Study design: Retrospective cohort study using secondary health data

Title: Creation of the Edmonton Obesity Staging System Dashboard: a retrospective cohort study using EMR data

Running Title: EOSS Dashboard

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Ethics

The project was approved by the University of Alberta Research Ethics Board (Pro00074666).

Contributors

DCS, RY, KL, AMS and DM conceived the project idea.
DCS, RY, DM, KL, AMS, RS, TMcG designed the study methods.
TMcG and TM completed the data analysis.
DCS, RY, TM, TMcG, and RS wrote the manuscript. RS, DM, KL, AMS, DCS, and RY refined the discussion and conclusion. All authors had access to data and analyses, reviewed the final manuscript and provided comments, and can take responsibility for data integrity and accuracy.

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ABSTRACT

Background: The Edmonton Obesity Staging System (EOSS) is a better predictor of mortality than body mass index (BMI). The feasibility of determining EOSS in administrative health data and creating clinical dashboards has not been demonstrated.

Methods: Data were extracted from the Northern Alberta Primary Care Research Network database and patient EOSS scores were assigned. Individuals ≥ 18 years old, with a BMI ≥ 30 and ≤ 60 kg/m^2 who had at least one visit from July 2016 to July 2019 with primary care clinicians contributing data to NAPCReN were included (n=23,460). Descriptive statistics and ordinary least squares regressions were conducted to describe the population.

Results: Of the 23,460 patients included, the majority had obesity class I (54%), and an EOSS score of 2 (53%), indicating established obesity-related comorbidities. Of the variables included, age was the main factor that explained EOSS variation (31%). Missing data ranged from 11-18% for comorbidities, with 97.7% of patients being able to be assigned an overall EOSS score. An obesity dashboard for primary care patient panels was created using the Canadian Primary Care Sentinel Surveillance Network Data Presentation Tool.

Interpretation: We demonstrated that the EOSS comorbidity-driven approach of risk stratification provides a more nuanced assessment than BMI alone. The dashboard makes this information easily accessible for quality improvement and individual clinical care. A high proportion of patients in our region are in the EOSS 2 category, providing an opportunity to intervene to improve clinical outcomes for people living with obesity.

Introduction

The 2020 Canadian Adult Obesity Clinical Practice Guidelines published in the CMAJ (1), highlight the recognition of medical comorbidities driving increased morbidity, mortality and health system costs for people living with obesity (2-6). Obesity is a highly prevalent chronic disease, defined as abnormal or excess adiposity that is causing physical or metabolic harm (7). There is a need for early person-centred interventions in primary care to prevent excessive weight gain and development of obesity-related comorbidities. The Edmonton Obesity Staging System (EOSS) incorporates functional status and comorbidities associated with obesity and provides an opportunity to understand the impact of obesity on an individual beyond weight status (8). In 2011, the EOSS was demonstrated to be an independent predictor of mortality among patients with obesity and was proposed to be used as a prognostic tool in obesity in conjunction with body mass index (BMI) (8).

EOSS uptake is hindered in practice due to a lack of access to clinical information. In this study, we examined data from the Northern Alberta Primary Care Research Network (NAPCReN) to determine the feasibility of using health administrative data to determine EOSS in primary care, and highlight the benefits of using the EOSS to classify obesity and guide management. We hope that the creation of a widely accessible primary care dashboard will facilitate a more systematic comorbidity- driven approach to risk stratification for individuals living with obesity. The dashboard can also be used as a tool to support practice-based quality improvement for the management of obesity.

Methods

Data Collection & Analysis

Data were extracted from the Northern Alberta Primary Care Research Network (NAPCReN) database. NAPCReN is one of 10 primary care research networks in Canada that contributes electronic medical record data to the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) (9). This data is heterogeneous. Physicians' practices voluntarily contribute to the database.

Administrative databases provisioned by Alberta Health Services were initially queried for heights and weights so that patient BMIs could be calculated. We discovered that these measures were not recorded in provincial databases, making it impossible to risk stratify the most common chronic disease in Alberta. NAPCReN data in the CPCSSN network records patient heights and weights as captured in routine clinical care, therefore it was chosen for use in this study.

