore, the aim of the study is to investigate how the prevalence of overweight and obese children (born between 2003 to 2010) changes between different ages (two, four and eight) in an urban municipality based on a large urban population with longitudinal data. A second aim is to predict overweight and obesity at eight years of age based on weight status at two and four years of age according to weight categories (normal weight, overweight, obesity grade I and II).

### *1.1.1 Research question*

1) What is the prevalence of overweight and obesity in children at two, four and eight years of age in a Norwegian urban municipality?
   - Does the prevalence differ between girls and boys, and the year when children were born (2003-2010)?

2) Can overweight and obesity at eight years of age be predicted at the ages of two and four years according to weight categories (normal weight, overweight, obesity grade I and II)?
   - Does the prediction differ between gender?

## *1.2 Theoretical background*

### *1.2.1 Physiology of obesity*

Adipose tissue is a connective tissue composed by fat cells, so called adipocytes, that store fats (17). The accumulation of fat tissue changes with a child's age and gender. At the age of one until five to six, the amount of fat tissue decreases, and the muscle mass increases. At the age of six to ten, the muscle mass still increases but the fat accumulation increases again. The age of five to six, is the time for "adiposity rebound". This concept describes the time when transition from increase in muscle mass to an increase in fat mass takes place. The adipose tissue is at its lowest at this point. Some results indicate an association between early adiposity rebound and increasing obesity in adolescent (12).

### *1.2.2 Definition and measurement of overweight and obesity*

Generally, overweight and obesity is being defined as an excess of body fat which is not optimal for an individual's health. In children, assessment can be more difficult than in adults

since body fat differs with age, gender and maturity. Therefore, multiple methods are being used for assessment of overweight and obesity in children. An estimation of the body composition is one method, which includes different techniques that measure for example percent of body fat and fat-free mass (18). These techniques are for example Dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA) (19), Computerised tomography (CT)- or magnetic resonance imaging (MR) and underwater weighing (UWW) (18).

Other methods for assessing overweight and obesity in children are waist circumference with different techniques and measures of skinfold thickness. Waist circumference is being used for prediction of abdominal fat. For children, waist-to-height ratio can evaluate metabolic risks. Skinfold thickness measure the subscapularis, suprailiac, triceps and biceps (18).

BMI is being used to measure overweight and obesity. BMI is defined as an individual's weight in kilograms (kg) divided by the square of the individual's height in meters ($kg/m^2$). This method is not recommended for children and adolescents since weight and height varies with gender and age. Therefore, for children and adolescents, overweight and obesity are being defined according to different categories as percentiles (20), BMI z-score (BMI SDS (standard deviation score)) (21, 22), and iso-BMI (5). Centres for disease control and prevention (CDC) is a health institute in the United states that uses BMI-for-age growth charts among children at 2 to 20 years of age. Overweight is defined as the $85^{th}$ up to $95^{th}$ percentile and obesity as equal to or greater than the $95^{th}$ percentile (20). Additional cut offs for children are BMI z-score. These indicates how many units the child's BMI is above or below the average BMI for that child's age group and gender. For example, a child with BMI z-score of 1.5, indicates of a 1.5 SDS above the average value (21, 22). BMI z-score is calculated using the formula as the following, where M, L and S corresponds to the child's age and gender (23).

$$z = \frac{(\frac{\text{BMI}}{\text{M}})^{L} - 1}{L \times S}$$

The international obesity task force (IOTF) is using international BMI cut-offs for thinness, overweight and obesity, called iso-BMI. Iso-BMI is considering that BMI changes with age and gender. When using iso-BMI, overweight is defined as iso-BMI ≥25-<30, obesity grade I as iso-BMI≥30-<35 and obesity grade II as iso-BMI≥35. Iso-BMI is being calculated by BMI and then compared with age-and gender specific references (appendix 1). These cut-offs

enable a global comparison of prevalence. Therefore, the cut-offs are used widely to assess the prevalence of overweight and obesity for children and adolescent. Iso-BMI is applied on children and adolescents at 2 to 18 years of age. For children younger than two years, weight-for-height percentiles are applied. These are used on children at two-years of age and younger since the weight in proportion to height are lower (5, 23). In Norway, iso-BMI is used to define overweight and obesity in children (12).

### *1.2.3 Prevalence*

Worldwide, the prevalence of obesity is increasing from 1% (5 million girls, 6 million boys) in year 1975 to 6% in girls (50 million) and 8% in boys (74 million) in 2016. The increase of overweight and obesity is accelerating in low- and middle-income countries, especially in Asia, while it is slowing down and plateauing in high income countries. The largest increase of obese children and adolescents is be seen in East Asia, the high-income English-speaking countries, the Middle East and North Africa (1).

In Norway, the Child growth study is a longitudinal study on the prevalence of overweight and obesity among third graders (eight years) in 2008, 2010, 2012 and 2015. The study is presenting height and weight from Norwegian registers and is following up the development of overweight and obesity among children (2). The results from the study indicate that the amount of overweight and obese children at 8 years of age is stable between 2008 to 2015. The study is showing a prevalence of 16.0% in girls and 14.0% in boys in 2008, and in 2015 16.7% in girls and 13.3% in boys (2, 3). Slightly similar results are being presented in another Norwegian study made in northern Norway. This study is using a retrospective cohort design with data on 532 adolescents from both urban and rural areas (24). In the age group two to five, a prevalence of overweight and obesity in girls are 14.6% and 8.6% in boys. In girls, overweight and obesity are 18.1% and 10.7% in boys in the age group six to eleven. In the age group 15 to 17, a prevalence of 19.7% is seen in girls and 20.5% in boys A gender difference is being presented in overweight where a higher prevalence is seen in girls compared to boys in the age group two and five (15.5% vs 9.6%, $p<0.001$) (25). Additional study from Bergen in Norway with a population from urban areas, is presenting the prevalence in this city. The prevalence of overweight and obesity in girls is 21.0% in two-year olds, 15.0% in four-year olds and 22.6% in eight-year olds. In boys the prevalence is 12.9% at the age of two, 8.9% at the age of four and 14.0% at the age of eight. Obesity grade I and II are showing a prevalence of 0% in boys at the age of two, 1.3% at the age of four and 2.7% at eight years of age. In

girls, the prevalence is 2.9%, 2.1% and 3.4% respectively, with the same age groups as previous (25).

The Child growth study is also showing differences in prevalence of overweight and obesity in children between health regions in south east-, west-, middle- and north Norway. This is presenting a lower prevalence in south east Norway (15%) and higher in north Norway (19.2%). In middle-Norway, the prevalence of overweight and obesity in eight year olds, girls and boys combined, is 18.4% (2). A study based on the data material from the Child growth study is examining the differences in prevalence of overweight and obesity in children between urban and rural areas. The main finding is showing that the proportion of children with overweight and obesity is higher in municipalities with low degree of centrality compared to municipalities with high degree of centrality (figure 1) (26).

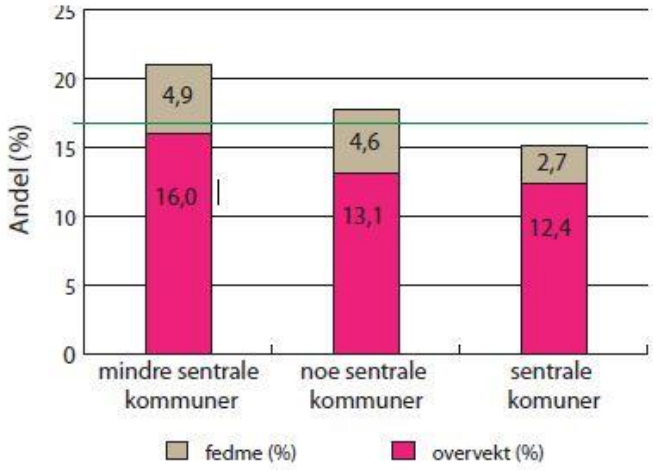


*Figure 1 Proportion of overweight and obesity in third graders separated by degree of centrality, year 2010 and 2012 (2)*

## *1.2.4 Causes*

A condition as obesity is complexed and multifactorial. There are three overall causes of obesity in childhood: physiological, psychological and environmental (27).

### *1.2.4.1 Genetic and heritability*

Genetic and heritability plays a big role in the development of obesity. Up to 70% of the genes defines overweight or obesity. Twin, family and adoption studies are showing indications of this. Twin studies are showing that the variance in fat mass is determined by genetic factors. Family studies is also showing that obesity runs in families. Also, adopted children's weight are more resembled to the biological parent than the adoptive parents (28).

Several genetic syndromes can cause obesity, for example Prader-Willi syndrome, Bardet-Biedel, Alstrom and Cohen. These syndromes are being caused by change on chromosomes. The consequences can be higher adiposity and obesity (29).

#### *1.2.4.2 Psychology*

Associations between overweight and obesity in children and several psychological issues are shown. Depression and obesity are associated with each other. However, there are conflicts about whether depression affects obesity or the other way around so a weighing between what is cause and comorbidity is needed. A systematic review and meta-analysis of longitudinal studies is concluding a stronger association where depression is leading to obesity (30). Temperament characteristics are also associated with weight gain in infants (31). Even sleep duration is having an impact on the development of overweight and obesity. A short sleep duration is associated with overweight and obesity curing childhood (32, 33).

