QUALITY OF TYPE 2 DIABETES CARE BY DEMOGRAPHIC FACTORS
AND COMORBIDITIES

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Global burden of type 2 diabetes and comorbidities increases simultaneously. Prevalence of diabetes and comorbidities is especially increasing in elderly people. Comorbidities and its type may impact quality of diabetes care. Quality of diabetes care may be also affected by age and gender. In Finland, about 4.5% people have type 2 diabetes and current care guideline is followed in treatment of diabetes. It is not well documented how comorbidity and demographic factors affect the diabetes care in Finland. We assessed the effect of comorbidities (concordant and discordant), age and gender in achieving the guideline recommended diabetes care.

This is a retrospective cohort study of 10,204 patients who were diagnosed with type 2 diabetes during 2011 and 2012 in North Karelia, Finland. Patients’ information and all laboratory data were collected from the regional electronic patient database. A total of 23 chronic diseases were included and categorized into concordant and discordant diseases using ICD-10 codes. The main outcome measures were the four quality indicators of diabetes care: measurement of HbA1c (Glycated hemoglobin) and LDL (Low-density Lipoprotein) and the level of HbA1c and LDL. Regarding the HbA1c and LDL levels, it was assessed whether they were in recommended level (HbA1c < 7%, LDL < 2.5 mmol/l). Linear and logistic regression analysis were used to examine the associations between achievements in diabetes care and the group of comorbidities, age and gender.

Only 16% of diabetic patients had no comorbidities. 41% of patients had both concordant and discordant diseases. Females had better glycemic control and worse LDL control (OR 1.22 [95% CI 1.10-1.35], OR 0.72 [95%CI 0.65-0.79] consecutively) compared with men. Older patients had their HbA1c measured more likely (OR 1.02 [95% CI 1.02 - 1.03]) but had less likely achieved the HbA1c goal (OR 0.99 [95% CI 0.98 - 0.99]). Patients in comorbid groups had better performance in HbA1c and LDL measurements. HbA1c measurement was best performed in patients with both concordant and discordant diseases (OR 1.98 [95% CI 1.73-2.27]). All patients with comorbidity were more likely to achieve target level of both HbA1c and LDL compared with patients without comorbidities, except, patients with both comorbidities who were more likely not to achieve HbA1c goal (OR 0.83 [95% CI 0.71-0.97]).

This study shows that diabetes patients with comorbidities and older age were more likely to achieve better outcomes of care than young patients with only diabetes. Overall in diabetic patients, the performance in glucose control (HbA1c) was considerably better than the control of LDL. This is obviously an important area to focus in future to prevent complications and the onset of comorbidities.
<table>
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<tr>
<td>ADA</td>
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<td>CAD</td>
<td>Coronary Arterial Diseases</td>
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<td>CHD</td>
<td>Coronary Heart Diseases</td>
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<td>CI</td>
<td>Confidence Interval</td>
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<td>HbA1c</td>
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<td>ICD</td>
<td>International Classification of Diseases</td>
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<td>LDL</td>
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<td>T2DM</td>
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<td>WHO</td>
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1 INTRODUCTION

About 8% of world population has diabetes and 90% of them have type 2 diabetes. It caused 1.5 million deaths in 2012 globally (WHO 2015a). It is expected that the number of diabetic patients would increase by 55% by 2035 and diabetes would be the 7th leading cause of death (International Diabetes Federation 2014a). The epidemic of type 2 diabetes has created a huge burden on health care system in terms of costs and quality (International Diabetes Federation 2014b).

Comorbidities are common among diabetic patients. Comorbidities can be defined as the presence of additional one or more diseases in relation to index disease, such as type 2 diabetes (Valderas et al. 2009). Comorbidities can be categorized as “related with diabetes” known as concordant, for example, cardiovascular diseases, retinopathy, neuropathy, nephropathy or “non-diabetes related comorbidities” known as discordant, such as, musculoskeletal and mental disorders (Struijs et al. 2006). Dealing with the patients who have comorbid condition is always challenging and needs additional resources and attention from the health care system (Parekh & Barton 2010). The number of diabetes cases is increasing globally due to aging and at the same time appearance of comorbidities as well as utilization of health care facilities have also increased with older age. Some comorbid conditions compete in treatment priority and interfere in diabetes care which leads to more complex condition of diabetes and comorbidities among diabetic patients (Piette & Kerr 2006). Ultimately, the ‘single diseases management approach’ for diabetes care is not adequately effective (Struijs et al. 2006).

Primary health care is essential for management and control of non-communicable diseases such as type 2 diabetes. Good preventive services and adequate care can reduce the incidence and prevent the further complications and comorbidities related to type 2 diabetes at the primary health care level. Although monitoring quality of diabetes care is a challenging task for the health care system but it is essential in evaluating the effectiveness of guideline implementation in health care. There are few standard indicators for diabetes care that are used to measure the quality of diabetes care in many countries in Europe and USA (International Diabetes Federation 2014c).

In Finland, about 5% of people have diagnosed type 2 diabetes and there are many undiagnosed people as well (Finnish Diabetes Association 2015a). The incidence and the costs of care of type 2 diabetes have increased since the last decade in Finland (Finnish Diabetes Association 2015b). Currently, Finland is following the “Current Care Guidelines” for
diagnosis and treatment of type 2 diabetes. According to the guidelines, diabetes patients are required to have measurement of HbA1c in six months interval and LDL level at least once in 1 to 3 years. However, treatment plan and targets can be modified according to the severity and complications of the disease (Current Care Guidelines 2013). However, in Finland, it is not very well known how well the current care guidelines for diabetes are followed and how well the treatment goals are achieved and how comorbidities are taken into account in care.

Comorbidities are strongly associated with the quality of diabetes care. Most of the diabetic patients have at least one additional chronic illness other than diabetes (Piette & Kerr 2006). Few studies have taken into account only single comorbid condition, for example, impact of mental disorder on care of diabetes (Desai et al. 2002, Goldberg et al. 2007). A limited number of studies have been done so far to assess the quality of diabetes care associated with comorbidities. However, studies on the impact of comorbidities on diabetes care show controversial results. Some earlier studies have found that diabetic patients with concordant diseases are more likely to achieve recommended HbA1c and LDL control (Woodard et al. 2011, Magnan et al. 2015a). On the other hand, discordant diseases were associated with a lower diabetes care or worse results (Frayne et al. 2005, Pentakota et al. 2012). However, it has also been observed that comorbidities have no significant association with quality of diabetes care at all (de Bruin et al. 2013).

Age and gender are also associated with diabetes care. It has been reported that older people are more likely to have more health care utilization and better diabetes care than the younger diabetes patients (Suh et al. 2008). In addition, gender disparities have been observed in diabetes care showing that women have worse LDL control than men (Yu et al. 2013).

The aim of this study is to find out the association of comorbidities and demographic factors such as age and gender with the quality of type 2 diabetes care in primary health care in North Karelia, Finland.
2 LITERATURE REVIEW

2.1 Definition of Type 2 diabetes

The American diabetes association (2010) defined Diabetes as a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action or both. It is a chronic disorder and can affect kidney, eye, nerve, heart and blood vessel, if uncontrolled.

Diabetes is broadly classified into two major types, type one and type two diabetes. Type one diabetes which is also known as insulin dependent or childhood-onset diabetes is characterized by the lack of insulin production in the body. Type 2 diabetes also known as non-insulin dependent diabetes or adult-onset diabetes is featured by body’s ineffective insulin response or insufficient insulin production. There are also other types of diabetes, for example, gestational diabetes which appears first time during pregnancy (American Diabetes Association 2010).

2.2 Epidemiology

387 million out of the world population has diabetes; it has been estimated that every one person out of twelve has diabetes (International Diabetes Federation 2014a). The number of diabetic patients is increasing globally due to ageing, urbanization and changing life styles leading to obesity epidemic. Type 2 diabetes is most prevalent in developing countries. Almost 80% of diabetes patients are living in less developed countries. Recently, Asia became an epicenter of type 2 diabetes and it is believed that by 2030 the five of the world top most countries for diabetes will be in Asia; namely China, India, Pakistan, Indonesia and Bangladesh (Chen et al. 2011).

2.3 Demographic factors

2.3.1 Ethnicity and migration

Studies in past have identified ethnicity as a key factor for prevalence of type 2 diabetes National diabetes statistics report of USA (2014) showed that the prevalence of type 2 diabetes has dramatically increased among different ethnic groups in 2010-2012. Prevalence of type 2 diabetes increased by 13% in Hispanics and non-Hispanic blacks and 7 % in non-Hispanic whites in 2010-2012. Highest prevalent of diagnosed diabetes was observed in American Indians (15.9%) (Centers for Disease Control and Prevention 2014). In addition, burden of diabetic comorbidities also varied by different ethnic background. For example, in a
A retrospective cohort study among veterans with type 2 diabetes, non-Hispanic blacks had 35% higher odds of having single comorbidity than non-Hispanic whites. On other hand, Hispanics had 10% lower odds for single comorbidity than non-Hispanic whites (Lynch et al. 2015). Ethnic variation in diabetic control had also been observed in another retrospective veterans study in USA. The study showed poor glycemic control among non-Hispanic blacks and Hispanics compared with non-Hispanic whites (Egede et al. 2011).