A cross-sectional population-based analysis was conducted. Individuals ≥ 18 years old who had a BMI ≥ 30 kg/m^2 and at least one visit with primary care clinicians contributing data to NAPCReN between July 1, 2016, and July 1, 2019, were included. As BMI validation measures were not in place at the time of extraction, patients with a BMI greater than 60 kg/m^2 were excluded from the analysis due to concerns for accuracy of coding and apparent erroneous measures. This study received ethics approval from the Health Research Ethics Board (Pr000074666) at the University of Alberta, Edmonton.

Assigning EOSS scores

The EOSS classification system was used to evaluate obesity-related comorbidities and was modelled on the work of Padwal (Appendix 1;8). Scores range from 0 to 3, where a higher score indicates higher risk of mortality (8). An individual's overall EOSS score is calculated by assessing several comorbidities:

hypertension, diabetes mellitus, osteoarthritis, liver disease, dyslipidemia, kidney disease, and vascular disease (coronary heart disease/congestive heart failure and cerebrovascular disease diagnosed). Each individual comorbidity receives a score ranging from 0 to 3; 0 is assigned if no obesity-related risk factors are present, 1 indicates that obesity-related subclinical risk factors are present, 2 indicates established obesity-related comorbidities, and 3 is used for severe disease. Once an EOSS score is assigned to each comorbidity, the highest EOSS score amongst all comorbidities is used as the overall EOSS score for the individual. For example, if a person has a score of 2 for liver disease, a score of 1 for hypertension, and a score of 0 for kidney disease, an overall EOSS score of 2 is assigned. People with osteoarthritis, coronary heart disease/congestive heart failure, or cerebrovascular disease were assigned a score of 3; we did not differentiate severity of disease for these comorbidities.

For clarity, "EOSS score" will be used to discuss scores for individual comorbidities, where "overall EOSS score" will be used for an individual's overall assigned scores based on their highest EOSS score across all comorbidities. EOSS scores will be referred to as no clinical risk factors (EOSS 0), subclinical risk factors (EOSS 1), established disease (EOSS 2), and severe disease (EOSS 3).

Obesity-related comorbidities

The data definitions for the EOSS comorbidities are included in Appendix 1. CPCSSN Case definitions are available from http://cpcssn.ca/wp-content/uploads/2019/07/CPCSSN-Case-Definitions-v2.pdf.CPCSSN definitions were used for hypertension, diabetes, and, osteoarthritis. Where additional granularity was needed or no definition was available, we used a combination of laboratory codes, medication Anatomical Therapeutic Chemical (ATC) codes, and International Classification of Diseases, Ninth Revision, Clinical Modification (ICD 9) codes. This approach was used for liver disease, dyslipidemia, kidney disease, and vascular disease (coronary heart disease/congestive heart failure and cerebrovascular disease diagnosed). If an individual's EOSS score could not be calculated for a certain comorbidity due to non-recorded measurements, an EOSS score was not provided for that comorbidity. As patients had multiple lab test results reported throughout the study period, depending on the lab test, the minimum or maximum value was used to calculate their comorbidity EOSS score (Appendix 1).

Demographic categorization

Both continuous and categorical BMI values were used for the analyses. BMI categories were assigned as Class 1 Obesity (30-34.9 kg/m^2), Class 2 Obesity (35-39.9 kg/m^2), and Class 3 Obesity (≥40 kg/m^2). Sex was dichotomized as male and female.

Data analyses

Oracle SQL Developer was used to clean and modify the data. All analyses were conducted using Python 3.4 and Stata 16. Ordinary least squares regression models were built using a step-wise approach to describe the relationship between overall EOSS scores, BMI, sex, and, age.

Dashboard

In collaboration with the NAPCReN unit affiliated with the Canadian Primary Care Sentinel Surveillance Network (CPCSSN), we created a primary care dashboard prototype in their Data Presentation Tool. Each family physician sentinel surveillance system member of CPCSSN provides access to their electronic medical record. This permits the physician to see patients: age, sex, EOSS score, BMI, time since last visit, distance they live from clinic, medical comorbidities, relevant medications, blood pressure,

smoking status, key laboratory values (total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), fasting blood glucose (FBS), hemoglobin A1c, estimated glomerular filtration rate (GFR), aspartate aminotransferase (AST), alanine aminotransferase (ALT).