#### *1.2.4.3 Environment*

Multiple environmental reasons can describe the increase of the obesity epidemy. Major changes are showing in the social structure during the past 40 years. The consumption of energy-dense food with a high percentage of fat and refined carbohydrates are increasing. The composition of the diet is also changing, and the portion sizes are larger (34). In addition to the increased intake of calories there are a decrease in energy expenditure through increased time spent in sedentary activities and reduced physical activity level (35).

### *1.2.5 Complications and comorbidities*

Overweight and obesity during childhood and adolescence are leading to multiple complications and comorbidities, both long- and short term (29).

Overweight and obesity during childhood is showing associations with cardiovascular disease (CVD) risk factors. CVD is diseases that affect the circulation organs as the heart and blood vessels (arteries and veins). Obesity in childhood is associated with increased risk of fatal and non-fatal myocardial infraction, hypertension and atherosclerosis in adulthood (6).

An increased risk of metabolic complications in adulthood are being associated with obesity in childhood and adolescence. These complications are insulin resistance, dyslipidaemia and type 2 diabetes (6). Insulin resistance is a condition where the cells have an impaired ability to handle insulin uptake, which contributes to a reduction in muscular skeletal glucose uptake and an increased glucose production (36). This can later result in type 2 diabetes (37).

Pulmonary diseases, as obstructive sleep apnea and asthma, in children and adults are closely related to obesity (6). Signs of obstructive sleep apnea are snoring, gasping during sleep, irregular breathing with pauses and daytime somnolence. Obstructive sleep apnea is associated with cardiovascular abnormalities which can lead to hypertension, increased right and left ventricular mass and left ventricular diastolic dysfunction (38).

Further comorbidities in children and adolescents with obesity are gastrointestinal disorders as non-alcoholic fatty liver disease (NAFLD) and gastroesophageal reflux. NAFLD is characterised by accumulation of macro vesicular fat in hepatocytes. For the development of NAFLD, obesity is the most prominent risk factor (6).

The musculoskeletal system is also affected by overweight and obesity. In children, the most common orthopaedic issues are tibia vara (Blount's Disease) and slipped capital femoral epiphysis. These problems occur due to increased weight on a developing skeletal system. Tibia vara affects the bones on the lower leg which causes them to bow outwards. Slipped capital femoral epiphysis is a rare disorder of the growth plate that needs surgical interventions (6).

Obesity can also be associated with early onset of sexual maturation in girls. Adolescent girls with obesity have a higher risk for developing polycystic ovary syndrome which can include menstrual irregularities, acne, hirsutism and infertility (39, 40).

Individuals with overweight or obesity are having an increasing risk for development of several types of cancer. Reeves et al (41) is evaluating the relation between BMI and cancer incidence and mortality. This is showing that increasing BMI is associated with an increased risk of cancer for 10 out of 17 specific types. It is also showing that about half of all women with cancer in postmenopausal are overweight or obese (41)

Among children with obesity, psychological problems are common which can include anxiety, depression (40), poor self-esteem (42) and decreased quality of life (43) These children are also more likely to become victims of bullying, discrimination (44), stigmatization and social exclusion (8).

In addition to the above comorbidities, children with overweight or obesity, independent by weight in adulthood, are having an increased risk to be affected by mortality and diseases in adulthood (7). As much as 80% of adolescents who are overweight or obese appears to carry

the overweight with them into adulthood. Therefore, it is of importance to identify and prevent this condition early (14).

### *1.2.6 Prevention*

Prevention can be divided into primary- and secondary prevention. Primary prevention is preventive work of the onset of diseases. With secondary prevention the aim is to avoid already overweight children to develop obesity and therefore help them to lose weight. In order to succeed with this prevention, it is important to intervene at an early stage while there is a greater chance of growing out of obesity and acquiring favourable living habits (45).

Worldwide, multiple large studies are made during a longer period with the purpose of prevention of overweight and obesity during childhood. These studies aim to correct eating habits and increase physical activity through various interventions with focus on the environment, diet and physical activity (46-50).

The Toy-box is a study with purpose to promote a healthy lifestyle in order to prevent overweight and obesity. This is a European study with researchers from ten different countries. The focus areas of the study are: One) environmental changes in classrooms at preschool, two) the schoolchildren should implement the changes in preschool, which involves increased water consumption, healthy snacks, increased physical activity and decreased sedentary time, three) fun activities in classrooms, which involves the whole class, four) involvement of parents to implement the above lifestyle behaviours in their home (47). Multiple sub-studies are analysing if the goals of the Toy-box study are being obtained (51-53). Pinket et al (52) are analysing if the Toy-box intervention is having an effect on intake of water and consumption of beverage in European preschool children. The results are showing no effect in the water intake, implemented only in preschool. However, in children with high implementation scores at preschool (mean diff: +58ml, $p<0.001$) and with parents (mean diff: +61ml, $p<0.001$), significant relationship between these and increased water consumption are shown. Thus, parents who are actively involved in the intervention is showing a better outcome than for those where parents are not (52). Studies is also evaluating the effect of the Toy-box study's intervention on four to six-year olds physical activity level. This shows an increase in vigorous physical activity and moderate to vigorous physical activity, both after school hours (53). Overall, the Toy-box study is not showing any significant difference in overweight and obesity from baseline to follow-up (14.3% vs. 13.9%, $p=0.892$) (54).

Identification and prevention of dietary- and lifestyle- induced health effects in children and infants (IDEFICS) is another longitudinal European study, with the primary focus to increase the knowledge of health effects with changed diet, lifestyle and social environment in preschool- and school children. The secondary purpose is to develop, implement and evaluate a preventive study to reduce the presence of diet- and life related diseases with focus on childhood obesity. The intervention has six main areas: one) increased water intake, two) increased fruit- and vegetables intake, three) decreased tv viewing, four) increased physical activity, five) sleep duration, six) strengthened relationship between parents and children (55). With focus on quality of diet in school, children are reporting a significant lower tendency of sugar intake when the whole family are included ($p<0,01$). Overall, the IDEFICS study is not showing distinct decrease in overweight and obesity among the participants. Verbestel et al (56) mentions that on a family level, more direct strategies for reaching out to parents are needed (56).

A successful municipality-based program is Ensemble Prévenons I'Obésité des Enfants' (EPODE, together let's prevent childhood obesity). This is aiming to decrease childhood obesity through a societal process where local environments, children- and family norms are directed and incurrent to facilitate the introduction of a healthy lifestyle in children from birth to twelve years of age. The program promotes involvement by multiple stakeholders on a central (ministries, health groups, non-governmental organizations and private partners) and local (political leaders, health professionals, families, teachers and local business) level. EPODE resulted in a decrease of 9.12% in the prevalence of overweight and obese children in Northern France (Fleurbaix and Laventie) from the year of 2005 to 2009 ($p=0.0001$) (57).

The overcoming obesity program in Seinäjoki Finland is another successful prevention program, which has achieved international attention. The aim is to decrease the prevalence of children and adolescents with a risk of overweight in adulthood. The prevention program is based on cooperation throughout the whole town including municipality, authorities, families and social- and health services. The program includes different actions as environmental promotion and encouragement of physical activity, availability of healthy dietary choices, access to lifestyle guidance and health control, diet and physical activity guidelines. Additional actions include that health promotion is included in education at schools and health centres and the last one is that families and communities participates in the program. The study is showing a decrease of overweight and obesity from 17% in 2009 to 7% in 2015 in five-year olds. Also, a decrease of 8% is presented in fifth graders from 2011 to 2015 (50).

Norway has recently signed up to WHO: s goal to reduce premature death by non-communicable diseases as overweight and obesity with 25% before the year of 2025. The government describes that it will be demanding to reach that kind of goal and therefore a combination of new thinking and current working methods needs to be applied (58). In Norway, specific guidelines are being used to prevent overweight and obesity. Primary and secondary prevention of overweight and obesity are performed on two levels; universal and individual prevention. Universal prevention refers to action in the population were family, kindergarten, school and health clinics are important arenas. The primary focus for prevention in kindergarten is good nutrition- and physical activity habits for all children (12). The family is the most important resource for the child. They can for example receive guidance from health centre and school health services to improve parent's knowledge within dietary and physical activity. Kindergartens are being recommended to focus on outdoor activities as walks and games in the woods (59). The school can prevent overweight and obesity by contributing with healthy meals and daily physical activities. They should also provide education within healthy living habits (12). In Norway, this is implemented in multiple cities which is presenting positive results on the increase of physical activity level (60).

The schoolyard is also important for prevention of overweight and obesity. This can be due to the high number of 2000 hours that a child is spending at the schoolyard, in total during primary school (61). The responsibility for healthy schoolyards is the owners of the schools such as municipalities and the counties. Examples on actions in Norway are street basket, volleyball court, ball wall, climbing wall and open gymnastic halls at lunchbreak (12). A national goal is that children should be able to go or walk safely back and forth to school. Therefore, the directorate of public roads in Norway is developing a proposal of solutions on safe school roads (62).