Migration has also impact on the prevalence of type 2 diabetes and its complications. In Singapore, a cross sectional population based study of 3,400 migrated Indians reported that the second generation of migrated Indians have higher prevalence of diabetes and eye complications than the first generation (Zheng et al. 2012). Similarly, migrated Indians in UK or other western countries have four time higher prevalence of type 2 diabetes than the inhabitants of India. Similar result has also been observed in the USA showing that the prevalence rate of type 2 diabetes in different ethnic groups living in US is higher than in their country of origin (Abate & Chandalia 2003). This clearly means that the westernization, environmental change and different life style may cause higher incidence of type 2 diabetes in different ethnic groups migrating US (Abate & Chandalia 2003).

2.3.2 Area level differences

Sometimes, the difference in prevalence has been observed within the same population depending upon their living area in a country. In India, prevalence of type 2 diabetes is four times higher in urban areas compared with rural areas (Abate & Chandalia 2003). In USA, a study among diabetic veterans showed that the number of comorbidities was significantly higher in rural residence and it also varied by different geographic regions. For instance, rural inhabitants were more likely to have 7% higher odds for single comorbidity (Lynch et al. 2015). However, in another veterans’ study in the USA, geographical regions and urban or rural residence disparities were only weakly associated with diabetic control (Egede et al. 2011).

2.3.3 Age and gender

Type 2 diabetes is generally more prevalent in adult population. However, a review study claimed that type 2 diabetes is nowadays also occurring in children and adolescents with high prevalence rate (Pinhas-Hamiel & Zeitler 2005). Likewise, in US, the prevalence of type 2 diabetes has increased among children and adolescents in last few decades. The common cause
of early onset of type 2 diabetes among the children is increasing obesity (American Diabetes Association 2000).

A case control study found a strong association with age and diabetes. People older than 65 years have the highest tendency to develop diabetes (Nayak et al. 2014). Many authors have argued that type 2 diabetes is not generally depended upon the gender. However, few studies among US population have found that number of women with diabetes is two time higher than male, particularly in age group 45-64 years (Gale & Gillespie 2001). Also puberty and family history are related to the prevalence of type 2 diabetes (American Diabetes Association 2000).

2.4 Risk factors

Risk factors for type 2 diabetes are broadly categorized under two main groups: modifiable and non-modifiable risk factors. Risk factors such as overweight, sedentary life style, smoking, food habits and hypertension are modifiable or preventable. On the other hand, factors such as age, gender, family history, and ethnicity are non-modifiable risk factors for type 2 diabetes.

Life style factors including diet, overweight, obesity and physical inactivity can be significant risk factors for type 2 diabetes. A 16 years follow-up study among 84,184 female nurses found that obesity was the single most important risk factor for type 2 diabetes. Besides, physical inactivity, smoking, and poor diet were also contributing risk factors of type 2 diabetes in women (Hu et al. 2001).

Physical inactivity is serious public health problem and it can be a major risk for many chronic diseases such as type 2 diabetes. It is now the fourth causal factor for adult death worldwide (WHO 2015d). A prospective study has demonstrated that the physical inactivity is a single and modifiable cause for type 2 diabetes (Al Tunaiji et al. 2014). Five hours exercise in a week could significantly reduce the risk of type 2 diabetes (Gill & Cooper 2008).

One study found that moderate alcohol consumption reduces the risk of diabetes and high alcohol intake increases the risk of obesity, pancreatitis and eventually diabetes (Koppes et al. 2005).

Cigarette smoking is associated with the risk of type 2 diabetes. Cigarette smoking can cause diabetes by increasing insulin resistance (Pathak & Pathak 2012). A meta-analysis showed that smokers have 45% higher risk of type 2 diabetes than nonsmokers (Hu 2011).
Depression is seen as a risk factor for type 2 diabetes, but diabetes itself can also cause depression. A meta-analysis found that depression is strongly associated with type 2 diabetes. Depressed adults have 37% higher risk for type 2 diabetes (Knol et al. 2006).

Diabetes is a complex disease caused by a complex interplay of genetics, epigenetics and environment. Many environmental factors alter the gene expression by the epigenetic modification. This modification for example, can occur during embryogenesis by exposure to heavy metals or smoking or due to lack of some nutrients (folate, methionine) leading to development of type 2 diabetes early in life or sometimes later in adulthood (Dayeh et al. 2014).

According to a recent study, about 120 susceptible genes have been identified as substantial contributing factors for type 2 diabetes (WHO 2015b). Genome wide association study is intended to search the genetic variations which are associated with many chronic diseases, such as diabetes, cancer and asthma. So far, this study has successfully proven the genetic contribution to risk of type 2 diabetes (National Center for Human Genome Research 2015).

Western dietary habits significantly increase the risk of type 2 diabetes, but a healthy diet reduces the risk of type 2 diabetes (van Dam et al. 2002). Persons with poor dietary habits are in greater risk for type 2 diabetes (Hu et al. 2001). Quality of carbohydrates and fats also play a role in the development of diabetes. High dietary glycemic load (GL) and intake of trans fats increase the risk of diabetes but dietary fiber and polyunsaturated fatty acids lower the risk for type 2 diabetes (Hu 2011).

A 12 year follow up study in US men documented that western food (meat, high fat dairy food, junk food) combined with physical inactivity and high BMI increases the risk for type 2 diabetes. On the other hand, prudent diet including vegetables, fruits, fish, poultry and whole grain substantially lower the risk of diabetes (van Dam et al. 2002).

Metabolic syndrome (which is a group of clinical conditions characterized by central obesity, elevated blood pressure, increased level of triglycerides and low level of high density lipoprotein) is also associated with risk for type 2 diabetes (Alberti et al. 2005). An 8 year follow-up study found that the subjects previously diagnosed with metabolic syndrome have considerably increased risk (Risk Ratio=6.9) for diabetes compared with persons without metabolic syndrome (Wilson et al. 2005).

Gestational diabetes which occurs first time during pregnancy causes glucose intolerance. A systemic review and meta-analysis found that women with gestational diabetes have higher
risk of developing type 2 diabetes than women with nondiabetic pregnancies (Bellamy et al. 2009).

Polycystic ovarian syndrome (PCOS) is an endocrine disorder affecting 6-8% of women in their reproductive age. It is characterized by the disturbed ovarian function, infertility, increased ovarian size and abnormal hormonal imbalance (High level of free testosterone and high ratio of luteinizing hormone/follicle-stimulating hormone). Moreover, women with PCOS have high incidence of insulin resistance. In PCOS, the insulin secretion is increased as a consequence of abnormal hormone levels followed by the compensatory hyperinsulinemia, which is the main risk factor for type 2 diabetes. The chance of developing type 2 diabetes in young women with PCOS is ten times more than in healthy women (Jakubowicz et al. 2012).

2.5 Prevention

Type 2 diabetes can be prevented by lifestyle modification, such as diet, weight control and physical activity. A meta-analysis found that the control of overweight was observed a single most effective measure in diabetes prevention. However, one study also claimed that Bariatric surgery is the most successful procedure for weight reduction rather than changing food habits, physical exercise or medication (Merlotti et al. 2014). Similar result has also been found in the Swedish obese subjects (SOS) study showing that in obese subjects who have had bariatric surgery the incidence of type 2 diabetes reduced by 75% after 2 to 10 years of surgery (Sjostrom 2013). In another study, authors analyzed the various interventions for preventing type 2 diabetes in different communities and suggested that the successful prevention of type 2 diabetes requires collective approach from the community level to the national political level to promote healthy lifestyles and health education (Palermo et al. 2014).

In Finland, a controlled randomized trial known as the Diabetes Prevention Study (2003) was conducted among 522 middle aged overweight subjects in high risk of developing type 2 diabetes. The subjects in the intervention group received dietary and intensive physical exercise intervention. After 3 years follow-up, the subjects of the intervention group had reduced their weight significantly and had lower glucose and lipid levels compared with the control group. They observed a 58% risk reduction for incident type 2 diabetes in four year follow-up among those in intervention group compared with those in control group. Therefore, the DPS study concluded that the type 2 diabetes can be prevented or postponed with lifestyle modification among high risk individuals (Lindstrom et al. 2003).
2.6 Diagnosis and measurement of quality care of type 2 diabetes

Type 2 diabetes is often underdiagnosed. Many people do not know that they have type 2 diabetes. The average time between the onset of type 2 diabetes and diagnosis is 7 years (Saudek et al. 2008). Diabetes screening test is highly recommended among the people with high risk of diabetes. In Finland, the approach for preventing and screening diabetes is to first assess to identify the persons with high risk for developing diabetes in the target population using the Diabetes Risk Test (FINDRISK) and then to screen undiagnosed cases of diabetes in primary health care (Finnish Diabetes Association 2015c).

Traditional and the most commonly used procedure to diagnose the diabetes is the measurement of fasting glucose level and two hours after a glucose load level. However, World Health Organization has also recommended Glycated hemoglobin (HbA1c) measurement for confirming the diagnosis (HbA1c > 7%) of diabetes since 2011 (WHO 2015c).

According to the recommendation from American Diabetes Association (2013), in treatment of diabetic patients the HbA1c level for adults should be below or around 7% to prevent microvascular complications. It is also recommended for adult diabetic patients to have annual screen test for fasting lipid profile. The recommended level of LDL is less than 2.5 mmol/L.