Results

58,672 patients over the age of 18 were identified in the NAPCReN database during the study period. We included those with BMI ≥30 kg/m^2 and ≤60 kg/m^2 who had a valid age and sex recorded. 8036 did not have BMI recorded and were excluded from the analysis. Among the patients with BMI recorded, 477 had BMI >60 kg/m^2 and were excluded due to the risk of an erroneous entry which may have resulted from use of imperial instead of metric units when entering data into the electronic medical record. Eleven patients had no recorded value for sex and were also excluded from the analyses.

In total, 23,460 patients were included in our analysis. 45.1% of patients were male, with the mean age being 54.3 years. Most patients were classified as having Class I obesity (54.4%), 26.6% had Class II obesity, and 19.0% had Class III obesity (Table 1). Majority of patients had an overall EOSS score of 2 (52.9%). 97.7% of people could be assigned an EOSS score based on the available information (Table 1). Given that there was missing data, there could be changes in EOSS scores with additional information.

[Insert Table 1 here]

Proportion of missing data was highest in the dyslipidemia category (17.8%) followed by liver disease (15.2%). Among the patients in whom we could assign EOSS scores (Figure 2), 2.3% had cerebrovascular disease, 8.5% had coronary heart disease and/or congestive heart figure, and 14.7% had osteoarthritis (EOSS 3). The majority had established hypertension and dyslipidemia (EOSS 2). Over half of the population had subclinical risk factors for diabetes (EOSS 1), with 20.3% having established diabetes. Kidney and liver disease were the least prevalent comorbidities with up to 80% of patients falling into the EOSS 0 category.

[Insert Figure 1 here]

[Insert Figure 2 here]

A stepwise OLS model was built to describe the relationship between EOSS and age, sex, and BM. Age alone describes 31% of the variation in EOSS scores; as age increases, overall EOSS score increases. Sex and BMI all explain very little of the variation in EOSS scores accounting for just over 1% of variation combined (Table 2).

[Insert Table 2 here]

When we compared individual BMI and overall EOSS scores, EOSS was a better risk stratification tool (Figure 3). For example, there were patients with obesity class I who fell into EOSS 2 and 3 categories due to established comorbidities.

[Insert Figure 3 here]

An obesity dashboard for primary care patient panels was created using the Canadian Primary Care Sentinel Surveillance Network Data Presentation Tool (Appendix 2).

Interpretation

Recognizing the importance of comorbidities in the classification of obesity, we have demonstrated the feasibility of using a combination of clinical and health administrative data from primary care practice to calculate EOSS scores and create a dashboard. In this data set, we were able to assign overall EOSS scores in 97.7% of patients. Comorbidity EOSS scores were assigned to 82 - 88% of patients, the highest proportion being for hypertension. 11-18% did not have the measurements required to assign them a comorbidity EOSS score. Among missing variables were measures of triglycerides and ALT, both of which have prognostic relevance in obesity. Triglycerides have been demonstrated in the literature to be associated with insulin resistance and ALT is now recommended in the new Canadian Adult Obesity Clinical Practice Guidelines to be used as a screen for nonalcoholic fatty liver disease (1,10).

Of those who could be assigned scores, 53% had an overall EOSS score of 2, indicating a high prevalence of established obesity-related comorbidities. Age was the main factor that explained variation in EOSS scores, with minuscule increases when sex and BMI were added onto the regression analysis. EOSS scores increased as age increased. The fact that the majority of individuals in our cohort were classified in the EOSS 2 category identifies a large subset of patients that we could provide targeted interventions to prevent development of obesity-related end-organ damage.

We have also demonstrated that the EOSS comorbidity driven approach of risk stratification provides a more nuanced assessment than BMI alone. EOSS has been shown to be predictive of mortality (8) and can be used as a tool to shift the conversation from weight management and weight loss alone, which is largely unsuccessful and highly stigmatized in our society (11), towards health preservation and prevention of disease as it relates to weight. This focus on patient-centred health outcomes has been highlighted in the new Canadian Adult Obesity Clinical Practice Guidelines (1). Using EOSS also provides an opportunity for prevention and earlier intervention.

Given the established feasibility of using a combination of clinical and administrative health data to calculate EOSS scores, an obesity dashboard for primary care patient panels was created to help make the information easily accessible. The dashboard, which will be widely available, will provide primary care practices with a broad overview of their patient population with obesity, to allow identification of patients who may require closer assessment and follow up. It can also be used as a tool to promote data-driven obesity quality improvement initiatives, including supporting evidence-based screening for obesity-related comorbidities at the level of the overall practice.