Individual prevention refers to prenatal clinics, child health centres, school health services, general practitioner. All pregnant woman receives general recommendations regarding dietary and physical activity, during and after pregnancy, from midwives at prenatal clinics. At the health clinics, the children are being followed up by a nurse through measurement of height and weight. Parents should also get recommendations concerning diet, physical activity and if necessary, actions for prevention of overweight. The school health services should give advice concerning diet and physical activity in school. These services can affect children and parents dietary and activity habits. They can also affect the type of food that is being served at and around the school. If a child comes to the doctor's clinic and shows indications on

overweight, the general practitioner should bring up the topic overweight and give advice and follow up (12).

When a child already is in the overweight or obesity category, it is important to treat this in time in order stabilize and limit an increase in weight. At this stage, families should get guidance and conversations. This can for example be about the child's current physical activity habits and recommendations for increased physical activity. These should be adapted for the specific child but can include reduction in sedentary activities as decreased screen time. Advice how to increase physical activity can for instance include walking or biking to kindergarten or school, have solid family activities and adapt activities to the season. Also, guidance about current diet habits and recommendations about good diets is done. Regarding diet, children are recommended to eat regular meals, reduce portion sizes, reduce intake of sugar and fat and increase intake of fruit and vegetables. The primary focus should be healthy eating habits and not restrictive diets. Beyond these recommendations, health staff is offering families guidance and conversations about overweight and obesity, since it can be a vulnerable and hard theme for most people. Conversations can include feelings, thoughts, experience about overweight and obesity and expectations. Parents can be scared to talk about overweight and obesity with their child, so health staff should also support parents with this. Health stuff should also assist the family to set realistic goals and to find motivation for life changes (12).

The prevalence of childhood overweight and obesity has reached a plateau in high income countries (3, 63), in spite of highly prioritized prevention initiatives. Multiple barriers can contribute to the non-decrease of overweight and obesity. Policies and societal preventative actions involve change in lifestyle through behavioural change at both an individual- and societal level. Barriers leading to difficulties of change are multiple (64). For example, the highly use of technology which contributes to a sedentary lifestyle. This can be difficult for policy to affect alone (65). Also, a higher stress level due to a competitive society, which may result in excessive eating, can lead to a plateau in overweight and obesity, (66). Other reasons can be the food industries, who aims to maximize profit which includes larger portions and normalization of sweets, fast food and snacks (67). These barriers show that to in order to control the development of overweight and obesity, the responsibility lies in each individual (64).

In Norway, evaluation is being made of how well the national guidelines for prevention and treatment of overweight and obesity in children and adolescents are implemented. Also,

examination on how public health nurses are perceiving the implementations are being analysed. Some determinants are affecting the implementation, which are competence, internal consensus, receptiveness among children and families, interdisciplinary collaboration, organizational embedding and resources. One determinant that stand out is the receptiveness among children and families. Many families are non-receptive to understand the need for change which led to a negative effect on the implementation from the public health nurses (68).

In conclusion, the preventive interventions are showing both positive and negative results (35, 51-53, 55-57). Norway is having guidelines for preventative actions (12), but these can be obstructed by the modern society (64-67) and negative implementation of the guidelines in practice (68) .

### *1.2.7 Tracking*

When evaluating the development of overweight and obesity, tracking analyses can add information. This approach can detect and evaluate children's risk for overweight or obesity (12). Multiple studies on tracking are published (15, 16, 69, 70). In the Child growth study, important weight development periods are made on eight-year olds. This study indicates that overweight or obesity at the age of eight are associated with a higher mean BMI through infancy and childhood. From the age of two to eight, a rapid increase in mean BMI SDS occur, both in overweight and obesity. This study is also showing an odds ratio (OR) of 5.80 in two-year olds and 63.80 in four-year olds per one z-score increase for overweight at the age of eight. Another result from this study indicates that having a high BMI at the age of six years results in a very high association with being overweight or obese at the age of 8 years (OR= >100, 95% CI=90.99->100) (16).

In northern Norway, association between adolescent and previous ages is also being analysed. When being overweight or obese in the age group two to four, the chance to become overweight or obese at the age of eight is 52.50%. Further, this study is showing that the chance for being overweight or obese in adolescent is 17.60% if thin or normal weight at one to four-year olds. Also, if thin or normal weight at the age group five to seven, a proportion of 13.30% of these are overweight or obese in adolescence (15).

Geserick et al (70) is showing the acceleration of BMI in childhood and the risk for sustained obesity. Their results are indicating that almost 90% of children with obesity at three years of age are overweight or obese in adolescence. Also, among adolescents with obesity, at the age

of five 46% are normal weight, 22% are overweight and 31% are obese at the age of five (70). Another study from Iceland is showing that between the ages six and 15 years, twice as many are becoming overweight or obese than are moving out of that category (71).

In conclusion, some studies are made in Norway with the aim to analyse the association of overweight and obesity in an early stage of life and later in life (15, 16). These results vary between the studies and are using different methods to present the results. These different methods may not represent a clear way of prediction of overweight and obesity, which may not fit the current guidelines in Norway where weight categories are based on iso-BMI.

# *2. Method*

This study was a descriptive and analytic retrospective registry study.

## *2.1 Data collection*

For this study, data was collected from the database HsPro in Trondheim which includes data obtained routinely at health care stations and school health services in Norway. Age, gender, height, weight, year of birth, date of birth and registered date were registered on children from 2003 to 2018. Routinely measurements were made multiple times before the age of two and then from 2 to 15 years of age. The yearly number of children born were around 2 200 and about 80% met up on the health care stations and school health services. This collection resulted in 23 844 participants.

Of these 23 844 participants, a selection was made be able to analyse the development of prevalence and compare multiple ages to each other. Data needed to be longitudinal, and a decision was made to only include those with three complete observations. To make sure most of the participants and multiple ages were included, different combinations between the ages 2 and 15 were tested. The selection led to a study sample of 7 643 participants with three observations at the ages two, four and eight years. Out of the 7 643 participants included, 3 727 (48.76%) were girls and 3 916 (51.24%) were boys. Participants were excluded if they did not have measures at all ages two, four, and eight years (figure 2).

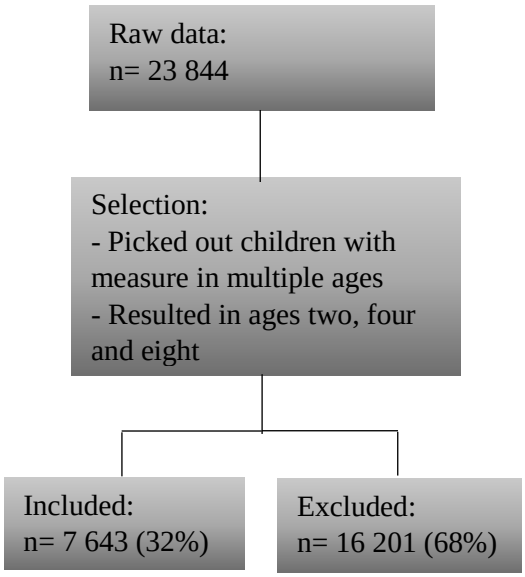


*Figure 2 Flow chart of data selection.*

## *2.2 Procedure and statistical analysis*

The prevalence in each weight category (normal weight, overweight, obesity grade I and II), before and after selection, was compared to each other. This showed hardly any difference (table 1).

*Table 1 Prevalence in each iso-BMI category at ages two, four, and eight years, girls and boys combined*

| **Age (years)** | **Selection** | **Normal weight %** *(n)* | **Overweight %** *(n)* | **Obesity I %** *(n)* | **Obesity II %** *(n)* |
|---|---|---|---|---|---|
| **2** | Before[a] | **87.91** *(17 461)* | **10.54** *(2 094)* | **1.26** *(250)* | **0.29** *(58)* |
| | After[b] | **88.60** *(6 772)* | **10.02** *(766)* | **1.18** *(90)* | **0.20** *(15)* |
| **4** | Before[a] | **90.08** *(19 519)* | **8.51** *(1 844)* | **1.02** *(220)* | **0.40** *(86)* |
| | After[b] | **90.17** *(6 892)* | **8.39** *(641)* | **1.03** *(79)* | **0.41** *(31)* |
| **8** | Before[a] | **84.02** *(8 776)* | **12.67** *(1 323)* | **2.67** *(279)* | **0.64** *(67)* |
| | After[b] | **84.18** *(6 434)* | **12.67** *(968)* | **2.62** *(200)* | **0.54** *(41)* |

[a] Before selection. All participants with normal weight, overweight, obesity grade I and obesity grade II.

[b] After selection. Those who have measure at two, four and eight years of age.

To answer the research question of whether the prevalence of overweight and obesity in children at two, four and eight years of age have changed in a Norwegian urban municipality (first research question), the number and proportions of persons in each weight category were

estimated. The variables used here were age and iso-BMI. Also, a comparison of the prevalence between the ages two and four, two and eight, four and eight was done, tested using the statistical test Pearson's chi-squared, to see whether significant difference occurred. Mean in BMI z-score in overweight participants at the ages two, four and eight was also analysed to see at what age the highest mean occurred.

