

**HEALTH CARE AND OUTCOMES IN PERSONS WITH OBESITY IN CANADA:
AN ANALYSIS OF CANADIAN INSTITUTE FOR HEALTH INFORMATION DATA
2018-2022**

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Abstract

Overweight and obesity are associated with physical, functional, and mental health risks across the continuum of care. The purpose of this thesis was to quantify the ICD-10 code use for overweight and obesity (E66) in healthcare settings across Canada, and explore patient care of persons with obesity within emergency departments in Ontario. This study utilized data from the Canadian Institute for Health Information Discharge Abstract Database and National Ambulatory Care Reporting System from April 1, 2018 to March 31, 2022. Regional variations in E66 use were observed, where the highest rates of coding were seen in Manitoba, and the lowest rates in British Columbia (2018-2019) and PEI (2020-2021). Ontario was the only province to show an increase in E66 coding over time. Compared to controls matched for age, sex, and main diagnosis, patients with an E66 code had higher average length of stay, longer wait time for physician initial assessment, and higher triage scores.

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Chapter 1.0 Introduction

Obesity is a chronic, progressive, and relapsing disease which is characterized by excess body fat that can impair physical (i.e. changes to normal functioning of the body), mental (i.e. changes to psychological and social well-being), metabolic health as well as quality of life (1). Obesity is also associated with a variety of health conditions including but not limited to type 2 diabetes (2,3), cardiovascular conditions (4-6), and a variety of cancers (7). According to Statistics Canada, 27% of the adults living in Canada (7.3 million adults) reported living with obesity, and a further 36% (9.9 million adults) reported being overweight in 2018 (8). Over the same period, the problem of overweight and obesity has received significant attention, including the 2006 Canadian Clinical Practice Guidelines which suggested screening, prevention, and treatment of obesity (9). More recently, the 2020 guidelines have also emphasized the importance of diagnosis, as well as the shift towards improving patient-centred health outcomes including focusing on patient's health and overall well-being, instead of focusing on just weight reduction (10). Although these guidelines provide recommendations, patterns of diagnosis and care remain unclear in Canadian healthcare in more recent years.

Thus, the purpose of this thesis will be to investigate: 1) trends of overweight and obesity diagnosis across Canada, and 2) health care for persons with overweight and obesity in Ontario emergency departments.

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Chapter 2.0 Background

2.1 Obesity

Obesity is a chronic, progressive, and relapsing disease that is characterized by the presence of abnormal or excessive fat accumulation, and presents a risk to health and social well-being (1,2). Abnormal or excessive fat accumulation can be harmful as it can alter the normal functioning of the body which can result in adverse health effects (3). These changes can be mechanical or chemical. Mechanical is caused by the extra weight putting pressure on muscles and bones which can result in joint pain, osteoarthritis, and mobility issues which in turn reduce the capacity to exercise (4). Chemical changes are defined by the changes that occur due to chemical productions from adipose tissue, where adipocytokines and inflammatory mediators are released from adipose tissue and alter glucose and fat metabolism, leading to metabolic conditions which in turn affect cardiovascular health (4).

While significant bias and stigma exist due to a prevailing notion that obesity is self-induced, research now suggests a complex array of factors such as genetics, environment, and health conditions that can lead to the onset and persistence of obesity. For example, in a systematic review of twin studies found significant heritability of body mass index (BMI) (5), with results from mixed designs showing that genetics account for 60% to 80% of the variability in body weight status of individuals with obesity (6). Obesity has also shown to be a disease of the brain (7-9), as demonstrated by functional MRI (Magnetic Resonance Imaging) studies demonstrating differences in brain activity in regions of cognitive control (10). Neural systems in charge of food intake and body weight regulation are also strongly influenced by the environment (11), where environmental factors such as the availability of high-calorie foods have been shown to promote overeating and contribute to obesity. Many other factors may

contribute to obesity, including various comorbidities, maternal smoking, medications including corticosteroids and anti-depressants, psychosocial stress, and sleep, to name a few (12).