Strengths and Limitations

Strengths of our study are that we analyzed data from a large cohort, utilizing a real-world clinical and administrative database to define the landscape of obesity in Northern Alberta. To our knowledge, this is the first study to define this population.

Although data in NAPCReN are not coded uniformly and data validation checks were not in place at the time of the extraction, the data was cleaned to remove any apparent outliers. It is important to note that the broader EOSS scoring system typically assesses multiple dimensions of health including physical symptoms, psychopathology, functional limitations, and impairment of well-being (12). As per other studies (8), some of these dimensions of health could not be evaluated using existing databases. Additionally, besides sex and age, data of relevant sociodemographic factors reflecting health

determinants, such as income and education levels of patients, were not reliably available. However, these additional patient characteristics could be used by primary care providers at beside and integrated into the interpretation of a patient's risk. This, together with an integration of knowledge of the person's life context, are crucial to co-creating a management plan (1,13).

Conclusion

Determining EOSS scores from electronic health data is feasible. Using EOSS instead of BMI when assessing patients with obesity is preferred, as EOSS has been shown to be a predictor of mortality and provides a more refined person-centred health outcomes approach. We have created a widely available primary care obesity dashboard to make EOSS information more easily accessible. Application of this dashboard supports patient panel management and data-driven obesity quality improvement initiatives. The majority of people with obesity in Northern Alberta fall into EOSS 2 category. While data on further dimensions of health and health determinants could be improved in future databases, the information currently available still affords an opportunity to intervene swiftly and effectively, to prevent progression of disease, and limit both the health and economic burden of obesity.

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[Insert Appendix 1 here]

[Insert Appendix 2 here]

Table 1: Demographic characteristics of patients included in the study

Characteristic	Value
N	23460
Mean age (SD)	54.3 (17.0)
% Male (N)	45.1 (10590)
Mean BMI kg/m^2 (SD)	35.5 (5.5)
BMI	% (N)
Obesity Class I (30-34.9 kg/m^2)	54.4 (12767)
Obesity Class II (35-39.9 kg/m^2)	26.6 (6246)
Obesity Class III (≥40 kg/m^2)	19.0 (4447)
EOSS	% (N)
Overall EOSS 0	2.6 (610)
Overall EOSS 1	19.3 (4525)
Overall EOSS 2	52.9 (12405)
Overall EOSS 3	23.0 (5392)
EOSS could not be calculated	2.3 (528)

Table 2: Regression results N=22,932 (528 missing/no EOSS score).

Stepwise Model: EOSS is Outcome Variable	% of variation in EOSS explained (R^2)	Additional explanatory power
Age	31.04	-
Age+Sex	31.05	0.01
Age+Sex+BMI	32.26	1.21