The sub research question of whether there was any gender difference in the prevalence, was answered by separation of gender at the ages two, four and eight in each weight category. The variables used were iso-BMI, age and gender. This was tested using Pearson's chi-squared test on each weight category. Also, gender difference based on mean in BMI z-score was analysed with independent t-test. The second sub research question, of whether there was a change between those born in different years, was answered using the variables iso-BMI, age and year of birth (2003-2010). The prevalence at each year of birth and the ages two, four and eight based on the weight categories were analysed through Pearson's chi-squared test.

First, descriptive statistics was used to evaluate the prediction of being overweight or obese at the age of eight (second research question). Then prediction of the chance for overweight or obesity at eight years of age from the ages of two and four years according to weight categories was done. First, logistic regression was done using the categorical variables normal weight (as 0) and overweight and obesity grade I and II (as 1). The independent variables used were BMI z-score, the weight categories (normal weight, overweight, obesity grade I and II), the ages two and four and gender.

Different models based on the independent variables were tested to evaluate what model that best could predict overweight and obesity at eight-years of age. This model test was done using An Akaike information criterion (AIC), which is a test to estimate the chance of a model to predict future values. The lowest AIC indicates a better fit (72). The first model involved BMI z-score and was tested against the outcome using logistic regression followed by a test for best prediction: An Akaike information criterion (AIC). Using BMI-z score showed an AIC of 6 012. The second model included four categories with normal weight at both the ages two and four (N2N4), normal weight at two and overweight or obese at four (N2O4), overweight or obese at two and normal weight at four (O2N4) and the last category included overweight or obesity at both the ages two and four (O2O4). This was also tested against the outcome using logistic regression followed by AIC test, which showed an AIC of 5 692. The third model included 4 categories with normal weight or overweight at both the ages two and four (NO2NO4), normal weight or overweight at two and obese grade I and II at

four (NO2OB4), obese grade I and II at two and normal weight or overweight at four (OB2NO4) and the last category included obesity grade I and II at both the ages two and four (OB2OB4). The same was done here with logistic regression followed by AIC test and showed an ACI of 6 302. Therefore, the second model was the best model for prediction of overweight or obesity at the age of eight and was further used to analyse if the outcome could be predicted from this model. After, a predicted value was calculated to percent points using margins. Gender was used to evaluate if the prediction was affected by this, also using margins.

Later, a second primary outcome of obesity grade I and II at the age of 8 was analysed. The exact same model testing was done here as above. For the first model, an ACI of 1 967 was shown. The second model showed an ACI of 1 887 and the third model an ACI of 1 879. This resulted in model three as the better one, since it showed the lowest ACI value. Therefore, this was used to analyse if this outcome could be predicted from this model. After, percent points were calculated for the predicted value using margins. Gender was then used to examine if this prediction was affected by this, also using margins.

## *2.3 Ethics*

The participants in the study were anonymous for the writer and the final publicity. The data from the participants was analysed on an individual level and the participants had an identification number, which could not be linked to individual participants by the writer.

The collection of the data on all the participants has been approved by Regional committees for medical and health research ethics (REC) (appendix 2).

# *3. Results*

Out of 7 643 participants included, 3 727 (48.76%) were girls and 3 916 (51.24%) were boys. The mean height and weight were slightly higher in boys compared to girls at all ages. The same was found when analysing the mean BMI but with a higher amount in girls than boys at the age of eight. Mean z-score was slightly higher in boys than girls at two years of age and lower at the ages four and eight (table 2).

*Table 2 Descriptive characteristics of the study sample at the ages two, four and eight years of age*

| Age (years) | Gender | Height (cm) Mean (SD) | Weight (kg) Mean (SD) | BMI (kg/m$^2$) Mean (SD) | Z-score Mean (SD) |
|---|---|---|---|---|---|
| **2** | Girls | 89.75 (3.61) | 13.28 (1.57) | 16.46 (1.35) | 0.15 (1.00) |
| | Boys | 90.96 (3.57) | 13.86 (1.57) | 16.72 (1.30) | 0.16 (0.96) |
| **4** | Girls | 104.88 (4.12) | 17.41 (2.16) | 15.79 (1.32) | 0.15 (0.94) |
| | Boys | 105.79 (4.17) | 17.42 (2.16) | 15.88 (1.24) | 0.09 (0.94) |
| **8** | Girls | 132.46 (5.78) | 29.42 (5.34) | 16.68 (2.25) | 0.38 (0.99) |
| | Boys | 133.62 (5.74) | 29.42 (5.34) | 16.55 (2.11) | 0.28 (0.94) |

SD, standard deviation.

## *3.1 Prevalence of overweight and obesity*

The majority of the children, boys and girls combined, were categorized as normal weight at all ages (>84.02%). Boys and girls combined, the prevalence of overweight slightly decreased between the ages two and four. Between the ages two and eight, the prevalence of overweight increased again. Also, the prevalence of obesity grade I, boys and girls combined, slightly decreased between the ages two and four, while it more than doubled between the ages two and eight and between four and eight. A similar pattern, girls and boys combined, was seen in obesity grade II between ages two and four where the prevalence doubled and between the ages two and eight where the prevalence almost tripled. Between the ages four and eight, the prevalence of obesity grade II increased with 0.13% (table 1).

Girls and boys combined, a significant decrease (p=0.000) in the prevalence of overweight between the ages two and four was shown. The prevalence of overweight increased significantly (p=0.000) between the ages four and eight. The prevalence of obesity grade I showed a significant decrease between the ages two and four (p=0.000), but an increase between the ages two and eight (p=0.000) and 4 and 8 (p=0.000). The same significant results were shown in the prevalence of obesity grade II.

The highest mean BMI-z-score in those with overweight was presented in eight-year olds (mean= 1.88, 95% CI= 1.24, 3.64). In two-year olds a mean in BMI z-score of 1.78 (95% CI=1.24, 4.29) was presented and in four-year olds a mean in BMI z-score of 1.77 (95% CI= 1.25, 4.23) was presented.

These results implied that from the ages two and four to the age of eight the prevalence of overweight, obesity grade I and II increases, girls and boys combined. Also, at the age of eight, the highest mean in BMI z-score was presented.

### *3.1.1 Difference between gender*

When separating girls and boys, girls showed a small decrease of the prevalence in overweight from two years of age to four years of age but had increased to eight years of age. Girls with obesity grade I at two years of age and four years of age had almost tripled at eight years of age. Obesity grade II showed a stable increase in the prevalence at all ages in girls. In boys, also a decrease from two years of age to four years of age was shown in overweight, however more pronounced in boys than girls. In boys with obesity grade I, the prevalence decreased from two to four years of age and then had more than doubled from the age of four to the age of eight. The boys on the other hand more than tripled from the age of two to four and between the ages two and eight the prevalence increased by more than fourfold (table 3).

No significant difference occurred between gender at age two, but at age four and eight a significant difference was presented (table 3). In both genders, significant increase was presented in the weight categories obesity grade I and II when comparing the ages two and four, four and eight (p=0.000). No significant difference between the ages two and eight years (p=0.077) was shown in the weight category obesity grade I in girls.

When combining overweight and obesity grade I and II in girls, a prevalence of 12.02% at two years of age, 11.56% at four years of age and 18.11% at eight years of age was presented. In boys the prevalence in overweight and obesity was 10.80% at the age of two, 8.17% at four years of age and 13.64% at eight years of age. No significant gender difference (p=0.0941) was shown at the age of two years in prevalence. Although, a significant higher prevalence was presented in girls compared to boys at the age of four and eight years (p=0.0000).

No gender difference was presented between girls and boys at the age of two in mean z-scores in overweight and obesity combined with a mean difference of 0.03 (95% CI: -0.02-0.09, p=0.2627). Similar results were seen in eight-year olds with a mean difference of 0.04 (95% CI: -0.02-0.09, p=0.1775). A gender difference was shown at the age of four in overweight and obesity combined with a mean difference of 0.16 higher in boys than girls (95% CI: 0.09-0.23, p=0.000).

These results implied that girls had a higher prevalence of overweight than boys. On the other hand, the results showed that boys have a higher prevalence of obesity than girls.

*Table 3 Prevalence in each weight category in girls and boys at ages 2, 4, and 8 years*

| **Age (years)** | **Gender** | **Normal weight % *(n)*** | **Overweight % *(n)*** | **Obesity I % *(n)*** | **Obesity II % *(n)*** | **P-value[a, b, c]** |
|---|---|---|---|---|---|---|
| **2** | Girls | **87.98** *(3 279)* | **10.76** *(401)* | **1.02** *(38)* | **0.24** *(9)* | **0.087** |
| | Boys | **89.20** *(3 493)* | **9.32** *(365)* | **1.33** *(52)* | **0.15** *(6)* | |
| **4** | Girls | **88.44** *(3 296)* | **10.17** *(379)* | **1.07** *(40)* | **0.32** *(12)* | **0.000** |
| | Boys | **91.83** *(3 596)* | **6.69** *(262)* | **1.00** *(39)* | **0.49** *(19)* | |
| **8** | Girls | **81.89** *(3 052)* | **14.70** *(548)* | **2.95** *(110)* | **0.46** *(17)* | **0.000** |
| | Boys | **86.35** *(3 382)* | **10.73** *(420)* | **2.30** *(90)* | **0.61** *(24)* | |

[a] Gender difference in the weight categories normal weight, overweight, obesity I and obesity II.