Obesity is associated with a variety of prominent mental and physical health conditions. This includes, but is not limited to a strong relationship between obesity and depression, particularly Class III Obesity (13,14), and anxiety disorders in bariatric surgery candidates (15). Obesity is also associated with conditions such as type 2 diabetes (16,17)) several cardiovascular conditions (stroke, coronary heart disease, etc.), (18-20) and cancers (particularly breast and colorectal cancers) (21). Furthermore, obesity has also been associated with many of the other leading causes of death worldwide (22). In addition to these physical and mental health conditions, obesity is associated with a range of symptoms, including breathing difficulties and wheezing (23), fatigue (24), physical discomfort (25), and skin issues (i.e. sweating, infections, cellulite) (26).

There are several approaches to measuring obesity, the most common of which is the Body Mass Index (BMI), a simple anthropometric measure which is calculated by dividing weight in kilograms by height in meters squared (2,27). **Table 1** shows established BMI classifications, where a BMI of 25.0-29.9 kg/m² is classified as overweight, and a BMI of 30.0 kg/m² or more is classified as Obesity, where obesity is further sub-categorized into three classes: Class I Obesity includes 30.0-34.9 kg/m², Class II Obesity includes 35.0-39.9 kg/m², and Class III Obesity includes BMI of 40.0 kg/m² or greater. Although BMI is well accepted for use at a population level (due to its ease of use and capture), BMI does not consider important factors (e.g. age, sex, ethnicity, muscle mass, bone density, overall body composition, health condition/state, etc.) that contribute to variability in health risk at the individual level (28). Thus, although BMI is a good tool for screening and population data capture, it should not be the only

factor considered when diagnosing obesity (27). The 2022 Clinical Practice Guidelines suggest considering BMI, waist circumference, a comprehensive history, appropriate physical examinations, and laboratory investigations when diagnosing obesity (29).

2.2 Obesity in Canada

The government of Canada has approximated that about 27% of adults in Canada in 2020 are living with obesity (30). Twells et al. studied the prevalence of obesity (using BMI) from 1985 to 2011 in Canada and found the prevalence of adult obesity had increased from 6.1% in 1985 to 18.3% in 2011 (31). Following this study, Lytvyak et al. examined trends of obesity in Canada from 2005 to 2018, and found that the prevalence of adult obesity had further increased to 27% in 2017/18 (32). Evidently, the prevalence of obesity has been on the rise in Canada through the past decades. Statistics Canada projections from 2017 indicated that by 2020, 24% of Canadian adults would suffer from obesity and 27% by 2030 (33). The rate of obesity has increased greater than expected, where projections of obesity prevalence in Canada for 2030 were reached much earlier in 2017/18.

Studies examining the prevalence of obesity in Canada have also noted geographic variations in patterns of obesity by region or province/territory. These studies have found Newfoundland and Labrador to have the highest (39.4%), and British Columbia to have the lowest prevalence of obesity (22.8%) (32). Furthermore, Quebec and Alberta were the provinces with the greatest increases in the prevalence of obesity from 2005 to 2018 (32). An earlier 2009 study by Pouliou & Elliot also found geographic variation in obesity trends over time, with higher prevalence in the Northern and Atlantic regions, and lower prevalence in the Southern and Western regions of Canada (34). Furthermore, differences across rural and urban regions have

been noted, where the prevalence is greater in rural (31.4%) compared to urban regions (25.6%)(30).

2.3 Obesity as a Disease

Following decades of research, in 2013 the American Medical Association recognized obesity as a disease with “multiple pathophysiological aspects requiring a range of interventions to advance obesity treatment and prevention” (35). Many Canadian provincial associations have also recognized obesity as a disease (Doctors of British Columbia, Alberta Medical Association, Saskatchewan Medical Association, Ontario Medical Association, New Brunswick Medical Association, Newfoundland and Labrador Medical Association, Yukon Medical Association) (2), along with medical associations (Canadian Medical Association, World Health Organization, American Association of Clinical Endocrinologists, The UK Royal College of Physicians), obesity associations (Obesity Canada, World Obesity Federation, European Association for the Study of Obesity, The Obesity Society, Canadian Obesity Advocacy Network (COAN), National Association of Clinical Obesity Services), and governments (Portugal, Sweden, Germany, and Italy Ministry of Health, European Commission) across the world (2). Recognizing obesity as a disease can have several implications such as helping remove stigma and bias associated with obesity, providing awareness of the severity required to prompt behavioural modification, and improve access to medical intervention, encourage governmental action, and more (36). Thus, actions taken by these governmental and non-governmental associations to define obesity as a disease are important for education, awareness, and advocacy, and likely to influence the landscape of obesity prevention and management at multiple levels.