Figure 1: Percentage of patients whose comorbidity EOSS scores could be assigned

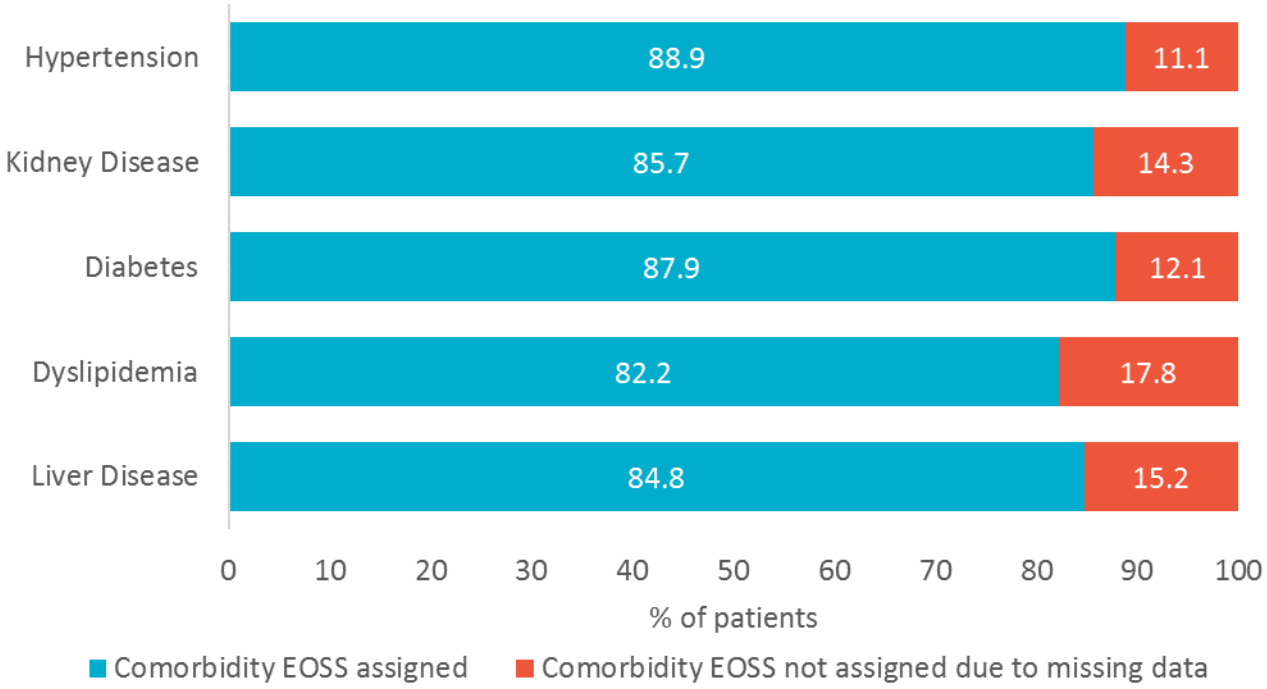
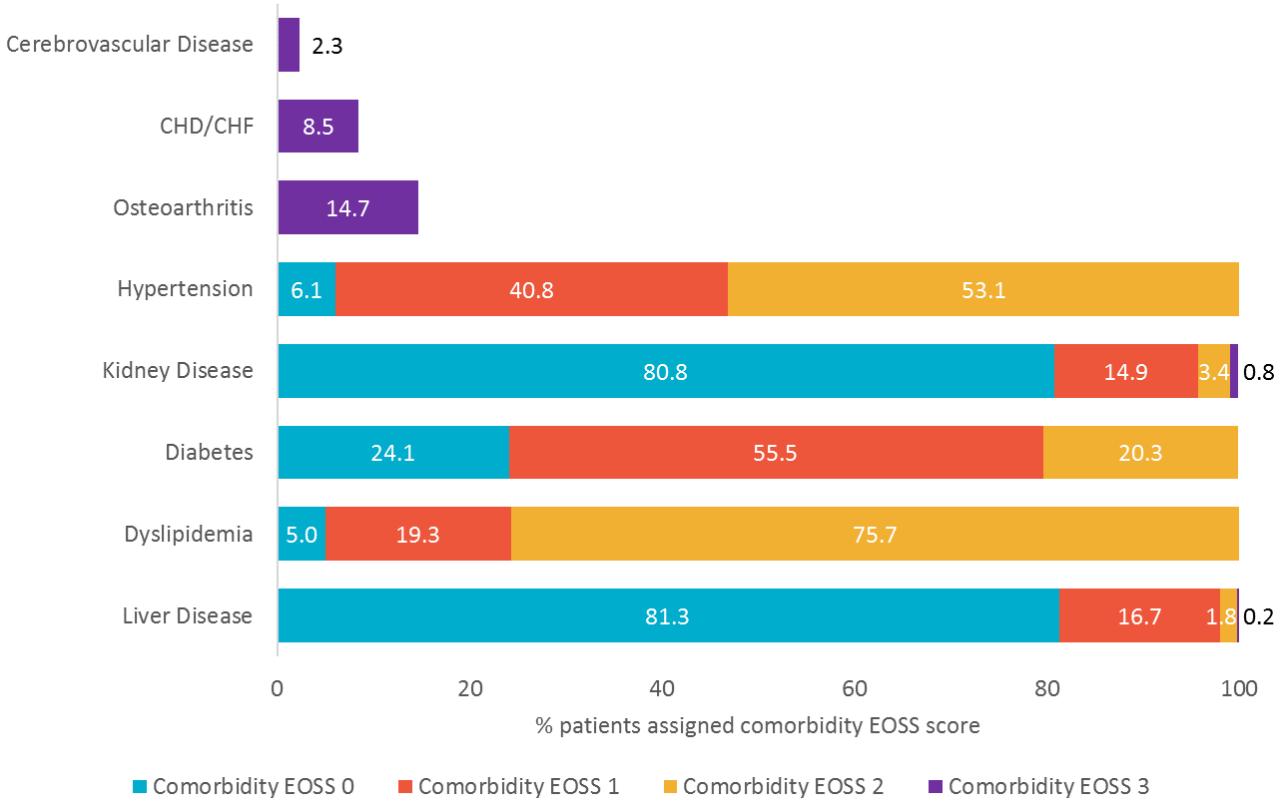