According to the Current Care Guidelines (2013) in Finland, the treatment goals for type 2 diabetes are HbA1c below 7%, fasting blood sugar less than 7 mmol/l, 2 hour after breakfast sugar level under 10 mmol/l and LDL less than 2.5 mmol/l.

Measuring the quality of type 2 diabetes care is challenging. In US, physician operated quality improvement program with the collaboration of the national diabetes quality improvement alliance (NDQIA) have initiated a work to recognize the main quality indicators of type 2 diabetes care. The goal was to improve the quality of diabetes care and to standardize the measurements systematically. After literature review, expert opinions and surveying the NDQIA identified nine indicators which have been widely accepted internationally. Out of the nine, six measurements are for care process and three for the outcomes of care (Nicolucci et al. 2006).

The study proposed three main groups of indicators for better diabetes care (table 1). Firstly, annual testing of HbA1c and low-density lipoprotein (LDL) followed by an annual screening of renal problems and eye examination are recommended for assessing the process of diabetes care. Secondly, achievement of recommended level of HbA1c and LDL indicates proximal
outcomes of diabetes care. Thirdly, a long term or distal outcomes of type 2 diabetes care are measured by the rate of lower-extremity amputations, the number of diabetic patients with kidney disease and the rate of cardiovascular mortality in patients with diabetes (Nicolucci et al. 2006).

The writers also argued about the inclusion of blood pressure measurement as a proximal outcome but the data collection would be challenging and the measurement of blood pressure technique is variable across the countries and need to be standardized further (Nicolucci et al. 2006). The positive side of the study was the addition of the distal or long term outcome indicators for diabetes care reflecting the overall diabetes care of chronically ill patients. Now, with the help of this study, it is possible to compare the type 2 diabetes care in different countries. Moreover, long term indicators of diabetes care will help to improve the development of health policy and quality of type 2 diabetes care in future. On the other hand, the study was specifically focused on Economic Cooperation and Development (OECD) countries and what would be the relevant diabetes care indicators in developing countries needs further research.

A prospective observational study known as the QUASAR (Quality Assessment Score and Cardiovascular Outcomes in Italian Diabetes Patients) was done in Italy in 2011. The intention of the study was to predict the development of the cardiovascular events based on the score counted from the quality of type 2 diabetes care. The score was obtained from the indicators for diabetes care’s measurements and achievement of target levels, such as HbA1c, blood pressure, blood cholesterol, other lipids and microalbuminuria. The result of the study established a significant association of future cardiovascular outcomes or consequences depending upon the quality of diabetes care (Rossi et al. 2011).

In US, the Translating Research into Action for Diabetes (TRIAD) study was done to find out the impact of the health structure and process indicators on quality of diabetes care. The aim of the study was to identify the modifiable barriers throughout the process and the health structure to achieve the optimal level of diabetes care across the different health care settings. The study included additional indicators such as aspirin prescription, smoking and cessation counseling as a measurement of diabetes care process. Furthermore, the study also examined costs and health care utilization (number of visit) as financial outcomes, and health related satisfaction of patients (TRIAD Study Group 2002).
Table 1: Measures of quality of type 2 diabetes care proposed for use in health system comparisons by NDQIA (Nicolucci et al. 2006)

<table>
<thead>
<tr>
<th>Area</th>
<th>Indicator name</th>
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<tr>
<td>Processes of diabetes care</td>
<td>Annual HbA1c testing</td>
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<td>Annual LDL cholesterol testing</td>
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<td></td>
<td>Annual screening for nephropathy</td>
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<td></td>
<td>Annual eye examination</td>
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<tr>
<td>Proximal outcomes</td>
<td>HbA1c control</td>
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<td></td>
<td>LDL cholesterol control</td>
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<tr>
<td>Distal outcomes</td>
<td>Lower-extremity amputation rates</td>
</tr>
<tr>
<td></td>
<td>Kidney disease in persons with diabetes</td>
</tr>
<tr>
<td></td>
<td>Cardiovascular mortality in patients with diabetes</td>
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HbA1c, hemoglobin A1c; LDL, low-density lipoprotein.

In Kuwait, Diabetes Quality Indicator Set (DQIS) was established to examine the quality of diabetes care by measuring five indicators in four major primary health care center. Two years of assessment had shown a significant improvement in all other indicators except evaluating smoking status. This study helped to assess the effectiveness of current policies in health care for managing diabetes care in Kuwait (Badawi et al. 2015).

2.7 Quality of type 2 diabetes care by demographic factors

Gender influences the quality of diabetes care. Many studies have found associations with gender and the quality of type 2 diabetes care. A literature reviewed concluded that gender gap is a prominent issue in diabetes care and it is recommended to focus this factor in diabetes care. The authors’ major findings showed that women were at more risk than men in developing diabetes and its complexity. For example, diabetic women usually have four to six time higher chance to develop coronary arterial diseases (CAD) and higher risk for hypertension,
dyslipidemia and obesity than men. However, women were less likely to receive CAD treatment and to achieve treatment goals than men (Legato et al. 2006).

In an observational study of Medicare managed care beneficiaries in US, it was demonstrated that women are less likely to have controlled level of LDL than men. However, women received more screening tests and eye examinations than men (Chou et al. 2007). In 2009, a cross sectional observational study took place to investigate the gender disparities in the quality of diabetes care among a large number of patients. The study revealed that women had higher levels of HbA1c, LDL and BMI and less adherence to medication than men. Foot and eye examinations were also performed in lower rates among women than men. This difference might be due to some basic pathophysiological reasons but there are some sociocultural associations as well (Rossi et al. 2013).

Another observational study among 801 white and 115 black patients assessed the process of diabetes care (measurement of HbA1c and LDL, nephropathy screen, foot and dilated eye examinations) and the intermediate outcomes of diabetes care (level of HbA1c, LDL and blood pressure). The finding of the study was that there are no racial disparities in HbA1c screening and foot examinations but black people have less LDL measurements and dilated eye examinations than white. On the other hand, black people have worse intermediate outcomes (lower proportion of those with LDL< 130 mg/l and blood pressure< 140/90mmHg) than white. However, there were no racial differences in the levels of HbA1c. The authors concluded that there were some racial disparities in diabetes care process and intermediate outcomes but did not find any racial differences in the medication of type 2 diabetic patients who had poor control of LDL and blood pressure (Heisler et al. 2003).

The quality of diabetes care is also associated with age of the patients. Many prior studies found that people who are above 65 years, are labelled as vulnerable group with higher number of chronic illness and better diabetes care (Min et al. 2007). On the other hand, it has been observed in a cohort study among urban African American that the younger people with type 2 diabetes had the highest HbA1c and BMI levels (El-Kebbi et al. 2003).

The quality of type 2 diabetes care is strongly correlated both with the socioeconomic status (SES) of individuals and the level of regional deprivation. A meta-analysis was done to assess the inequalities in the process of diabetes care (measurement of HbA1c) and intermediate outcomes (HbA1c level) of type 2 diabetes care by socioeconomic status. The study
demonstrated that individuals with low SES have the worst diabetes care (both process of care and intermediate outcomes) (Grintsova et al. 2014).

Most of the studies have assessed the impact of individual socioeconomic status (based on the income and education). However, regional deprivation is also correlated with diabetes care. It is reported that both lower individual SES and higher regional deprivation are associated with worse quality of diabetes care (Grintsova et al. 2014).

In Finland, a study found that the area-level socio-economic status has impact on diabetes care (diabetes process and outcome) in North Karelia region. The study included a total of 10,204 diabetes patients and the information of socioeconomic characteristics of participants were based on the postal code area level data. The study stated that lower level of socio economic status in the postal code area is related with poorer measurement activity of HbA1c among the type 2 diabetes patients. In addition, the study also found a positive correlation with higher education level and the achievement of recommended HbA1c level (Sikiö et al. 2014).

2.8 Comorbidities

2.8.1 Definition

Different researchers have defined comorbidities in different ways. In 1970, Feinstein introduced the idea of comorbidity and defined it as “any clinically relevant phenomenon separate from the primary disease of interest that occurs while the patient is suffering from the primary disease, even if this secondary phenomenon does not qualify as a disease per se”.

Many authors argued that comorbidities are the presence of two or three diseases that are related with each other based on a common pathogenic mechanism, while multimorbidities are the simultaneous presence of two or more diseases that are not related to each other by a pathogenic mechanism. According to Valderas et al. (2009), comorbidity is the condition where one or more diseases appear in addition to an index disease. On the other hand, multimorbidities refer to existence of multiple diseases in one individual.

According to Jakovljević and Ostojić (2013), comorbidities commonly have three different meanings,

“1. Two or more medical conditions existing simultaneously, but independently with each other;
2. two or more medical conditions existing simultaneously and interdependently with each other what means that one medical condition causes, is caused, or is otherwise related to another condition in the same individual;
3. Two or more medical conditions existing simultaneously regardless of their causal relationship”.

2.8.2 Epidemiology

As the living standard and the health care are improving, the average life expectancy is also increasing. It is expected that the number of population having life expectancy in average of 60 years would be doubled by 2050. Bearing the cost of health care for older population has emerged as a new challenge. A huge burden of diseases also appears when we are dealing with aging population. Currently, single disease approach is not sufficient when we are treating multiple diseases as Salive (2013) estimated in his review study of multimorbidity among 31 million older persons in US. In Salive’s study, more than two thirds of all subjects had multimorbidity and the proportion increased with age.