2.4 Diagnosis and Coding of Obesity in the Healthcare System

First developed by the World Health Organization in the 19th century, the newest *International Classification of Disease* (ICD) coding system (37,38) used in Canada is ICD-10 (10th revision). The ICD coding system is employed globally and serves various functions, such as providing comparable statistics on causes of mortality and morbidity across time and location (37). Used by healthcare personnel in primary, secondary, and tertiary care, ICD provides a standardized set of codes to apply to diagnoses and billing for claims reimbursement (37,38). The ICD-10 code for overweight and obesity is the E66 code, which consists of: E66.0 Obesity due to excess calories, E66.1 Drug induced obesity, E66.2 Extreme obesity with alveolar hypoventilation, E66.3 Overweight, E66.8 Other obesity (morbid obesity), E66.9 Obesity, unspecified. Thus, the E66 code would be used once an individual receives a diagnosis of overweight and obesity, where the physician (or coder in some cases), would enter this information into the electronic record system.

To date, limited research has been done to explore the use of ICD-10 coding for overweight and obesity, especially in Canada. Among the studies conducted to date, several are based on hospital administrative data that have compared the utility of BMI versus E66 coding within a select sample. For example, Thapa et al. investigated physicians' ability to diagnose and document obesity at academic urban primary care clinics (39). In this study, 66% of the patients were correctly diagnosed with obesity; however, fewer correct diagnoses were made among Hispanic patients, attending physicians documented obesity more frequently than residents, and normal weight physicians documented obesity more frequently than overweight physicians (39). In a second example, Gribsholt et al. investigated ICD-10 diagnosis of obesity in Danish hospitals and reported a positive predictive value (PPV) of 87.6% (probability of having a

diagnosis when the individual has the disease), where PPV increased with patients age (40). This study also found amongst those with a BMI of 25 kg/m² and greater, only 10% had obesity diagnosis code, thus concluding that although there was a high PPV (87.6%), it was not consistently used (only used in 10%) (40). Finally, Mocarski et al. investigated the prevalence and accuracy of the ICD-9 code for obesity in the United States (41). Based on BMI, approximately 75% of the patients were categorized with overweight or obesity, but only 15% had ICD-9 codes for overweight and obesity, despite a positive correlation between obesity coding and increasing BMI (41). Amongst patients with a BMI of 30 kg/m² and greater, patients who had the code were more often female and had a greater comorbidity burden, where the most common comorbidities were hypertension, dyslipidemia, type 2 diabetes, and gastroesophageal reflux disease (41). The lone Canadian study examining this topic was carried out by Martin et al. where they investigated the validity of obesity coding using the Discharge Abstract Database 2002-2008 (42). This study revealed a 65.9% PPV, where a diagnosis of obesity was associated with an increased risk of cardiac procedures. Approximately 73% of the patients with the code were classified as having Class I Obesity based on their BMI from a linked registry.

2.5 Emergency Department Outcomes

A consistent finding of the administrative healthcare literature investigating obesity and the use of health care services has found that patients with obesity have higher mean number of visits to primary care and specialty care, and more frequent emergency department use and hospitalization (43). These findings are not surprising, given that obesity is a chronic disease requiring long-term management. In addition to higher use of health care services, other studies have also found that obesity increases difficulty of patient management in the emergency department, where BMI was found to be strongly correlated with difficulty finding anatomical

landmarks, venous pressure measurement, physical examination, patient positioning, and procedures (44).