[b] Pearson's chi-squared test was used to compare gender in each weight category.

[c] Statistically significant at $p<0.05$.

### *3.1.2 Difference between year of birth*

There was a stable number of children in the different weight categories when dividing them between their year of birth (2003 to 2010) No significant difference was presented between the participants year of birth based on weight categories at all the ages two ($p=0.642$), four ($p=0.500$) and eight ($p=0.797$). Figure 3 shows the development of the prevalence of each weight category from 2003 to 2010 at the ages two, four and eight. See also appendix 3 for a more thorough picture of the development.

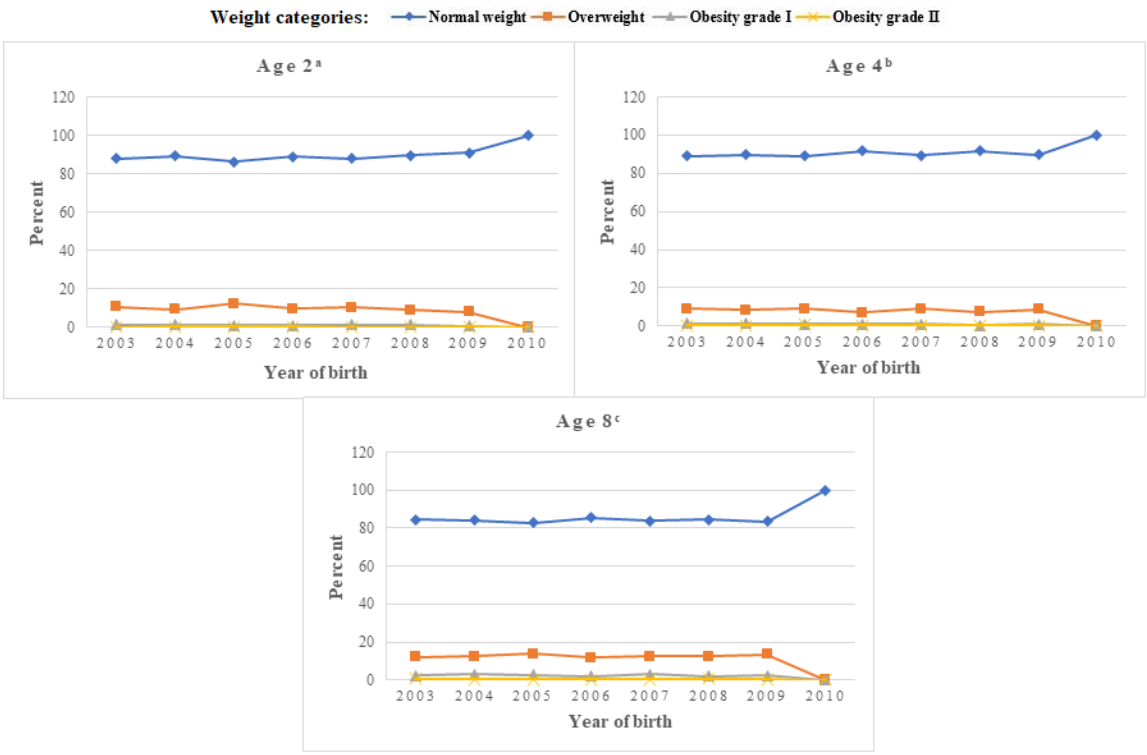


*Figure 3 Development of weight categories at the ages 2, 4 and 8 between 2003 and 2010*

[a] Percent of normal weight, overweight, obesity grade I and II in 2-year olds

[b] Percent of normal weight, overweight, obesity grade I and II in 4-year olds

[c] Percent of normal weight, overweight, obesity grade I and II in 8-year olds

## *3.2 Prediction of overweight or obesity at eight-years of age based on weight status at two and four years*

Just a small amount of 10% from the group normal weight at both the ages two and four (N2N4) became overweight or obese at the age of eight. Out of 329 who were normal weight at two and overweight or obesity at four (N2O4), the chance for overweight or obesity at the age of eight was 61%. Similar was presented when overweight or obesity at both the ages two and four (O2O4). A quarter with overweight or obesity at the age of two and normal weight at the age of four (O2N4) became overweight or obese at eight years of age (appendix 4).

The OR for being overweight or obese at eight-years of age was 13.80 for those with O2O4 compared to being N2N4. The risk was partially the same for those with N2O4, with OR of 14.37. However, for those with O2N4, the OR was only 2.93 compared to those with N2N4.

When comparing the weight groups to N2N4, the highest differences were in N2O4 and O2O4 with 51% and 50% respectively. A smaller marginal difference was shown between the group O2N4 compared to N2N4. Separating girls and boys, girls showed a higher average marginal compared to boys (table 4).

In conclusion, being overweight or obese at four presented a high chance for overweight or obesity at the age of eight.

*Table 4 Average marginal effects for overweight or obesity at eight years of age in each iso-BMI category and age group. All participants and separated by gender*

| **Outcome: Overweight or obese at 8-years of age** | **Average marginal effects (95% CI)** | **S.e.** | **z** | **P-value[a, b]** |
|---|---|---|---|---|
| **Difference** | | | | |
| **N2O4 vs. N2N4** | 0.51 (0.46, 0.57) | 0.03 | 18.98 | 0.000 |
| **O2N4 vs. N2N4** | 0.15 (0.10, 0.19) | 0.02 | 7.04 | 0.000 |
| **O2O4 vs. N2N4** | 0.50 (0.46, 0.55) | 0.02 | 10.94 | 0.000 |
| **Girls** | | | | |
| **N2O4 vs. N2N4** | 0.56 (0.49, 0.63) | 0.03 | 16.11 | 0.000 |
| **O2N4 vs. N2N4** | 0.12 (0.07, 0.18) | 0.03 | 4.11 | 0.000 |
| **O2O4 vs. N2N4** | 0.55 (0.49, 0.61) | 0.03 | 17.72 | 0.000 |
| **Boys** | | | | |
| **N2O4 vs. N2N4** | 0.45 (0.37, 0.53) | 0.04 | 10.63 | 0.000 |
| **O2N4 vs. N2N4** | 0.16 (0.11, 0.22) | 0.03 | 5.80 | 0.000 |
| **O2O4 vs. N2N4** | 0.44 (0.37, 0.52) | 0.04 | 11.72 | 0.000 |

CI, confidence interval, S.e, standard error.

N2N4 = Normal weight at 2 years of age and normal weight at 4 years of age.

N2O4 = Normal weight at 2 years of age and overweight or obese at 4 years of age.

O2N4 = Overweight or obese at 2 years of age and normal weight at 4 years of age.

O2O4 = Overweight or obese at 2 years of age and overweight or obese at 4 years of age.

[a] Margins was used for significance test.

[b] Statistically significance ($p<0.05$).

## *3.3. Prediction of obesity grade I and II at eight-years of age based on weight status at two and four years*

Just a small amount of 2% from the group with normal weight or overweight at both the ages two and four (NO2NO4) became obese at the age of eight. Just 4% with obesity grade I or II at the age of two and normal weight or overweight at the age of four (OB2NO4) became overweight or obese at eight years of age. Out of 33 who were normal weight or overweight at

the age of two and obesity grade I or II at the age of four (NO2OB4), the chance for obesity grade I or II at the age of eight was 58%. Slightly smaller amount was presented if obesity grade I or II (OB2OB4) with 53% (appendix 5).

The chance of obesity grade I or II at the age of 8 was 55% higher if a child was in the group NO2OB4 compared to NO2NO4. If in the group OB2OB4 compared to the group NO2NO4, the chance for obesity grade I and II at the age of was 51%. No significant difference was presented between the groups OB2NO4 and NO2NO4. The same pattern was shown when gender was separated. However, boys had a larger average marginal effect than girls in the groups NO2OB4 and OB2OB4 (table 5).

These results implied normal weight or overweight at the age of two and obese at the age of four and obese at both the ages two and four to be the highest chance for obesity at the age of eight. Boys was showing the highest chance for obesity at the age of eight based on weight categories and the ages two and four.