Comorbidity is a global phenomenon. People with advanced age have more comorbidities. In USA, 75 million people have two or more concurrent chronic diseases spending 65% of the health care expenditure which is a very challenging situation for health care in US. 10% of Americans have diabetes and 90% of diabetes patients have two or more chronic diseases (Parekh & Barton 2010).

Chronic diseases are common with type 2 diabetes patients. Medical expenditure survey estimated that most of the adult diabetic patients have at least one chronic condition and 40% have at least three. Nowadays diabetic patients receive good care, have good glycemic control and thus increased life expectancy which eventually give more chance to have other chronic diseases with advancing age (Piette & Kerr 2006).

2.8.3 Comorbidities and quality of type 2 diabetes care

Comorbidity or multimorbidity are often used to describe the coexistent multiple conditions in a patient. It has robust impact on health care utilization, financial resources and overall quality of health care as well. Quality of diabetes care also depend upon the number and the nature of the comorbidities. Many studies have found that quality of care varied by the nature of diseases,
number of diseases, number of visits to physicians and by some other socioeconomic factors as well (Piette & Kerr 2006, Zulman et al. 2014).

Effective management of diabetes is a great challenge, especially when diabetes patients come with one or more comorbid diseases. Both physicians and patients may escape or ignore diabetes related comorbid conditions and the management may focus only on acute conditions or dominant illnesses. It may lead to severe consequences of diabetes, lower the quality of care and increase the risk of mortality (Piette & Kerr 2006).

So far, many studies have been done to determine the impact of comorbidity on diabetes care in an individual and on the entire health system level. For instance, in a retrospective cohort study, Pentakota et al (2012) assessed the relationship between diabetes care and the type of comorbidity among the veterans. They examined the diabetes care by measuring number of visits per year, level of HbA1c and level of LDL cholesterol. Finally, they argued that diabetes patient with concordant illness (illness which overlaps with diabetes pathogenesis and management, for instance, cardiovascular diseases) have either similar or better quality of care regardless the number of visits. On the other hand, diabetes patients with discordant illness (for example, mental health illness) have poorer quality of care. Woodard et al. (2011) and Magnan et al. (2015a) found the similar impact of comorbidities on the diabetes care showing that diabetic patients with concordant diseases had better care and better achieved the recommended goal for controlling diabetes. They also found that diabetic patients with more chronic illnesses had better care. On the other hand, opposite association have also been observed in many studies. For example, Halanych et al (2007) studied the association of individual medical condition on diabetes care measured by Charlson Comorbidity Index (CCI). The authors reported that the rate of lipid and HbA1c tests reduced in the patient with higher number of comorbidities.

There are many reasons for unequal care of diabetes patient with comorbidity. Inadequate support and time limitation leads to non-optimal diabetes care and leads to poor outcomes. For example, in primary health care in US, patients with chronic diseases have been allocated more attention and time from physician for counseling and for making the management plan compared with some acute conditions (Ostbye et al. 2005).

Prioritizing the treatment goals in diabetic patients with comorbidities is not well documented among the physicians and patients. A systemic review suggested that high blood pressure is the most important factor predicting the adverse outcomes of type 2 diabetes but many physicians
may often ignore this when patients come with acute problem such as chronic pain (Vijan & Hayward 2003). Sometimes, nature of diseases and onset of diseases causes the disparity in care of diabetes. Nam et al. (2011) reviewed literature about different barriers of diabetes management in patients and care providers. The authors argued that the patients’ self-care is overshadowed by urgent and prominent complaints like chronic pain, arthritis, asthma and heart diseases. In addition, 33% of diabetes patients are suffering from depression which is also a strong barrier for patients’ self-management and glycemic control.
3 AIMS OF THE STUDY

The main aim of this study was to analyze the association of the demographic factors and comorbidities with processes and outcomes of the type 2 diabetes care in primary health care in North Karelia, Finland. Specifically, the objective was to analyze the associations of the age group, gender and comorbidities with quality of type 2 diabetes care.
4 METHODOLOGY

4.1 Study design

This study is a register based retrospective cohort study.

4.2 Study setting, subjects and data

The North Karelia region is in Eastern Finland. There were 13 municipalities in the region in the end of 2012. Total population was 165,258 by the end of 2014, of whom 49.2% were males and 50.2% females. In the beginning of 2000, all municipalities agreed to establish a common electronic patient database system for keeping patient records centrally. The setup of regional database was started in early 2009 and finally completed in all the municipalities by 2011. From the beginning of 2011 all municipalities of North Karelia started using same regional electronic patient database (the Mediatri). The North Karelia IT-center maintains the patient database. The information on type 2 diabetes patient has been received from this database (Sikiö et al. 2014).

In the years 2011 and 2012, information was collected from all the patients who were diagnosed having type 2 diabetes according to ICD-10 code E11. The information on residency with postal code, date of birth, date of diagnosis, gender, laboratory data (different tests and dates of the tests) and all other permanent diagnoses (according to ICD-10 code) along with type 2 diabetes of the patients was collected. Personal identifying number were not given to us to ensure privacy of the patients (Sikiö et al. 2014).

The database includes a total of 10,204 type 2 diabetes patients who were alive at the end of 2012. The proportion of females (n= 4802) was 47.1% and males (n=5402) 52.9%. Subsequently, in this study we included patients who were aged 30 years or above to include adult age group in our study. After applying that criteria, our final patient number was 10,168 including 4780 females (47.1%) and 5388 males (52.9%).

4.3 Study variables

4.3.1 Background variables

In our study, background variables are age, gender and comorbidities. We analyzed age and gender as demographic variables. Age was continuous variable and gender was dichotomous variable. However, in basic characteristics table, age was divided into seven groups starting from age 30 until age 99 years with the range of 10 years in each group. There was a limitation
for including other demographic variables as the data has been obtained from the patient records not including information for example on socioeconomic characteristics.

Other background variable is comorbidities. We included a total of 23 chronic comorbidities (table 2) in our study to see the effect of comorbidities on the outcomes of diabetes care. We used ICD-10 codes for diagnosis of diseases. We followed the framework proposed by Piette and Kerr (2006) for inclusion of chronic comorbidities with type 2 diabetes. The framework was established to assess diabetes care with comorbid conditions. We divided the comorbidities into concordant and discordant diseases. First, we defined the two type of comorbidities as follows

Concordant diseases: Conditions, which share relatively same pathophysiology and etiology with the primary disease (for example, hypertension and diabetes) and the treatment of the condition has almost similar management plan. (Piette & Kerr 2006)

Discordant diseases: Type of diseases that are not directly related by their pathogenesis or etiology with primary disease (e.g. diabetes and asthma) and they have different management plan. (Piette & Kerr 2006)

We also categorized patients (n = 10168) into four different groups depending upon the presence of comorbidity and diabetes: only DM, only concordant diseases with DM, only discordant diseases with DM and both type of comorbidities with DM.

4.3.2 Outcome variables

Our study assessed four outcome variables. Two of them indicates the process of diabetes care, HbA1c measurement and LDL measurement. The HbA1c and LDL measurement were regarded to have been measured according to the Current Care Guideline recommendations if they were measured during 2011-2012, HbA1c at least 3 months after and LDL at least 1 month after diagnosis. The other two outcome variables were the level of HbA1c and the level of LDL. These two variables indicate the outcome of diabetes care whether it is in recommended level after diagnosis and treatment. Although these two variables are continuous we also categorized HbA1c and LDL level as dichotomous variables (In HbA1c level, 1=7% and above and 2=less than 7% whereas in LDL, 1=2.5 mmol/l or above and 2=less than 2.5 mmol/l) according to treatment targets. These two dichotomous variables reflect how well glycemic and lipid control was achieved. We included those patients whose HbA1c was measured at
least 3 months and LDL at least one month after the diagnosis of diabetes to ensure sufficient
time for treatment effect. The last recorded value of measurements was used.

Table 2. List of comorbidities categorized to concordant and discordant diseases and their ICD-
10 codes.

<table>
<thead>
<tr>
<th>Concordant</th>
<th>Discordant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension (I10)</td>
<td>Tumor (D00-D48)</td>
</tr>
<tr>
<td>Coronary heart diseases (120-125)</td>
<td>Malignancies (C00-C97)</td>
</tr>
<tr>
<td>Atrial fibrillation (I48)</td>
<td>Asthma (J45)</td>
</tr>
<tr>
<td>Heart failure (I50)</td>
<td>Depression (F32)</td>
</tr>
<tr>
<td>Peripheral arterial diseases (I70-I79)</td>
<td>Gout (M10)</td>
</tr>
<tr>
<td>Ischemic stroke (I63-I64, Excluded I63.6)</td>
<td>Glaucoma (H40-H42)</td>
</tr>
<tr>
<td>Cerebrovascular diseases (I60-I69)</td>
<td>Dementia (F00, F01, F03)</td>
</tr>
<tr>
<td>Chronic kidney diseases (N18)</td>
<td>Mental diseases (F40-F48)*</td>
</tr>
<tr>
<td>Peripheral neuropathy (G60-G64)</td>
<td>Respiratory diseases (J41-J44)**</td>
</tr>
<tr>
<td>Hemorrhagic stroke (I60-I62)</td>
<td>Rheumatoid arthritis (M05, M06)</td>
</tr>
<tr>
<td>Blindness (H54)</td>
<td>Osteoporosis (M80-M85)</td>
</tr>
<tr>
<td></td>
<td>Neuromuscular diseases (G70-G73)</td>
</tr>
</tbody>
</table>

*Including other neurotic, stress related and somatoform disorders.
** excluding asthma
Fig 1: Flowchart showing the subject selection and how the quality of care have been measured.