Several studies have also examined care and outcomes in patients with obesity, predominately in the U.S. hospital setting. Bochicchio et al. prospectively assessed patients admitted to the ICU over a two year period and found patients with obesity had a higher risk of acquiring a bloodstream, urinary tract, or respiratory infection, that they were more likely to be admitted to the intensive care unit, and more likely to die in the hospital (45). Retrospective analyses have also revealed similar findings, reporting that patients with class III obesity were more likely to have complications, longer hospital stays, and longer stays in the intensive care unit (46). Other retrospective studies examining patients admitted to Pennsylvania trauma centres grouped into weight categories revealed similar results, where trauma patients in the 96th weight percentile and above were more like to develop major complication and were found to be at least 30% more likely to die (47). Similar to these, systematic reviews and meta-analyses examining Covid-19 in relation to hospitalization has also revealed worse in-hospital outcomes for Covid-19 patients with obesity (48). Collectively, these studies revealed that Covid-19 patients with obesity had a higher incidence of hospitalization, intensive care unit admission, invasive mechanical ventilation, and in-hospital mortality (48).

2.6 Canadian and U.S. Healthcare Differences

Over the years, a considerable amount of attention has focussed on structural differences between the Canadian and U.S. healthcare systems as the shortcomings of each have been exposed. Canada's healthcare system is known as "Medicare", where health insurance coverage is organized and delivered by the government, and covers the entire population (49). Through this system, patients do not participate in the reimbursement process and reimbursement takes

place between the government and health care provider (49). Each province has a ministry of health responsible for controlling medical expenses (49). By contrast, the healthcare system in the U.S. does not have a single nationwide system for health insurance, but health insurance can be purchased privately or provided to certain groups by the government (49). Public health insurance available in the U.S includes “Medicare” for aged and disabled individuals, and “Medicaid” for economically disadvantaged individuals (50). Unlike the U.S., under the Canadian healthcare system, patients wanting to visit a specialist must have a referral from a general physician. Training of Canadian healthcare professionals also differs from the U.S. in the process to acquire a board certificate (e.g. years and levels of schooling), and criteria to maintain a practicing licence, and so forth. Furthermore, the manner in which internal medicine and obesity specializations are trained, and obesity care accessed, are not uniform. As a result of these and other differences between Canadian and U.S. healthcare, research examining U.S. healthcare patterns of E66 coding might not be applicable to the Canadian healthcare system.

2.7 Rationale

While the relation between obesity and chronic conditions are well described, little attention has been paid to understanding the use of healthcare resources in persons with obesity (PwO) within the realm of emergency department care in Canada. To this end, the current thesis project will have two distinct, but related research aims.

2.7.1 Study 1: E66 code across Canada

The first study focuses on exploring patterns in the use and predictors of ICD-10 codes for overweight and obesity (E66) in Canada. Previous studies on this topic have examined ICD-9 or

ICD-10 codes for overweight and obesity in only U.S. healthcare settings and predate important changes in both the treatment paradigm for, and recognition of, obesity as a “disease”.

Furthermore, these earlier U.S. studies focused on the accuracy of administrative (nosologist) coding (i.e. how accurate was the use of E66 in relation to BMI), instead of examining patterns of use of the E66 code – an important area of focus, given provincial funding mechanisms, and potential differences in obesity rates and healthcare access by sociodemographic characteristics and rural/urban status. The proposed study will therefore build on these earlier analyses to explore the prevalence and predictors of E66 code use across Canada.

2.7.2 Study 2: Emergency department care and outcomes

The second study focuses on exploring patient care and outcomes in PwO within emergency departments. Previous research in this area is limited to trauma patients in the U.S. In these studies, patient outcomes and complications (e.g. organ failure, length of hospital stays, more ICU stays, higher mortality risk, etc.) were markedly higher for PwO. Given regional (U.S.-Canada) and temporal differences in healthcare access and population dynamics, results from previous studies using U.S. administrative healthcare data may not be applicable to Canada today. By using 2018-2022 CIHI data, we will be able to examine these topics in greater detail, and within the Canadian healthcare context. Given the high rate of obesity (and its comorbidity burden) in Canada, it is essential to examine differences in emergency department care in PwO and matched controls to better understand future needs for bariatric equipment and specialized care within Canadian hospitals.