*Table 5 Average marginal effects of obesity grade I and II, with comparison of weight categories overall, and for girls and boys separately*

| **Outcome: Obese I or II at 8-years of age** | **Average marginal effects (95% CI)** | **Std. err.** | **z** | **P-value[a, b]** |
|---|---|---|---|---|
| **Group comparison** | | | | |
| **NO2OB4 vs. NO2NO4** | 0.55 (0.44, 0.66) | 0.06 | 9.89 | 0.000 |
| **OB2NO4 vs. NO2NO4** | 0.02 (-0.03, 0.06) | 0.02 | 0.75 | 0.453 |
| **OB2OB4 vs. NO2NO4** | 0.51 (0.34, 0.68) | 0.08 | 5.75 | 0.000 |
| | | | | |
| **Girls** | | | | |
| **NO2OB4 vs. NO2NO4** | 0.54 (0.38, 0.69) | 0.08 | 6.76 | 0.000 |
| **OB2NO4 vs. NO2NO4** | 0.03 (-0.05, 0.11) | 0.04 | 0.80 | 0.426 |
| **OB2OB4 vs. NO2NO4** | 0.44 (0.16, 0.71) | 0.14 | 3.14 | 0.000 |
| | | | | |
| **Boys** | | | | |
| **NO2OB4 vs. NO2NO4** | 0.57 (0.42, 0.72) | 0.08 | 7.22 | 0.000 |
| **OB2NO4 vs. NO2NO4** | 0.01 (-0.05, 0.06) | 0.03 | 0.19 | 0.845 |
| **OB2OB4 vs. NO2NO4** | 0.56 (0.33, 0.78) | 0.11 | 4.93 | 0.000 |

CI, confidence interval, S.e, standard error.

NO2NO4= Normal- or overweight at 2- and 4 years of age

NO2OB4= Normal- or overweight at 2 years of age and obese grade I or II at 4 years of age

ON2NO4= Obese grade I or II at 2 years of age and normal- or overweight at 4 years of age

OB2OB4= Obese grade I or II at 2- and 4 years of age

[a] Margins was used for significance test.

[b] Statistically significance ($p<0.05$).

# *4. Discussion*

## *4.1 Results discussion*

The main findings in this population-based longitudinal registry study was that when being overweight or obese at the age of four, the chance for being overweight or obese at the age of eight was high. However, overweight or obesity at the age of two, even with normal weight at four also increased the risk for overweight or obesity at eight years of age. Most of the children with overweight or obesity at eight years of age were normal weight at the ages two and four. A gender difference was shown with a higher proportion of overweight in girls compared to boys. However, in obesity grade I and II, boys presented the highest proportions.

In the current study, results concerning prevalence and gender difference corresponded to the Child growth study. The Child growth study showed similar prevalence of overweight and obesity of 16.7% in girls and 13.3% in boys at eight years of age (2). The current study presented a slightly higher prevalence in girls compared to boys, which also were shown in the Child growth study (2). Looking at a large city municipality over a longer period, similar results according prevalence of overweight and obesity were presented compared to national data (2) . Based on this, the existing urban-rural gradient in Norway should perhaps be confirmed even more. This is also enhanced by the results from the Bergen growth study, which also are like the national data. These results may indicate that the preventative and treatment actions probably are important both in urban and rural municipalities.

When separating girls and boys, the prevalence of overweight in both genders increased almost the same amount of percent points from the age of four to the age of eight. However, the girls had a higher prevalence of overweight through all the ages compared to boys. It is a common pattern in multiple studies that girls presents a higher prevalence in overweight than boys (2, 15, 25). Also, in obesity grade I, a higher proportion was presented in girls than boys. In girls, obesity grade I more than tripled from the age of four to the age of eight. In boys, the proportion of obesity grade I more than doubled between the ages four and eight. The Bergen growth study does not present this high amount of increase in proportion in girls, but in boys the results more than doubled (25). These differences could be due to that the current study separated obesity grade I and II, which the Bergen growth study did not.

The prevalence of obesity grade II in boys presented a higher increase according to age as the prevalence of obesity grade II increased fourfold from the age of two to eight in contrast to girls where the accordingly increase almost doubled. Evensen el al. (15) found different

results which showed that from the age group two to four to the age group five to seven years, boys more than doubled in the prevalence of obesity. In girls the prevalence of obesity more than tripled (15). Additional difference between the current study and Evensen et al. is the gender difference. The current study presented a difference between gender in obesity grade II. Evensen et al. on the other hand did not found any gender difference. These differences between the current study and Evensen et al. can differ because in the current data set, obesity grade I and II were not combined. Evensen et al. on the other hand combined obesity grade I and II.

The current study and the Child growth study both presented high OR using BMI z-score (16). The studies were most likely similar, so even if a difference between these two results could not be excluded, both presented a very high risk for overweight or obesity at the age of eight. If a difference existed, it could depend on the urban-rural gradient, because the current study included urban areas while the Child growth study included both urban and rural areas.

In Norway, guidelines for prevention, investigation and treatment for children and adolescents have been developed on a national level. These guidelines presented different levels of interventions based on iso-BMI. The first level refers to primary prevention of children with iso-BMI lower than 25. The aim here was to emphasize preventive work from toddler age in order to avoid development of overweight (12). In the current study, more than 84% in the dataset were normal weight at all ages. A proportion of 10% became overweight or obese at an older age if they were categorized as normal weight at younger ages. Approximately the same results were seen in other studies. In northern Norway, a study showed that a proportion of 17.6% with thinness or normal weight at two to four-years of age became overweight or obese at 15 to 17 years of age (15). Geserick et al. (70) examined a population-based sample to determine at which age children were vulnerable to weight gain. The study showed that out of the adolescents with obesity, 46% of them were normal weight at the age of five (70). Additional result in a study from Iceland, showed that between the ages 6 and 15 years, twice as many became overweight or obese than moved out of that category (71). In summary, all these results, including the current study, showed that more than double-digit went from being normal weight at younger ages to overweight or obese at later ages. This may indicate that the primary preventative work should be continued but with an increase in the intensity.

Further results which may indicate that an even larger effort in the preventative work should be applied, are the results according the participants year of birth. These results showed no difference in the development from 2003 to 2010 in the different weight categories normal

weight, overweight, obesity grade I and II at all the ages two, four and eight. This result can be interpreted as the prevalence has not changed during these time intervals, even if a large preventative effort is prioritized.

Results from the current study showed a high proportion of overweight and obesity combined in eight-year-old girls and boys with a proportion of 18.1% and 13.6% respectively. Hovengen et al. (2) points out that on a national level in Norway, the prevalence of overweight and obesity has started to level off in eight- to nine-year olds, but a proportion of 16.7% in girls and 13.3% in boys is still too high (2). In the current study, the prevalence of overweight and obesity were even a bit higher than the proportions in the Child growth study and the efforts in the preventative work need to improve. The results of high prevalence in the current study may partly be explained by a study looking at how well Norway's guidelines for preventive work is implemented at health services. This study showed that families were non-receptive to understand the need for change which led to negative affect on the implementation of the guidelines from the health staff (68).

The chance for obesity grade I and II at the age of eight was 58% if normal weight or overweight at the age of two and obese at the age of four. Slightly smaller results were shown of 53% if obese at both the ages two and four. A population-based study with 51 505 participants between the ages 0 and 14 and 15 and 18 presented different results. The study showed that among adolescents with obesity, 31% were obese already at the age of five (70). A large difference was shown between these studies, with a higher proportion in the current study. This difference can be due to that the current study used eight-year olds as the outcome, while the other study used adolescents. These results may indicate that the intensity of the secondary preventative work should increase.

The current study presents several more results that indicates that an even larger effort in secondary prevention would be of priority. The results in the current study indicates a large increase in obesity grade II in boys. From the age of two to the age of four, the prevalence of obesity grade II more than tripled in boys. Also, in the current study, results indicated that the age of two were a vulnerable age for overweight or obesity at the age of eight since 25% of the children who normalised their weight between the age of two to four fell back to overweight or obesity at the age of eight. Therefore, the overweight at the age of two should not be underestimated and should be payed attention to at child health care services and school health services. From the perspective of secondary prevention, an even larger contribution would be of importance to decrease these numbers in the future. In order to

success with this prevention, it's important to intervene at an early stage while there is a greater chance of growing out of obesity and acquiring favourable living habits (12).

High risk for overweight and obesity were presented at the age of eight, if overweight or obese both at the ages two and four. The current study corresponds to multiple other studies, both on a national- and international level, which indicates that an early onset of actions in prevention is needed to decrease the amount of childhood- and adulthood overweight and obesity. Also, the current study corresponds to national data according the prevalence of overweight and obesity. The national data included both urban and rural areas while the current study only involved urban areas. Even if urban-rural gradient is presented in Norway, this should perhaps be confirmed even more.

## *4.2 Method discussion*

The data set in the current study was after selection 7 643 participants, which is a large data set. Before the selection, the data set involved 23 844 participants which would perhaps lead to an even smaller standard error than in the current results. The aim of the study was however to follow participants who were measured at multiple ages, so tracking could be performed. Therefore, the selection was done were the ages of two, four and eight were chosen because that resulted in the largest proportion of participants (32%). No difference could be seen before and after selection, which may indicate that the results and conclusions of the study were not affected by this.

In the current study, the ages two, four and eight were included while the ages three, five to seven and 9 to 15 were excluded. Looking at other studies were tracking has been made, more ages were included in the analyses (15, 16, 70). Including several ages in the current study could have provided more information.