4.4 Statistical analyses

We used IBM SPSS for Windows version 21 (SPSS Inc., Chicago, IL, USA 9) for statistical analysis. Descriptive analysis and cross tabulation were used to access the basic characteristics of the patients. We used linear and logistic regression analyses to analyze the associations between dependent and independent variables. The results of linear and logistic regression analyses were expressed as Beta (B) coefficients with 95% confidence intervals (CI) or as odd ratios (OR) with 95% CI. The P value was set at < 0.05 for statistical significance.

First, we cross tabulated patient’s age and gender with comorbid group variable followed by determination of mean value of HbA1c and LDL with 95% CI of each group. Secondly, we used multivariate logistic regression model to see the association of gender and age for process and outcomes of diabetes care. Subsequently, we used linear regression model for explaining dependence of HbA1c and LDL levels on patients’ age and gender.

We used cross tabulation to show the prevalence of different comorbidity groups by age and gender. We also analyzed all outcome variables in comorbidity categories to determine the effect of comorbidity on diabetes care. We used bivariate logistic regression model to assess
the association of comorbidity and diabetes care. Patients belonging to the ‘Only DM’ group were the reference group in the logistic regression analysis.

4.5 Ethical considerations

The ethics approval has been received from the ethics committee of the Northern Savonia Hospital District on 13th November, 2012. Patients’ personal identification information was not revealed at all. Access of data was limited to the required information (variables) needed in the study.
5 RESULTS

Table 3 presents general characteristics and the process of care and outcome indicators by different age groups and gender. More than half (58.4 %, n= 5936) of our study population were in between the ages of 60 to 80 years. Mean age of the study population was 68.2 years. Only 1.2 % of patients were 30-39 years old and 1.8 % very old (90-99 years). Every seven out of ten subjects in both genders had HbA1c and LDL measured. The proportion of females who achieved HbA1c target level was greater (73.1 %) than of males (70 %) but LDL goal was achieved better by males than females (57.5 % vs 51.3 %). High level of HbA1c (> 9 %) were observed less in females than males (5.1 % vs 6.8 %).

In table 4, the characteristics of the study population are presented in four groups depending on the presence of different comorbidities and among all subjects as well. Highest number of our patients (41%) had both concordant and discordant diseases besides diabetes. About one third of our study subjects were diagnosed as having diabetes and concordant diseases and every one patient out of ten had diabetes and discordant diseases. Only 16% of our patients were free from other chronic diseases except diabetes. Our study also found that older patients were more likely to have higher disease burden than younger patients (OR 1.05 [95% CI 1.04-1.05, P < .001]).

Patients with only diabetes and discordant diseases were more likely to be younger and male. On the other hand, patients with both concordant and discordant were more likely to be older. Male patients were dominant part in the only DM group and the concordant group, while female patients were the majority in other categories.

Group with both type of comorbidities had the highest level (6.74 %) of mean HbA1c, whereas the rest of the groups had lower HbA1c level than the mean (6.63 %). Diabetic patients with only concordant or both concordant and discordant diseases had significantly lower mean of LDL level compared with other groups.
Table 3: Process of care and outcome indicators by gender and age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>No. of patients by gender in each group</th>
<th>HbA1c measured after 3 months from diagnosis (%)</th>
<th>LDL measured after 1 month from diagnosis (%)</th>
<th>HbA1c mean* (95% CI)</th>
<th>HbA1c median*</th>
<th>LDL mean** (95% CI)</th>
<th>LDL median**</th>
<th>% of those HbA1c &lt; 7%*</th>
<th>% of those HbA1c &gt; 9%*</th>
<th>% of those LDL &lt; 2.5 mmol/l**</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-39</td>
<td>59/65 (1.2)</td>
<td>61.0</td>
<td>59.3</td>
<td>72.3</td>
<td>6.3 (5.85-6.84)</td>
<td>6.8 (6.34-7.29)</td>
<td>5.9 6.5</td>
<td>2.8 (2.48-3.11)</td>
<td>2.7 (2.43-3.00)</td>
<td>2.8 2.5</td>
</tr>
<tr>
<td>40-49</td>
<td>201/322 (5.1)</td>
<td>73.6</td>
<td>71.1</td>
<td>64.6</td>
<td>6.4 (6.27-6.70)</td>
<td>7.0 (6.79-7.22)</td>
<td>6.0 6.5</td>
<td>2.7 (2.66-2.91)</td>
<td>2.6 (2.53-2.76)</td>
<td>2.5 2.6</td>
</tr>
<tr>
<td>50-59</td>
<td>672/1002 (16.5)</td>
<td>69.6</td>
<td>67.6</td>
<td>68.7</td>
<td>6.5 (6.40-6.43)</td>
<td>6.6 (6.49-6.70)</td>
<td>6.1 6.2</td>
<td>2.6 (2.56-2.67)</td>
<td>2.4 (2.34-2.96)</td>
<td>2.6 2.5</td>
</tr>
<tr>
<td>60-69</td>
<td>1258/2044 (32.5)</td>
<td>80.5</td>
<td>79.5</td>
<td>76.2</td>
<td>6.5 (6.44-6.59)</td>
<td>6.6 (6.60-6.73)</td>
<td>6.2 6.3</td>
<td>2.4 (2.42-2.51)</td>
<td>2.2 (2.43-2.44)</td>
<td>2.4 2.3</td>
</tr>
<tr>
<td>70-79</td>
<td>1324/1310 (25.9)</td>
<td>84.2</td>
<td>79.8</td>
<td>79.3</td>
<td>6.5 (6.51-6.64)</td>
<td>6.6 (6.54-6.67)</td>
<td>6.3 6.4</td>
<td>2.4 (2.42-2.51)</td>
<td>2.2 (2.43-2.33)</td>
<td>2.3 2.2</td>
</tr>
<tr>
<td>80-89</td>
<td>1120/607 (17.0)</td>
<td>82.7</td>
<td>67.1</td>
<td>70.0</td>
<td>6.7 (6.70-6.85)</td>
<td>6.8 (6.73-6.94)</td>
<td>6.5 6.5</td>
<td>2.4 (2.42-2.55)</td>
<td>2.2 (2.17-2.32)</td>
<td>2.3 2.1</td>
</tr>
<tr>
<td>90-99</td>
<td>146/38 (1.8)</td>
<td>75.3</td>
<td>38.4</td>
<td>42.1</td>
<td>7.0 (6.79-7.24)</td>
<td>7.0 (6.55-7.50)</td>
<td>6.8 6.8</td>
<td>2.8 (2.55-3.10)</td>
<td>2.2 (1.81-2.76)</td>
<td>2.5 2.0</td>
</tr>
<tr>
<td>Total: 10168</td>
<td>4780/5388 (100)</td>
<td>79.8</td>
<td>77.2</td>
<td>73.1</td>
<td>6.6 (6.79-6.74)</td>
<td>6.6 (6.65-6.72)</td>
<td>6.3 6.4</td>
<td>2.5 (2.53-2.58)</td>
<td>2.4 (2.38-2.43)</td>
<td>2.4 2.3</td>
</tr>
</tbody>
</table>

*Patient included who are over 29 years old and HbA1c has been measured at least after 3 months from diagnosis (n = 7977. F: 3816 M: 4161)

** Patient included who are over 29 years old and LDL has been measured at least after 1 month from diagnosis (n = 7476. F: 3496 M: 398)
Table 4: General characteristics of different comorbidity groups by age group and gender

<table>
<thead>
<tr>
<th>Age group</th>
<th>DM only (n=1630)</th>
<th>DM + Concordant only (n=3341)</th>
<th>DM + Discordant only (n=1027)</th>
<th>DM+ Both types of comorbidities (n=4170)</th>
<th>Overall (n=10168)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>30-39</td>
<td>39.5</td>
<td>24.2</td>
<td>24.2</td>
<td>12.1</td>
<td>1.2</td>
</tr>
<tr>
<td>40-49</td>
<td>34.0</td>
<td>26.8</td>
<td>17.8</td>
<td>21.4</td>
<td>5.1</td>
</tr>
<tr>
<td>50-59</td>
<td>24.9</td>
<td>30.8</td>
<td>12.5</td>
<td>31.8</td>
<td>16.5</td>
</tr>
<tr>
<td>60-69</td>
<td>17.6</td>
<td>34.9</td>
<td>11.2</td>
<td>36.3</td>
<td>32.5</td>
</tr>
<tr>
<td>70-79</td>
<td>11.2</td>
<td>36.2</td>
<td>8.2</td>
<td>44.4</td>
<td>25.9</td>
</tr>
<tr>
<td>80-89</td>
<td>5.8</td>
<td>29.3</td>
<td>5.9</td>
<td>58.9</td>
<td>17.0</td>
</tr>
<tr>
<td>90-99</td>
<td>5.4</td>
<td>23.9</td>
<td>3.3</td>
<td>67.4</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>16.0</td>
<td>32.9</td>
<td>10.1</td>
<td>41.0</td>
<td>100</td>
</tr>
<tr>
<td>Mean age</td>
<td>62.2</td>
<td>68.2</td>
<td>64.0</td>
<td>71.2</td>
<td>68.0</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>58.5</td>
<td>60.5</td>
<td>43.1</td>
<td>47.3</td>
<td>53.0</td>
</tr>
<tr>
<td>Female</td>
<td>41.5</td>
<td>39.5</td>
<td>57.0</td>
<td>52.7</td>
<td>47.0</td>
</tr>
</tbody>
</table>

Mean HbA1c: 6.60 (6.53-6.71) 6.59 (6.55-6.64) 6.46 (6.39-6.54) 6.74 (6.68-6.76) 6.63 (6.61-6.66)

Mean LDL: 2.73 (2.68-2.77) 2.43 (2.40-2.46) 2.67 (2.62-2.73) 2.47 (2.44-2.50) 2.52 (2.50-2.53)

Table 5 shows the diabetes care process and outcome indicators by comorbidity group. Achievement of recommended diabetes treatment goals varied across the different groups. The highest proportion of the patients who had been measured for HbA1c after three months of type 2 diabetes diagnosis was in group with both concordant and discordant diseases (82.9 %). HbA1c and LDL had been measured at lowest (67.8 % and 65.0%) percentage in patients who had only diabetes. Overall, the greater proportion of patients had been measured for HbA1c than LDL.