Figure 2: Percentage of population in each EOSS category for each comorbidity



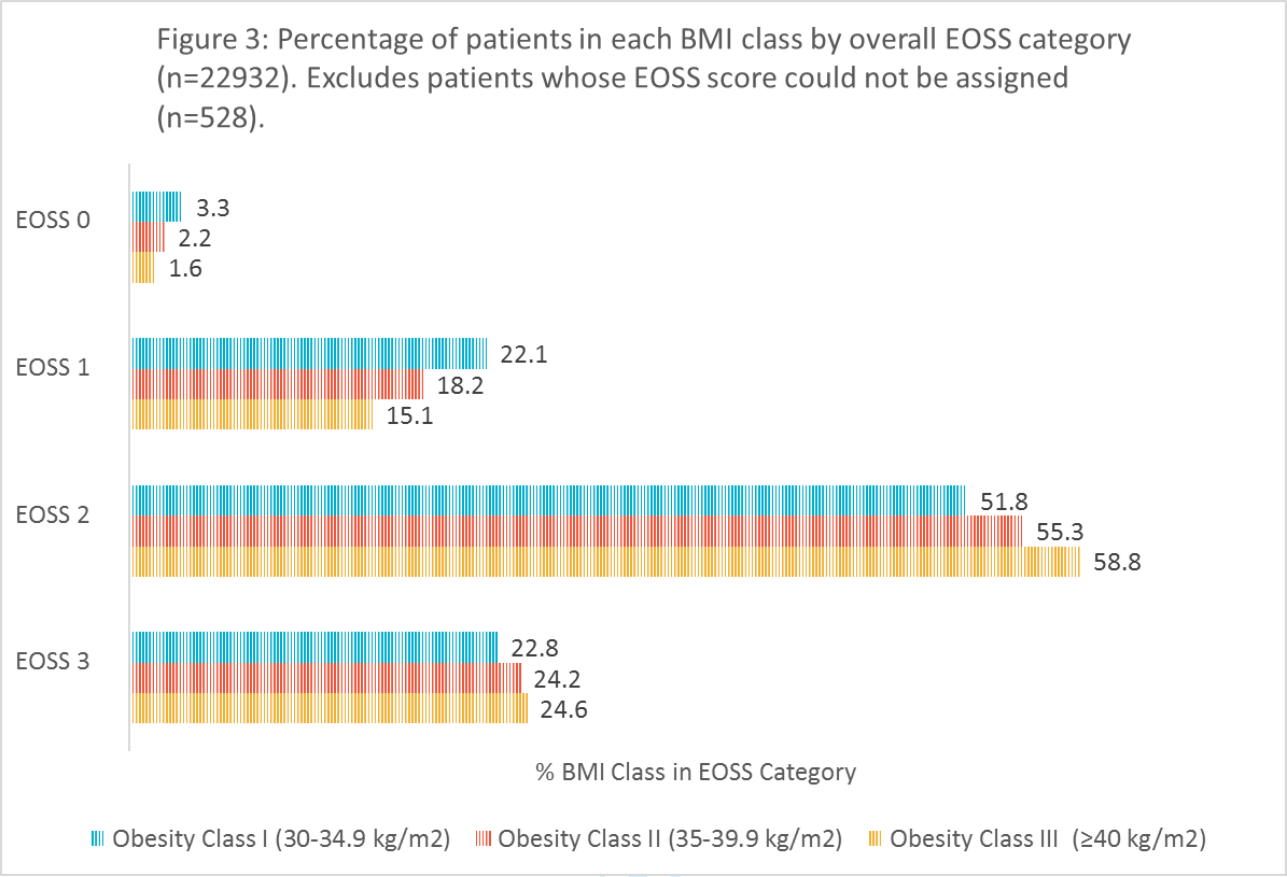


Figure 3: Percentage of patients in each BMI class by overall EOSS category (n=22932). Excludes patients whose EOSS score could not be assigned (n=528).
EOSS 0
3.3
2.2
1.6
EOSS 1
22.1
18.2
15.1
EOSS 2
51.8
55.3
58.8
EOSS 3
22.8
24.2
24.6
% BMI Class in EOSS Category
Obesity Class I (30-34.9 kg/m2)
Obesity Class II (35-39.9 kg/m2)
Obesity Class III (≥40 kg/m2)