2.8 Objectives

This thesis has two major objectives:

1. To quantify ICD-10 code use for overweight and obesity (E66) across Canadian provinces and territories.
 - a. Examine the prevalence, demographic, and geographic variation in E66 coding across Canada;
 - b. Assess E66 coding across BMI categories, and;
 - c. Examine sociodemographic and clinical predictors of E66.
2. To explore patient care of PwO (vs matched controls) in the Emergency Department.
 - a. Examine trends of care in PwO across Canadian Triage and Acuity Scales (CTAS), and;
 - b. Examine trends of care in PwO pre- and post-onset of Covid-19

2.9 Tables and Figures

Table 1. BMI Categories.

Weight classification	BMI (kg/m²)
Underweight	<18.5
Normal weight	18.5-24.9
Overweight	25.0-29.9
Obesity: Class I	30.0-34.9
Obesity: Class II	35.0-39.9
Obesity: Class III	≥40.0

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Chapter 3.0 Manuscript I

Overweight and Obesity Code (E66) Trends and Predictors in Canada: Cross-Sectional Analysis of Discharge Abstract Data (DAD), 2018-2022

3.1 Abstract

Introduction

Since the adoption of billing codes for obesity, a number of U.S. and Canadian studies have examined their use and utility in administrative healthcare datasets. This includes an examination of the validity, trends, and outcomes of persons with obesity (PwO: ICD-10, E66) codes. Notably, this work has shown low sensitivity and general under-use of ICD-10 codes for obesity.

Aim

The aim of this study was to explore the prevalence and predictors in the use of ICD-10 codes for overweight and obesity (E66) across Canada.

Methods

This secondary analysis made use of 2018-2022 Canadian Institution for Health Information's (CIHI) Discharge Abstract Dataset (DAD). The sample consists of 166,335 individuals 20 to 64 years old of any gender/sex with a E66 diagnosis across all provinces and territories, excluding Québec. Prevalence of E66 was assessed across Canada, and multivariable logistic regression analysis will subsequently be used to estimate the odds (OR, 95% CI) of correct E66 coding by BMI.

Results

Regional variations were prevalent in the use of E66, with Manitoba having the highest prevalence of coding. Over time, Ontario was the only province to increase E66 coding. Of those with a E66 code, 78.9% were within the overweight/obesity BMI category. Females, individuals with 4 or more days length of stay and individuals with one significant comorbidity had lower odds of

correct E66 by BMI, however individuals with higher age had a higher odds of correct E66 by BMI.

Conclusion

This study offers new insight into the use of E66 across Canada, and points to the need for consistent use of weight and height information, as well as E66 coding within existing electronic medical records systems to inform inter-provincial care gaps.

3.2 Introduction

Obesity is a complex chronic disease which is characterized by excess body fat that can have a negative impact on physical, mental, metabolic health as well as quality of life(1). Many individuals living in Canada suffer from obesity: in 2018, 27% of the adults (7.3 million adults) reported obesity, and a further 36% (9.9 million adults) reported being overweight by body mass index (BMI)(2). In Canada, regional and temporal variations in BMI-defined overweight and obesity are well-defined(3,4). Obesity is also a leading cause of death (5) that is associated with many chronic (e.g. type 2 diabetes (6,7), certain CVD (8-10) and cancers (11,12)) and ambulatory care sensitive conditions (13). At the population level, the economic burden of obesity in Canada is estimated to be \$5 to \$7 billion annually(14).

The *International Classification of Disease* (ICD) coding system is used for both diagnosis and billing for claims reimbursement (15). The ICD system was developed by the World Health Organization (WHO), and its current version (ICD-10) includes a code for overweight and obesity (E66), which consists of 8 subtypes. Few studies to date have explored the use of E66 codes within the healthcare setting. Of those that have, E66 trends have been mainly examined in the United States, where differences in the healthcare system structure, healthcare provider curricula, and reimbursement mechanisms may not generalize to Canada.