There was a wide variation in the achievement of the recommended levels of HbA1c and LDL in our study subjects. Patients with both comorbidities were more likely to have the highest ratio of those who failed to achieve recommended levels of HbA1c (68.4 %). And those with diabetes only were least likely to achieve LDL treatment goals (42.7 %). Patients diagnosed with concordant diseases achieved best in all goals.
Table 5. Achieved diabetes care targets by comorbidity groups.

<table>
<thead>
<tr>
<th>Diabetes care indicators</th>
<th>DM only (n=1630)</th>
<th>DM + Concordant only (n=3341)</th>
<th>DM + Discordant only (n=1027)</th>
<th>DM + Both types of comorbidities (n=4170)</th>
<th>Overall (n=10168)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HbA1c measured after 3 months from diagnosis</td>
<td>67.8%</td>
<td>79.4%</td>
<td>74.1%</td>
<td>82.9%</td>
<td>78.4%</td>
</tr>
<tr>
<td>LDL measured after 1 month from diagnosis</td>
<td>65.0%</td>
<td>76.7%</td>
<td>68.5%</td>
<td>75.6%</td>
<td>73.5%</td>
</tr>
<tr>
<td>HbA1c &lt; 7%</td>
<td>73.3%</td>
<td>72.8%</td>
<td>77.9%</td>
<td>68.4%</td>
<td>71.5%</td>
</tr>
<tr>
<td>LDL &lt; 2.5 mmol/l</td>
<td>42.7%</td>
<td>59.7%</td>
<td>47.6%</td>
<td>56.0%</td>
<td>54.6%</td>
</tr>
<tr>
<td>Both laboratory markers measured*</td>
<td>60.2%</td>
<td>72.0%</td>
<td>64.4%</td>
<td>71.2%</td>
<td>69.0%</td>
</tr>
<tr>
<td>Both outcome goals achieved**</td>
<td>25.5%</td>
<td>36.9%</td>
<td>28.5%</td>
<td>32.2%</td>
<td>32.3%</td>
</tr>
</tbody>
</table>

*Both HbA1c and LDL measured
** HbA1c <7 % and LDL< 2.5 mmol/l

We found (table 6) that females were more likely to have better glycemic control than males (OR 1.22 [95%CI 1.10-1.35]) but males had better LDL control (OR 0.72 [95%CI 0.65-0.79]) than females. Gender had no association with the performed measurement of HbA1c or LDL in our study. Older patients were more likely to have their HbA1c measured and LDL controlled but less likely to have their HbA1c controlled. Furthermore, in linear regression model (table 7), we found positive association of age with the HbA1c level and negative association of age with LDL level meaning that HbA1c levels were increasing and LDL levels decreasing by age. Females had significantly higher LDL levels and lower HbA1c levels compared with males.
Table 6: Multivariate logistic regression model explaining the effect of gender and age on process indicators and outcomes care of type 2 diabetes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Is HbA1c measured after 3 month of diagnosis? (0=no, 1=yes) n = 10168</th>
<th>Is LDL measured after 1 month of diagnosis? (0=no, 1=yes) n = 10168</th>
<th>HbA1c level (1= 7% and above, 2= less than 7%) n = 7977</th>
<th>LDL level (1= 2.5 mmol/l or above, 2=less than 2.5 mmol/l) n = 7476</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (Reference = male)</td>
<td>1.07 (0.97 – 1.18)</td>
<td>0.97 (0.89 -1.06)</td>
<td><strong>1.22 (1.10 - 1.35)</strong></td>
<td><strong>0.72 (0.65 -0.79)</strong></td>
</tr>
<tr>
<td>Age</td>
<td><strong>1.02 (1.02 - 1.03)</strong></td>
<td>1.00 (0.99 -1.00)</td>
<td>0.99 (0.98 - 0.99)</td>
<td>1.02 (1.02 -1.03)</td>
</tr>
</tbody>
</table>

Table 7: Linear regression model assessing the effect of age and gender on HbA1c and LDL level.

<table>
<thead>
<tr>
<th>Variable</th>
<th>HbA1c value after 3 month of diagnosis n = 7977</th>
<th>LDL value after 1 month of diagnosis n = 7476</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B-coefficients</td>
<td>95% CI</td>
</tr>
<tr>
<td>Gender (0= male, 1= female)</td>
<td>- 0.039</td>
<td>(- 0.15 - (- 0.040))</td>
</tr>
<tr>
<td>age</td>
<td>0.048</td>
<td>(0.003 - 0.007)</td>
</tr>
</tbody>
</table>

Table 8 presents the result of the multivariate logistic regression model showing the association of comorbidities and outcomes of diabetes care adjusted by age and gender. The patients diagnosed with only diabetes were our reference group. All the patients with concordant or discordant diseases or both were more likely to have their HbA1c measured compared with those who had only diabetes. Those who had both concordant and discordant illnesses were almost twice more likely to have HbA1c measurement than those with only diabetes (OR 1.98 [95% CI 1.73- 2.27]). All the comorbidity groups were more likely to have their LDL measured compared with those who had only diabetes. The odds ratio was highest in the group with type 2 diabetes and concordant diseases. However, the likelihood of having LDL measured was lowest in the group with discordant diseases. All patients with comorbidity were more likely to have both laboratory markers measured than patients with only diabetes.
On other hand, patients with discordant comorbidities had increased likelihood to achieve HbA1c goal than without any comorbidity. However, diabetes patients with both comorbidities were significantly less likely to have recommended HbA1c level than without any comorbidity (OR 0.83 [95% CI 0.71-0.97]). Recommended level of LDL had been achieved significantly better by groups with concordant diseases and both comorbidities (OR 1.79 [95% CI 1.55-2.08], OR 1.53 [95% CI 1.33-1.78]) compared with group with diabetes only.
Table 8: The impact of outcomes of diabetes care by different comorbidity groups adjusted by age and gender.

<table>
<thead>
<tr>
<th>Comorbidity group</th>
<th>HbA1c measured after 3 months from diagnosis (0=no, 1=yes) n = 10168</th>
<th>LDL measured after 1 month from diagnosis(0=no, 1=yes) n = 10168</th>
<th>Both laboratory markers measured</th>
<th>HbA1c level (1= 7% and above, 2= less than 7%) n = 7977</th>
<th>LDL level (1= 2.5 mmol or above, 2=less than 2.5 mmol/l) n = 7476</th>
<th>Both outcome goals achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM only (Reference group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM+ Concordant only group(3)</td>
<td>1.66 (1.45 - 1.90)</td>
<td>1.85 (1.62 - 2.11)</td>
<td>1.74 (1.53- 1.98)</td>
<td>1.03 (0.87- 1.21)</td>
<td>1.79 (1.55 - 2.08)</td>
<td>1.54 (1.32 – 1.79 )</td>
</tr>
<tr>
<td>DM+ Discordant only group(2)</td>
<td>1.30 (1.09 - 1.55)</td>
<td>1.19 (1.00- 1.41)</td>
<td>1.20 (1.02-1.41)</td>
<td>1.26 (1.02-1.57)</td>
<td>1.25 (1.03 - 1.52)</td>
<td>1.22 (1.00-1.49)</td>
</tr>
<tr>
<td>DM+ Both types of comorbidities group</td>
<td>1.98 (1.73- 2.27)</td>
<td>1.77 (1.56 - 2.02)</td>
<td>1.74 (1.53-1.98)</td>
<td>0.83 (0.71- 0.97)</td>
<td>1.53 (1.33 - 1.78)</td>
<td>1.25 (1.07 – 1.45)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.02 (1.01 - 1.02)</td>
<td>0.99 (0.98 - 1.00)</td>
<td>0.99 (0.99-1.00)</td>
<td>0.99 (0.98 - 1.00)</td>
<td>1.02 (1.01 - 1.02)</td>
<td>1.01 (1.00-1.02)</td>
</tr>
<tr>
<td>Gender (reference: male)</td>
<td>1.07 (0.97-1.18)</td>
<td>0.99 (0.90-1.08)</td>
<td>0.99 (0.91—1.09)</td>
<td>1.22 (1.11-1.35)</td>
<td>0.73 (0.67-0.81)</td>
<td>0.89 (0.81-0.98)</td>
</tr>
</tbody>
</table>
6 DISCUSSION

We assessed the quality of diabetes care in North Karelia, Finland and determined how it varied in different comorbidity groups in 10,168 patients. We also assessed the quality of diabetic care by age and gender of subjects. Our study reveals that diabetic patients with concordant diseases are more likely to have overall better care and achieve recommended treatment goals than those having only diabetes. Similar result was also seen in patients with both concordant and discordant diseases having considerably better care (except HbA1c goal) than those who had diabetes and discordant conditions or only diabetes. However, we found that discordant conditions were not associated with worse diabetes care and outcome, rather it resulted in better care compared with no comorbidities. In general, our study results suggest that diabetic patients with comorbidity have better care and control than those without any comorbidity, with the exception of achievement of targeted HbA1c level by the patients with both types of comorbidities.