Appendix 1: Criteria for assigning EOSS scores

COMORBIDITY	EOSS SCORES[1]			
	0	**1**	**2**	**3**
LIVER DISEASE • **Maximum ALT and/or AST from study period**	Normal liver enzymes ALT **OR** AST < 50	Elevated liver enzymes ALT **OR** AST ≥50	n/a	n/a
	No record of NASH, fatty liver disease, cirrhosis	No record of NASH, fatty liver disease, cirrhosis	Diagnosis of NASH or liver disease (ICD 9: 571.8 or 571.9)	Diagnosis of cirrhosis (ICD 9: 571.5)
DYSLIPIDEMIA • **Minimum HDL cholesterol** • **Maximum LDL cholesterol, total cholesterol, triglycerides**	**HDL cholesterol** >1.6 mmol/L	**HDL cholesterol** Males 1.0 to 1.6 Females 1.3 to 1.6	**HDL cholesterol** Males <1.0 Females <1.3	n/a
	LDL cholesterol <3.4 mmol/L	**LDL cholesterol** 3.4 to 4.0 mmol/L	**LDL cholesterol** >4.0 mmol/L	
	Total cholesterol <5.2 mmol/L	**Total cholesterol** 5.2 to 6.1 mmol/L	**Total cholesterol** >6.1 mmol/L	

	Triglycerides <1.7 mmol/L	**Triglycerides** 1.7 to 2.3 mmol/L	**Triglycerides** >2.3 mmol/L	
	No statin use	No statin use	Statin use	
DIABETES • **Maximum fasting glucose, hemoglobin A1c**	No CPCSSN Diabetes Diagnosis[3]	No CPCSSN Diabetes Diagnosis	CPCSSN Diabetes Diagnosis	n/a
	Fasting glucose < 5.6 mmol/L	**Fasting glucose** 5.6 to <7 mmol/L	**Fasting glucose** ≥7 mmol/L	
	HbA1c <6.0	**HbA1c** 6.0 to <6.5	**HbA1c** ≥ 6.5	
KIDNEY DISEASE[2] • **Minimum eGFR** • **Maximum ACR**	**eGFR** ≥60[3]	**eGFR** ≥45 to <60	**eGFR** [3] 30 to <45	**eGFR** <30
	Albumin Creatinine Ratio (ACR) <3 mg/mmol	**ACR** 3 to 30 mg/mmol	**ACR** >30 mg/mmol	

HYPERTENSION • **Maximum blood pressure**	BP<130/85* *BP <125/75 if CPCSSN diabetes	For individuals classified as having CPCSSN diabetes, SBP 125 to 129.9 **OR** DBP 75 to 79.9 Otherwise, SBP 130 to 139.9 **OR** DBP 85 to 89.9	For individuals classified as having CPCSSN diabetes ≥ BP 130/80. Otherwise BP 140/90 (only if no CPCSSN diabetes)	n/a
	No CPCSSN diagnosis of hypertension[3]	No CPCSSN diagnosis of hypertension	CPCSSN hypertension	
OSTEOARTHRITIS				CPCSSN Osteoarthritis[3]
CORONARY HEART DISEASE/CONGESTIVE HEART FAILURE				ICD9- 402* ICD9 - 410* ICD9 - 411* ICD9 - 412* ICD9 - 413* ICD9 - 414.0* ICD9 - 414.8* ICD9 - 414.9* ICD9 - 429.2* ICD9 - 428*

CEREBROVASCULAR DISEASE				ICD9 - 430* ICD9 - 431* ICD9 - 432* ICD9 - 433* ICD9 - 434* ICD9 - 435* ICD9 - 437* ICD9 - 438*

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Appendix 2: An example of the EOSS Dashboard