In those that have, a major finding of this work points to its underutilization and lack of precision (low sensitivity or correct identification) in the prediction of obesity-related health complications within U.S. hospitals (16, 17). In one 2018 study, five times as many patients within the registry were categorized as being overweight or having obesity by body mass index (BMI) than by ICD-10 (74.6% vs 15.1%) (16). As expected, this study found that E66 code use increased positively across BMI categories and was found to be higher amongst persons with

obesity, younger individuals, females, and those with a greater comorbidity burden (particularly hypertension, dyslipidemia, type 2 diabetes mellitus, and gastroesophageal reflux disease) (16). A second study of U.S. hospital EMR data found similar trends in BMI and disease prevalence for males and females across all racial/ethnic groups alike (18). This may be due in part to the difficulty healthcare providers have in recognizing obesity, except at the extremes (BMI above 35 kg/m² or class II+ obesity), leading to its under-recognition among patients with overweight or Class I obesity (16,18). The extent to which these differences may be due to a lack of validity and low completeness of ICD-10 coding for overweight/obesity is unclear and warrants further study. In the lone Canadian study, data from the 2002-2008 Canadian Institute for Health Information Discharge Abstract Database (DAD) was compared to registry data in Calgary to compare validity of the E66 code. Results from this study show that less than 8% of individuals with a BMI \geq 30kg/m² were coded using E66, with a positive predictive value (PPV) of 65.94% (19).

Thus, this study builds on earlier analyses by exploring the E66 code across Canadian provinces and territories to 1) examine the prevalence, demographic, and geographic (provincial) variation in E66 coding across Canada; 2) assess E66 coding across BMI categories, and; 3) examine predictors of E66 use.

3.3 Methods

3.3.1 Study Design and Data Source

The Canadian Institution for Health Information (CIHI) is an independent, not-for-profit organization. CIHI provides data and information that helps accelerate improvement in health care across Canada, while protecting privacy and confidentiality of Canadians (CIHI). This study

makes use of a four-year purpose-built dataset from the CIHI Discharge Abstract Data (DAD), a nation-wide registry of hospital discharges. The DAD captures data between April 1 to March 31 of a given fiscal year; this study pooled data from fiscal years 2018-19, 2019-20, 2020-21 and 2021-22. This study is a secondary analysis of anonymized data accessed through the [Graduate Student Data Access Program](#) and purpose-built for the parameters of interest and time-period of this study.

3.3.2 Study Sample and Setting

The study sample will be derived from the pooled CIHI DAD cycles 2018-19 to 2021-22 which includes administrative, clinical, and demographic information on hospital discharges across Canada. The sample consists of 166,335 individuals 20 to 64 years old of any gender/sex with a E66 diagnosis (n=35,296 with BMI information, n=131,039 without BMI information) across all provinces and territories, excluding Québec (which does not participate in the DAD).

Participants 65y and above were excluded due to expected changes in body composition for a given BMI in older adults (20) and resulting attenuation in the relationship between BMI and health in older adults (21). Participants within the overweight BMI range were included due to the specific mention of “overweight” as a sub-diagnosis of E66. The sample excludes duplicate records, therapeutic abortions, cadaveric donors, and stillbirths. Due to differences in the calculation of BMI between adults and children / youth (and the expected low fidelity of E66 information), individuals under the age of 20 were also excluded (22).

3.3.3 Variables

Socio-demographic characteristics include gender/sex, age, income, province/territory, and area (urban or remote). Gender/sex categories include male and female. Age was reported in custom five year age groups and subsequently categorized as: 20-29, 30-39, 40-49, 50-59 and 60-64 years old. Income was assessed as household income through census data using postal codes and reported as income quintiles which are quintiles of annual income per person equivalent and range from one (lowest) to five (highest).