6.1 Quality of diabetes care by concordant diseases

Our results showed that diabetic patients with concordant diseases were more likely to have better care than those who had only diabetes. This result is supported by previous literature showing the same impact of concordant comorbidity on diabetes care and control. Woodard et al. (2011) reported that patients with concordant comorbidities had received over all better care and control of glucose, LDL and blood pressure than the patients without comorbidities. Similar result was also found in a study by Magana et al. (2015a) stating that concordant diseases were associated with achieving better diabetes treatment goals whereas discordant diseases were not (except HbA1c control). Few other studies have also found better diabetes care among those who had diabetes and concordant chronic conditions (Lagu et al. 2008, Aung et al. 2013, Magnan et al. 2015a)

Also opposite results have been observed in previous studies. For instance, Pentakota et al. (2012) found among veteran diabetic patients who had concordant diseases, they had similar care compared with those patients without any comorbidity. An observational study of quality of diabetes care in the eight Dutch diabetes care groups also showed insignificant differences of diabetes care between the patients with or without comorbidity mainly due to skillful health care provider and management program in Dutch health care (de Bruin et al. 2013). Hudon et
al. (2008) suggested that achievement of controlled glucose level is not dependent upon the number of comorbidities, but it rather depends upon the duration of diabetes.

6.2 Quality of diabetes care by discordant diseases

In our study, discordant diseases such as, depression, anxiety disorder and dementia were associated with better quality of diabetes care compared with those who had only diabetes. This finding is supported by earlier study which showed that diabetic veterans with mental disorders had better diabetes care in indicators, like, retinal examination, foot examination and HbA1c determination (Desai et al. 2002). Woodard et al. (2011) also reported that diabetic patients with only discordant diseases were more likely to have better control of glucose and lipids than patients with other comorbidities. The possible explanation for better care could be due to multiple visits sought by the comorbid patients (Piette & Kerr 2006). However, the different clinical presentation and management plan for mental disorder may draw more attention from the providers.

In contrast, our result is different from the result of a previous study by Pentakota et al. (2012). They found that discordant diseases reduce the quality of diabetes care. This opposite result may be driven by the fact that they included terminally ill patients with dominant conditions and life threatening conditions (such as, end-stage renal disease, liver disease, metastatic carcinoma) which result higher attention and priority for management and may divert attention from diabetes care (Piette & Kerr 2006). Keating et al. (2007) found in his study that diabetic patients with cancer may have less care than patients without history of cancer. In addition, some studies found comorbid disorder, for example, depression as a strong barrier for diabetes care and patients with such conditions received less care or inconsistent care than patients with other comorbidity and diabetes (Desai et al. 2002, Frayne et al. 2005).

6.3 Quality of diabetes care by both concordant and discordant diseases

Another important finding in our study was that the patients who had both concordant and discordant comorbidities were more likely to have better diabetes care, with the exception of achievement of targeted HbA1c level. This result is also indicating that those who had more than one chronic illness had probably better care than the patients with single chronic disease. This result is supported by previous study from adult patients including veterans and vulnerable elderly patients from the three cohort communities. This study reported that patients with
higher number of chronic diseases received better quality of care (Higashi et al. 2007). Bae & Rosenthal (2008) also reported that diabetic patients with more than one chronic diseases, either concordant or discordant, were more likely to have HbA1c tests and eye examinations performed and had higher number of physician visits.

Few other studies, however, have reported the opposite results. Halanych et al. (2007) concluded in his study that patients with multiple chronic diseases are less likely to receive HbA1c and lipid test than patients with a single disease. This study examined only subject who were older than 65 years who are more likely to have more disease burden and physician may overlook routine tests for diabetes. El-Kebbi et al. (2001) concluded in his cohort study of diabetes patients that the relationship between comorbidity and glycemic control was insignificant whereas age of the patients and duration of diabetes were more likely associated with glycemic control.

One notable finding in our study was that the HbA1c goal was less likely achieved in patients with both concordant and discordant diseases. This finding is in line with previous literature showing the similar impact of both comorbid conditions on achievement of HbA1c goal (de Bruin et al. 2013). The possible explanation for this variation could be the higher number of diseases or mix of diseases which may include critical illness that may cause physician to overlook the achievement of targets. The patient may also have diseases, conditions or otherwise such a health status that does not allow for such tight control of HbA1c (<7%). The recommendations of treatment goal by ADA mainly depend upon the health status and characteristics of the older diabetic patients. For instance, HbA1c < 7.5 % is recommended goal for relatively healthy patients with few chronic illneses. For those who have complex health status with multiple chronic conditions, recommended goal is <8.0 %. For older diabetic patients having more complex disease and poor health status (end-stage chronic diseases) with limited life expectancy the recommended HbA1c goal is <8.5 % (American Diabetes Association 2013).

6.4 Quality of diabetes care by any comorbid condition

Our result also suggested that diabetic patients with any type of comorbidity were more likely to have better diabetes care than patients without any comorbidity. This finding is consistent with many prior studies which have argued on various factors that might be responsible for playing key role in quality of diabetes care. Many authors have agreed on the fact that comorbid
patients receiving better diabetes care might be due to the higher number of visits to physician and higher health care utilization (Struijs et al. 2006, Bae & Rosenthal 2008, Pentakota et al. 2012). Struijs et al. (2006) observed that the increased health care utilization was largely dependent on the vascular and non-vascular complications of diabetes. In addition, frequent visits by comorbid patients to the health care provider could develop a good physician-patients relationship which may be a contributing factor for adherence to the diabetes management resulting better outcomes of diabetes care (Kerse et al. 2004, Osterberg & Blaschke 2005). In contrast, diminished capability in self-care of diabetic patients could be a reason for poor quality of diabetes care. It is observed in diabetic patients that chronic pain or vascular complications such as diabetic retinopathy are strong barriers for self-care (Krein et al. 2005, Kerr et al. 2007).

Another potential reason for comorbid diabetes patients to receive better care is the treatment prioritization given to those who have clinically dominant illnesses, symptomatic illnesses or high risk for cardiovascular diseases (Laiteerapong et al. 2011). Sometimes, physicians are intensified to manage hypertension and blood glucose of diabetic patients with concordant disease and recent onset of complication (Voorham et al. 2012). Similarly, providers usually prioritize the treatment of coexisting illnesses in a complicated diabetes case. For example, CVD is one of the major common consequences of uncontrolled diabetes which draws the treatment priority to control hypertension and hyperlipidemia for preventing CVD (American Diabetes Association 2011).

Conversely, quality of diabetes care is also varied upon individual concordant or discordant diseases. For example, Magnan et al. (2015b) assessed the relationship of 62 chronic conditions with the quality of diabetes care. The quality of diabetes care was varied from disease to disease. For instance, patients having major conditions including depression and obesity failed to achieve recommended HbA1c level. Kidney testing was remarkably high in patients with renal failure. On the other hand, patients with diseases like congestive heart failure (CHF), hypertension, and obesity failed to achieve LDL and blood pressure goals to prevent cardiovascular risk of diabetic patients. However, discordant diseases such as osteoarthritis, cancer and gout had significant positive association with HbA1c control goal achievement. The results also showed that patients having cardiovascular and mental diseases (which were 33 diseases out of 62 studied) most likely failed to achieve both recommended treatment target and testing goals.
6.5 Quality of diabetes care by age

Our study revealed that older patients were more likely measured for HbA1c but had higher HbA1c level than younger patients. It was also revealed in our study that older people were more likely to have higher diseases burden. This finding is consistent with a cross sectional study by Selvin et al. (2006) showing that diabetic patients who are aged more than 65 years, had higher prevalence of comorbid diseases and higher HbA1c level. Similar result was also found in US in a population based cross-sectional survey (1988-1994 and 1999-2004) which concluded that the incidence of comorbidity increased with age and poor glycemic control was observed in those older patients who had higher number of comorbidities. This study also observed that the percentage of patients who had higher LDL-cholesterol reduced by 30% among older patients between the two phases of the survey (Suh et al. 2008). Our result also reflects this similar observation that the older diabetic patients were more likely to have lower LDL levels and to achieve LDL target than younger.