In the current study, the prevalence of overweight decreases from two years of age to the age of four, and then increases again at the age of eight. Other studies have also showed similar results with a larger proportion in toddlers and then a decrease at the age around four and five (16, 25, 73). A study from northern Norway presented a similar pattern but with the age groups two to four, five to seven and 15 to 17. These results showed that the prevalence of overweight and obesity were lower in the age group five to seven compared to the age group two to four and then went up again in the age group 15 to 17 years (15). This higher number in toddler ages can be due to measuring error which can lead to bias in the outcome. There can be a struggle to measure toddlers height because they don't stretch out enough or are

moving too much (74). However, overweight or obesity at the age of two showed associations with overweight or obesity at eight years of age, which indicates that the result most likely are correct.

## *4.3 Conclusion*

The results in this urban population-based study indicated that being overweight or obese at four years of age, the chance for overweight or obesity at eight years of age was high. An increased risk for overweight or obesity at the age of eight was also presented if overweight or obese at the age of two, even with normal weight at four. The prevalence of overweight and obesity was comparable with data on a national level. A gender difference was shown with a higher proportion of overweight in girls compared to boys. However, in obesity grade I and II, boys presented the highest proportions.

Further research within this area should focus on involving more ages when tracking overweight and obesity to be able to get a bigger picture of the situation. Also, further research from two years and younger would be relevant to analyse to see if earlier ages can conclude younger ages for intensification of preventive work in urban municipalities. Finally, a further research within the urban-rural gradient in Norway should be performed.

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# *Appendix 1*
## Iso-BMI table

*Table 6 Iso-BMI of overweight, obesity I and II, age and gender specific (11)*

| | Iso-BMI 25 | | Iso-BMI 30 | | Iso-BMI 35 | |
|---|---|---|---|---|---|---|
| Age (years) | Boys | Girls | Boys | Girls | Boys | Girls |
| 2 | 18 | 18 | 20 | 20 | 25 | 25 |
| 2.5 | 18 | 18 | 20 | 20 | 25 | 25 |
| 3 | 18 | 18 | 20 | 19 | 25 | 24 |
| 3.5 | 18 | 17 | 19 | 19 | 24 | 24 |
| 4 | 18 | 17 | 19 | 19 | 24 | 24 |
| 4.5 | 17 | 17 | 19 | 19 | 24 | 24 |
| 5 | 17 | 17 | 19 | 19 | 24 | 24 |
| 5.5 | 17 | 17 | 19 | 19 | 24 | 24 |
| 6 | 18 | 17 | 20 | 20 | 25 | 25 |
| 6.5 | 18 | 18 | 20 | 20 | 25 | 25 |
| 7 | 18 | 18 | 21 | 21 | 26 | 26 |
| 7.5 | 18 | 18 | 21 | 21 | 26 | 26 |
| 8 | 18 | 18 | 22 | 22 | 27 | 27 |
| 8.5 | 19 | 19 | 22 | 22 | 27 | 27 |
| 9 | 19 | 19 | 23 | 23 | 28 | 28 |
| 9.5 | 19 | 19 | 23 | 24 | 28 | 29 |
| 10 | 20 | 20 | 24 | 24 | 29 | 29 |
| 10.5 | 20 | 20 | 25 | 25 | 30 | 30 |
| 11 | 21 | 21 | 25 | 25 | 30 | 30 |
| 11.5 | 21 | 21 | 26 | 26 | 31 | 31 |
| 12 | 21 | 22 | 26 | 27 | 31 | 32 |
| 12.5 | 22 | 22 | 26 | 27 | 31 | 32 |
| 13 | 22 | 23 | 27 | 28 | 32 | 33 |
| 13.5 | 22 | 23 | 27 | 28 | 32 | 33 |
| 14 | 23 | 23 | 28 | 29 | 33 | 34 |
| 14.5 | 23 | 24 | 28 | 29 | 33 | 34 |
| 15 | 23 | 24 | 28 | 29 | 33 | 34 |
| 15.5 | 24 | 24 | 29 | 29 | 34 | 34 |
| 16 | 24 | 24 | 29 | 29 | 34 | 34 |
| 16.5 | 24 | 25 | 29 | 30 | 34 | 35 |
| 17 | 24 | 25 | 29 | 30 | 34 | 35 |
| 17.5 | 25 | 25 | 30 | 30 | 35 | 35 |
| 18 | 25 | 25 | 30 | 30 | 35 | 35 |

# *Appendix 2*
Approval REC

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

| Region: | Saksbehandler: | Telefon: | Vår dato: | Vår referanse: |
|---|---|---|---|---|
| REK midt | Marit Hovdal Moan | 73597504 | 24.05.2017 | 2017/601/REK midt |
| | | | Deres dato: | Deres referanse: |
| | | | 28.03.2017 | |

Vår referanse må oppgis ved alle henvendelser

Rønnaug Ødegård
St. Olavs Hospital

## 2017/601 Barnefedme og risiko for voksenfedme

**Forskningsansvarlig:** St. Olavs Hospital HF
**Prosjektleder:** Rønnaug Ødegård

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK midt) i møtet 05.05.2017. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

**Prosjektleders prosjektomtale**
Vi ønsker å undersøke hvordan en kohort av barn fordeler seg på fire BMI-kategorier (normal, overvekt, fedme I og II) fra fødsel til 20 år, nærmere bestemt sannsynligheten for å skifte BMI-kategori med økende alder. Herunder betydningen av kjente sosiale faktorer. Sannsynlighet for overgang mellom kategorier vil bli brukt som input til en simuleringsmodell for å predikere nye kohorters utvikling av overvekt og fedme. Simuleringsmodellen gir grunnlag for å undersøke langtidseffekt av ulike forebyggings- og behandlingstiltak. Vi vil bruke helsestasjonsdata for alder opp til 15 år og supplere med overgangssannsynligheter opp til 20 år fra andre kilder. Vi vil bruke ekstrapolerings og valideringsteknikker for å etablere et komplett sett av overgangssannsynligheter, og såkalt Markov-modellering for å konstruere simuleringsmodellen.

**Vurdering**
*Komiteens prosjektbeskrivelse*
Hensikten med prosjektet er å undersøke hvordan en kohort av barn fordeler seg på fire BMI-kategorier (normal, overvekt, fedme I og II) fra fødsel til 20 år, nærmere bestemt sannsynligheten for å skifte BMI-kategori med økende alder. Sannsynlighet for overgang mellom kategorier vil bli brukt som input til en simuleringsmodell for å predikere nye kohorters utvikling av overvekt og fedme. Simuleringsmodellen gir grunnlag for å undersøke langtidseffekt av ulike forebyggings- og behandlingstiltak. Data: helsestasjonsdata (alder, kjønn, høyde og vekt og om barnet bor med en eller begge foreldre) fra et utvalg av urbane kommuner (Trondheim og Bergen hovedsakelig) og mindre kommuner for barn fra 2 til 15 år (eller 13år?) i perioden 2013-2017. Det suppleres med overgangssannsynligheter opp til 20 år fra andre kilder. Det søkes om fritak fra å innhente samtykke.

*Forsvarlighet*

Besøksadresse:
Fakultet for medisin og helsevitenskap Håkon Jarls gate 11, Øya helsehus

Telefon: 73597511
E-post: rek-midt@mh.ntnu.no
Web: http://helseforskning.etikkom.no/

All post og e-post som inngår i saksbehandlingen, bes adressert til REK midt og ikke til enkelte personer

Kindly address all mail and e-mails to the Regional Ethics Committee, REK midt, not to individual staff

Komiteen har vurdert søknad, forskningsprotokoll, målsetting og plan for gjennomføring. Under forutsetning av at vilkårene nedenfor tas til følge, framstår prosjektet som forsvarlig og hensynet til deltakernes velferd og integritet er ivaretatt.

*Dispensasjon fra kravet om å innhente samtykke*
Komiteen finner at vilkårene for å innvilge dispensasjon fra kravet om å innhente samtykke i helseforskningsloven §35, jf. §§ 15 annet ledd og 28 første ledd, er oppfylt. Studien er vurdert å være av vesentlig interesse for samfunnet, og hensynet til deltakernes velferd og integritet er ivaretatt. Komiteen vurderer videre at innhenting av samtykke i dette tilfellet vil være vanskelig, grunnet det store antallet deltakere.

*Meldeplikt til Helsedirektoratet*
Komiteen ber prosjektleder avklare med Helsedirektoratet om prosjektet gjelder klinisk utprøving av medisinsk utstyr og derfor er meldepliktig til Helsedirektoratet.