BMI was calculated using measured weight (kg) and height (m) on admission to the reporting facility and subsequently categorized as “underweight” (BMI <18.5 kg/m²), “normal weight” (BMI: 18.5-24.9 kg/m²), “overweight” (BMI: 25.0-29.9 kg/m²), “obesity class I” (BMI: 30.0-34.9 kg/m²), “obesity class II” (BMI: 35.0-39.9 kg/m²), and “obesity class III” (BMI ≥40.0 kg/m²). Diagnosis of overweight and obesity consists of the E66 code and available subtypes. Other clinical variables include length of stay (days: 0-1, 2, 3, 4-5, 6≤), admission category (elective, emergent/urgent), ambulance code (air, ground, combination, or did not arrive by ambulance), entry code (clinic, direct, emergency department, day surgery), comorbidity count (number of significant comorbidity diagnoses captured on the abstract 0, 1, 2, 3≤), comorbidity level (cumulative resource impact of comorbidities on the patient’s stay, 0: no comorbidity, 1: 1.25 to 1.5 times more resource intensive, 2: 1.5 to 2 times more resource intensive, 3: 2 to 3 times more resource intensive, 4: 3 or greater times more resource intensive), and responsibility for payment (provincial/territorial responsibility, other).

3.3.4 Data Analysis

Characteristics of the sample were reported as frequency counts and prevalence (gender/sex, age, income, province/territory, area, ambulance code, entry code, admission category, significant

comorbidity count, comorbidity level, length of stay, and responsibility for payment). Characteristics were stratified into those with and without BMI information, and chi-square analyses were performed to assess significant differences across the two groups. Prevalence of E66 coding across Canadian provinces was examined to understand geographic and demographic variations and trends across time. E66 prevalence was mapped to further visualize provincial and temporal variations, with standardization done by dividing the absolute value of E66 coding per province/territory for a given year by the population of individuals aged 20-64 in that province/territory for that year. E66 diagnosis was classified into BMI categories of “underweight” and “normal weight” ($<25 \text{ kg/m}^2$) and “overweight/obesity” ($\text{BMI} \geq 25.0 \text{ kg/m}^2$) to examine positive predictive value (PPV). Logistic regressions were subsequently used to estimate the odds (OR, 95% CI) of correct E66 coding by BMI, to examine potential predictors such as gender/sex, age, income, comorbidity count and pre- and post-onset of Covid-19. To account for possible differences in the pattern of E66 diagnosis and overall volume of healthcare visits, a sensitivity analyses was undertaken to assess pre- and post-Covid-19 years (2018-19 versus 2020-21 and 2021-22).

3.4 Results

Table 1 shows the demographic and hospital information of the complete sample ($n=166,335$), which includes 35,296 individuals with BMI information and 131,039 without. Overall, the sample contains more females (with BMI: 62.4%, without BMI: 70.8%), individuals in the first income quintile (lowest) (with BMI: 22.5%, without BMI: 23.7%), residents of urban areas (with BMI: 71.5%, without BMI: 72.4%). A high proportion of sample (with BMI: 84.2%, without BMI: 82.5%) contained no significant comorbidities. **Table 2** E66 diagnosis across Canadian

provinces and territories within the complete sample. Majority of the E66 coding was done in Ontario (43.0%) and Manitoba (30.7%).

Figure 1 shows the standardized prevalence of overweight/obesity diagnosis (E66) across Canada from 2018-2021 (frequency of diagnosis per 10,000 residents). From 2018 to 2021, E66 diagnosis was most common in Manitoba. In 2018-2019, E66 coding was least frequent in British Columbia (2018: 6; 2019: 5 per 10,000), and in 2020-2021 was least common in Prince Edward Island (2020: 3; 2021: 2 per 10,000). Over the study period, Ontario was the only province to show an increase in frequency of E66 diagnosis ($p < 0.05$), while six of the provinces or territories showed a decrease (Alberta, Saskatchewan, Manitoba, Newfoundland and Labrador, Prince Edward Island, and New Brunswick) ($p < 0.05$).