However, in our study the proportion of patients whose HbA1c was measured was higher among older patients although the target of HbA1c (<7%) was less achieved. The rationale for this finding could be the older patients with higher comorbidity burden including diabetes may have more adherence to health care system and are thus better followed up for treatment regularly. In addition, tight control of HbA1c is not always beneficial. It depends upon the individual health status, comorbid condition, complications and life expectancy. Furthermore, tight glycemic control in frail older patients could be risk for hypoglycemia, drug to drug or diseases interaction and brings more harmful effects than benefit (Brown et al. 2003). Controlling blood glucose by oral anti-hyperglycemic drug, for example metformin, is contraindicated in renal diseases or in heart failure, which could be potential reason for higher glucose levels in older diabetic patients with such comorbidities (GLUCOPHAGE 2009).

However, tight glycemic control is recommended and beneficial for older people who are healthy, cognitively intact and with long life-expectancy (American Diabetes Association 2011).

6.6 Quality of diabetes care by gender

Our result suggests that females are more likely to achieve HbA1c treatment goal and have lower HbA1c level than males. This finding is supported by a cross sectional study among high
risk patients who were selected from Pathways study (which is a prospective observational cohort study to determine the prevalence of depression in diabetes patients and the impact of depression on diabetes outcomes in USA). The study found that females were more likely to have better odds of glycemic control than males (Yu et al. 2013). The higher use of health services and higher number of comorbidity among diabetic females compared with males could partly explain this (Shalev et al. 2005). It has been also observed that adherence to insulin and oral anti-glycemic drugs is higher in diabetic females than males (Franzini et al. 2013). Women with some chronic diseases like asthma or mental diseases are frequently visiting health center which could be one factor for their better care (Hoff et al. 1998, Osborne et al. 1998). Attendance to diabetes education and the level of diabetes self-care and awareness are more common in females which might also be potential reasons for better diabetes care in females than males (Gucciardi et al. 2008).

Contrary to our findings, it has also been observed in some studies that females are more likely to have poor glucose control. The authors argued this to be largely because physicians may be inclined to prescribe minimum dose of required medicine and females are more likely to have poor adherence to treatment plan (Franzini et al. 2013, Rossi et al. 2013).

In our study, female diabetic patients had poor LDL control and higher LDL levels than males. These gender disparities have also been commonly observed in many prior studies that females have higher LDL levels and are less likely to achieve the LDL treatment target compared with males (Franzini et al. 2013, Rossi et al. 2013, Yu et al. 2013). A study suggested that female diabetics with CHD were less likely to receive lipid lowering drug or CHD risk modifiable drug (Aspirin) than males which could result higher LDL levels and poor achievement of treatment targets (Wexler et al. 2005). However, in another cross sectional study, there were no gender differences observed in the adherence to lipid lowering and anti-diabetes medication among diabetic patients in 229 primary health care centers in Sweden (Nilsson et al. 2004).

Nonetheless, our study did not find any significant gender differences in HbA1c and LDL measurement activity which was supported by previous study in women veterans (Tseng et al. 2006). It is likely that the access to the health care in Finland is equal for all patients regardless their gender.
6.7 Overall quality of diabetes care in our study

The proportion of diabetes patients whose HbA1c and LDL had been measured was rather high in our study (78.4%, 73.4%). The achievement of HbA1c treatment goal (71.5%) was relatively good, but more than half (54.6%) of our subjects failed to achieve LDL goal. In nutshell, seven out of ten patients had both HbA1c and LDL measured in the follow-up and one patient out of three had achieved controlled level. Our result is in line with a population-based study from Sweden showing that 84% of the study patients had annual measurement of HbA1c performed and 60% had achieved acceptable range (HbA1c: 6.5% - 7.5%) (Farnkvist & Lundman 2003).

Another study by Beaton et al. (2004) found that HbA1c and LDL measurements were common in diabetic patients but goal achievement for LDL was poor. More recent study from Sweden also showed that the measurement activity and control level of HbA1c is better than of LDL (Sundquist et al. 2011). In that study only one third achieved LDL target.

One potential reason for poor LDL achievement could be lower adherence to lipid lowering medication than to anti hyperglycemic medication (28 % vs 72 %) (Beaton et al. 2004). It could also be the health professionals treating diabetes patients are still concentrating more on glycemic control to avoid microvascular complications than to treat risk factors of macrovascular complications. Uncontrolled LDL cholesterol level is one of the major risk factors for cardiovascular diseases in diabetes patients. However, other studies suggest that the poor achievement of LDL targets is more likely due to multiple coexisting risk factors in diabetes patients in addition to high level of LDL such as, obesity, comorbidities and age (Spann et al. 2006, Rifas-Shiman et al. 2008). Authors of North Carolina Medicare study claimed that lower rate of LDL measurements in diabetes patients was more likely associated with socioeconomic factors, comorbid conditions and age of the patients (Massing et al. 2003).

In our study 21.6% of patients had not been measured for HbA1c during the follow-up. One possible reason for this might be that they are self-monitoring blood glucose and thus do not find the follow-up is necessary in health care (Bruno et al. 2012). In Lebanon University health care, 99% of diabetic patients had been measured for fasting plasma glucose. On the other hand, only 40% had had HbA1c measurement which is the most important test for estimating glycemic control. Poor levels were observed in both glucose and lipid control, but blood pressure control was good. The authors suggested that well-structured health education and the standard guidelines followed by physician could improve diabetes care (Akel & Hamadeh 1999). Education can be important predictor of good diabetes control. In North Karelia it was
found that better diabetes care was more likely achieved in the areas where the level of education is high (Sikio et al. 2014).

A relatively new concept of comorbidity interrelatedness which was introduced by Zulman et al. (2014) might play a significant role in the quality of care. According to the concept, different comorbidities interact with each other producing more complex condition where the providers might face the challenges of diagnostic uncertainty, selection of medication and following guideline recommendations. Subsequently, patients’ behavior, socioeconomic status, cultural influences and social support also influence producing complexity in the quality of care. The authors raised up critical issues like choosing the proper guideline to be followed in comorbid conditions and choosing medication in such condition where drug to drug interactions or drug to diseases interactions are very common. The study concluded that such ‘multimorbidity interrelatedness’ should be considered while measuring quality of care.

6.8 Strengths of this study

The large number of study subjects without selection bias is clearly a strength of this study. As the data is collected from patient records, it includes all the patients treated either in primary or specialized care in North Karelia. Such data is not affected by the difficulties of non-response. There are some private occupational health clinics not using the Mediatri electronic patient records in North Karelia. Some patients might use only these occupational health services and would thus be missing from our data. However, the number of those patients is marginal and it is unlikely that this would affect the results.

For register based studies, the level and the quality of data recording is essential. In North Karelia, it has been observed that for example the percentage of physician visits in primary health care having diagnosis recorded is very high (Laatikainen et al. 2013).

All of the municipalities in North Karelia are using the same regional laboratory and thus the same standardized techniques applied for HbA1c and LDL measurement ensuring the comparability of results between patients. There is very little chance for missing information of laboratory investigations since the results are transferred directly from the laboratory to the electronic patient database.
6.9 Limitations of the study

Our study had many limitations. Firstly, it was not possible to include all diabetes cases in North Karelia since many people still are undiagnosed in Finland (Finnish Diabetes Association 2015a). Therefore, our study obviously did not have data of those patients who had not used health services during our study period. Also utilizing parallel health services such as occupational health care could have dropped some patients from our data (Sikiö et al. 2014).

Another important limitation of our study is the missing data on the onset of diseases. We were unable to get the exact date of diagnosis either for diabetes or for comorbid conditions. Thus we could not identify the order of onset and were only able to analyze the co-existent diseases.

Besides, we enlisted only most common diseases which is not reflecting all the diseases patients actually had. However, many prior studies have also taken a number of comorbidities into account for assessing quality of diabetes care. This approach can be justified by the fact that many comorbid conditions are so rare that the group of patients having them would have been too small for analyses.

We were unable to confirm the exact number of diseases existing in patients individually but we knew the type of diseases and when patient had both concordant and discordant diseases, we considered them having more than one disease. We also believe that just counting the number of different diseases together is not very informative as their severity and impact to primary disease or its treatment can vary remarkably. Cancer alone might be having much bigger effect than hypertension, non-malignant tumor and gout together. Furthermore, we did not include in our disease list many dominant conditions associated with short life expectancy (for example, end-stage kidney and liver diseases or class IV heart failure) which could have strong impact in outcomes of diabetes care (Pentakota et al. 2012).

Quality of diabetes care is also associated with the number of visits by patients to the health care as this relationship has been observed in many studies. We could not analyze the impact of health care visits on quality of diabetes care. Most of the prior literature shows that individual socioeconomic status is associated with quality of diabetes care. We could not asses this in our study as such information is lacking in the electronic patient records.
7 CONCLUSION

In summary, we found that elderly diabetic patients achieved better outcomes in diabetes care, probably partly due to their higher number of comorbidities. Younger adults who had only diabetes reached the poorest outcomes. It is obviously an area to focus further research and to pay attention to this population group in health care processes and guidelines. Furthermore, LDL measurement rates and achievement of goals was lower than for HbA1c. This level of care is not adequate to prevent future cardiovascular consequences related to diabetes. It is essential to develop new strategies for prevention of modifiable risk factors to minimize diabetes complications and other comorbidities. Life style modification and adherence to medication in diabetes patients particularly require special attention in future.

In spite of rather good achievements in diabetes care in North Karelia, there is still room for improvement. Some people are undiagnosed and some are not attending the follow-up screenings. It is worth to study further, for example, the barriers for the attainment of diabetes care goals considering socioeconomic factors and structure and processes in the health care.
8 REFERENCES


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