**Vilkår for godkjenning**

1. Godkjenningen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden og protokollen. Prosjektet må også gjennomføres i henhold til REKs vilkår i saken og de bestemmelser som følger av helseforskningsloven (hfl.) med forskrifter.
2. Dispensasjonen fra taushetsplikt gjelder kun for de opplysningene som er relevante for studien.
3. Enhver publikasjon basert på studien må skje i en slik form at enkeltpersoner ikke kan gjenkjennes.
4. Registerkoblingene i prosjektet kan ikke deles med andre forskergrupper for andre forskningsformål enn det som er beskrevet i dette vedtaksbrevet.
5. Dispensasjonen fra taushetsplikt gjelder i studieperioden for de prosjektmedarbeidere som prosjektleder har delegert nødvendig tilgang til. Av mulige kontrollhensyn innvilges prosjektleder også dispensasjon i fem år etter sluttmelding er sendt REK.
6. Komiteen forutsetter at ingen personidentifiserbare opplysninger kan framkomme ved publisering eller annen offentliggjøring.
7. Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder for «Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og omsorgssektoren». Av kontrollhensyn skal prosjektdata oppbevares i fem år etter sluttmelding er sendt REK. Data skal derfor oppbevares til denne datoen, for deretter å slettes eller anonymiseres, jf. hfl. § 38.
8. Prosjektleder skal sende sluttmelding til REK midt når forskningsprosjektet avsluttes. I sluttmeldingen skal resultatene presenteres på en objektiv og etterrettelig måte, som sikrer at både positive og negative funn fremgår, jf. hfl. § 12.

**Vedtak**
Regional komité for medisinsk og helsefaglig forskningsetikk Midt-Norge godkjenner prosjektet med de vilkår som er gitt.
Komiteens beslutning var enstemmig.

*Sluttmelding og søknad om prosjektendring*
Prosjektleder skal sende sluttmelding til REK midt på eget skjema senest 31.12.2021, jf. hfl. § 12. Prosjektleder skal sende søknad om prosjektendring til REK midt dersom det skal gjøres vesentlige endringer i forhold til de opplysninger som er gitt i søknaden, jf. hfl. § 11.

*Klageadgang*
Du kan klage på komiteens vedtak, jf. forvaltningsloven § 28 flg. Klagen sendes til REK midt. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK midt, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

Sven Erik Gisvold
Dr.med.
Leder, REK midt

Marit Hovdal Moan
seniorrådgiver

**Kopi til:** baard.kulseng@ntnu.no; siv.morkved@stolav.no; personvernombudet@stolav.no

# *Appendix 3*
## 2x8 table of weight categories

*Table 7 A 2x8 table on year of birth in normal weight, overweight, obesity grade I and II in eight-year olds*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **8-year olds** | | |
| **Year of birth** | **Normal weight (%)** | | **Overweight (%)** | | **Obesity grade I (%)** | | **Obesity grade II (%)** | | **Total** |
| **2003** | 760 | (87.86) | 93 | (10.75) | 11 | (1.27) | 1 | (0.12) | 865 |
| **2004** | 1 043 | (89.15) | 109 | (9.32) | 15 | (1.28) | 3 | (0.26) | 1 170 |
| **2005** | 989 | (86.30) | 142 | (12.39) | 12 | (1.05) | 3 | (0.26) | 1 146 |
| **2006** | 1 088 | (89.03) | 119 | (9.74) | 12 | (0.98) | 3 | (0.25) | 1 222 |
| **2007** | 1 071 | (88) | 126 | (10.35) | 18 | (1.48) | 2 | (0.16) | 1 217 |
| **2008** | 1 214 | (89.59) | 123 | (9.08) | 17 | (1.25) | 1 | (0.07) | 1 355 |
| **2009** | 605 | (90.84) | 54 | (8.11) | 5 | (0.75) | 2 | (0.30) | 666 |
| **2010** | 2 | (100) | 0 | (0.00) | 0 | (0.00) | 0 | (0.00) | 2 |
| **Total** | 6 772 | | 766 | | 90 | | 15 | | 7 643 |

Pearson's chi-squared test was used for significance test. P=0.777.

Statistically significance ($p<0.05$).

# *Appendix 4*
## Descriptive data

*Table 8 Predicted value of overweight or obesity at eight years of age*

| | **Numbers in each group n=7 643** | **Overweight or obese at age 8 n=1 209 (%)** |
|---|---|---|
| **N2N4** | 6 443 | 642 (10) |
| **N2O4** | 329 | 202 (61) |
| **O2N4** | 449 | 110 (25) |
| **O2O4** | 422 | 255 (60) |

N2N4 = Normal weight at 2 years of age and normal weight at 4 years of age.

N2O4 = Normal weight at 2 years of age and overweight or obese at 4 years of age.

O2N4 = Overweight or obese at 2 years of age and normal weight at 4 years of age.

O2O4 = Overweight or obese at 2 years of age and overweight or obese at 4 years of age.

# *Appendix 5*

## Descriptive data

*Table 9 Predicted value of obesity grade I and II at eight years of age*

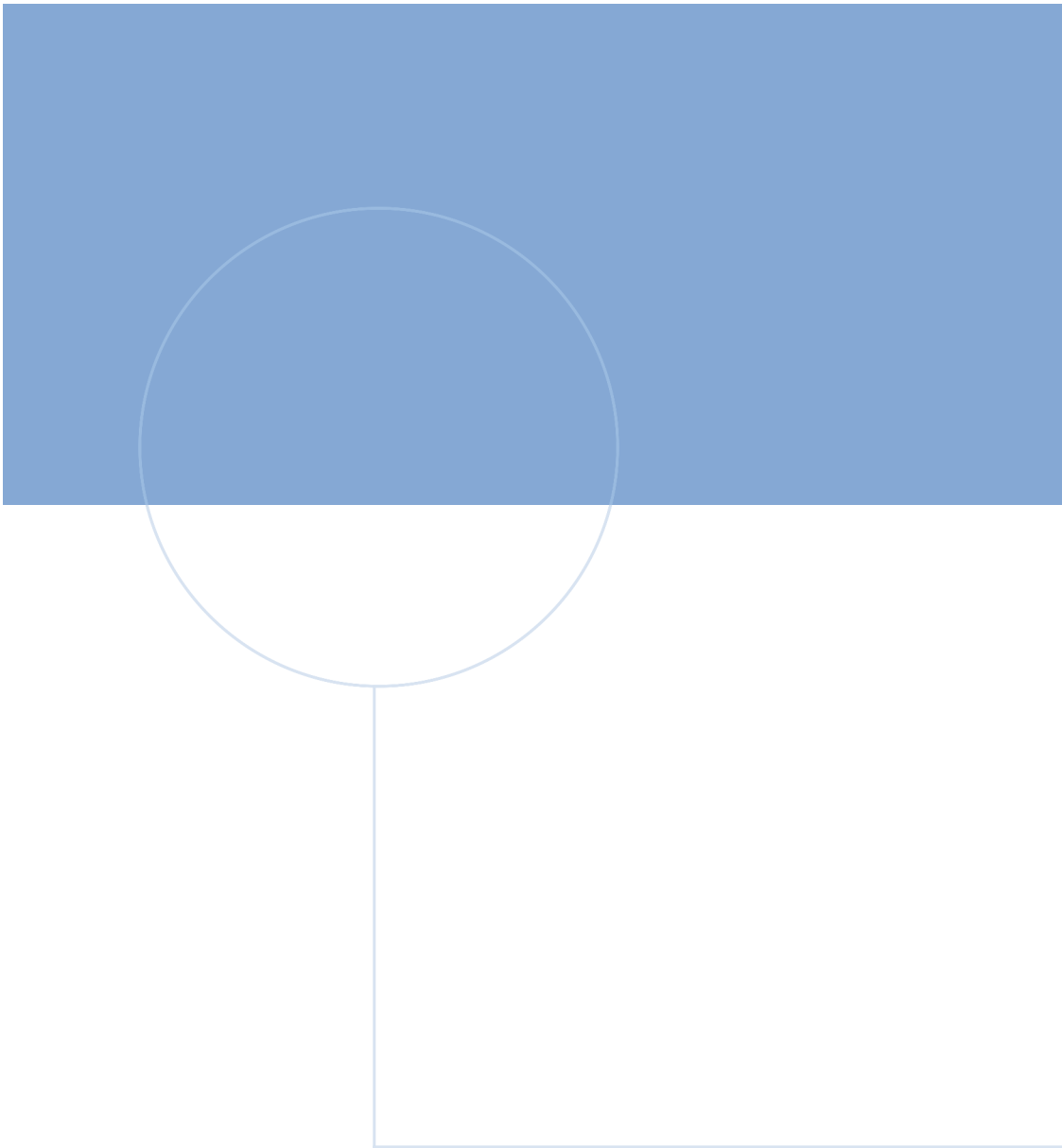
| | **Numbers in each group n=7 643** | **Obesity grade I or II at age 8 n=241 (%)** |
|---|---|---|
| **NO2NO4** | 7 284 | 176 (2) |
| **NO2OB4** | 33 | 45 (58) |
| **OB2NO4** | 70 | 3 (4) |
| **OB2OB4** | 15 | 17 (53) |

NO2NO4= Normal- or overweight at 2- and 4 years of age

NO2OB4= Normal- or overweight at 2 years of age and obese grade I or II at 4 years of age

ON2NO4= Obese grade I or II at 2 years of age and normal- or overweight at 4 years of age

OB2OB4= Obese grade I or II at 2- and 4 years of age



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Kunnskap for en bedre verden