Table 3 shows the prevalence of E66 coding across BMI categories ($BMI < 25 \text{ kg/m}^2$ and $BMI \geq 25.0 \text{ kg/m}^2$). The probability of having overweight/obesity by BMI when there is an E66 diagnosis is 78.78% (PPV). **Figure 2** shows the demographic and clinical predictors of correct E66 coding by BMI. Odds of correct E66 coding by BMI was positively related to age [20-29y (OR=1.00, referent), 30-39y (1.17, 95% CI: 1.07-1.28), 40-49y (1.36, 1.23-1.50), 50-59y (1.58, 1.45-1.72), 60-64y (1.56, 1.43-1.70)], where females had a lower odds of E66 coding by BMI (0.94, 0.88-0.99). Individuals with a two day length of stay had a higher probability of correct E66 coding (1.30, 1.21-1.40), whereas those with longer lengths of stay had a lower odds [4 to 5 days (0.81, 0.72-0.88) and 6 or more days (0.59, 0.54-0.64)] compared to those with zero to one day length of stay. Relative to those with no significant comorbidities, individuals with one had a lower odds of correct E66 coding by BMI (0.91, 0.83-0.99). Finally, odds of correct coding by BMI was lower after the onset of Covid-19 (0.71, 0.67-0.75).

3.5 Discussion

Previous studies on this topic have examined ICD-9 or ICD-10 codes for overweight and obesity predominately in U.S. healthcare settings in a period that predates important changes in both the recognition and treatment of obesity as a “disease”(16-18). These earlier U.S. studies also largely focused on the accuracy of administrative coding, instead of examining patterns – an important area of focus, given provincial funding mechanisms, and potential differences in obesity rates and healthcare access by sociodemographic characteristics and rural/urban status in Canada.

In this study we report regional variation in E66 coding, with the highest rates observed in Manitoba for all years, and the lowest rates in British Columbia (2018-2019) and PEI (2020-2021). Over time, Ontario was the only province to show an increase in E66 coding. Studies using measured BMI data also report regional variation. Consistent with E66 data from the current study, the 2017/18 Canadian Community Health Survey also reported that British Columbia had the lowest prevalence of obesity by measured BMI (3). Similarly, in 2017/2018, Saskatchewan was amongst the top provinces with the highest prevalence of obesity (3), and in this study Saskatchewan was also third in 2018 with a high incidence of E66 coding. Other studies have found geographic variations with higher prevalence of obesity in the Northern and Atlantic regions of Canada (4), but this study has revealed the lowest prevalence of coding occurring in Northern regions. Although these geographic variations were studied in 2009, similar findings were shown in other studies using CCHS data (3).

Overall, a majority of the sample were found to have no significant comorbidities (82.8%), with almost two-thirds reporting no comorbidities at all (63.8%). These findings are surprising as overweight and obesity is associated with many conditions (5-12), and that following the onset of Covid-19, most hospital cases became more complex (i.e. had higher comorbidity burden) in

Canada (23). Indeed, across Canada there was a 11% decrease in the utilization of the E66 code from fiscal year 2018-19 to 2021-22. This decline may be attributed to the impact of Covid-19 and hospitalization. Following the onset of Covid-19, hospitalization dropped overall (24,25), with fewer “low severity” cases (26). It is possible then that this contributed to less frequent E66 use for more severe illnesses. This stands in contrast to the observed rise in the use of E66 in Ontario, but could be explained in part by the recognition of obesity as a risk factor for more severe outcomes (27, 28) and hospitalization (28) in those with Covid-19.

Compared to the lone Canadian study that used DAD 2002-2008 (19), the current study demonstrated a higher PPV value of 78.9%, relative to 65.9%. These differences could in part be due to the threshold of BMI used in the two studies. While this study used the BMI measurement of 25.0 kg/m² and above (overweight and obesity), the previous study assessing DAD used a threshold of 30.0 kg/m² and above (obesity). Changes could have also resulted over time, where data from this study has been captured after the recognition of Obesity as a “disease”.

Studies examining U.S. data have found BMI to be a predictor of E66 coding (16,18), with E66 coding being more common amongst younger individuals, females, and those with a greater comorbidity burden in U.S. settings (16). In the present study, “correct” coding was associated with the male gender and higher age categories. Furthermore, the odds of “correct” coding was lower after the onset of Covid-19. These differences in coding could be due to the many differences that exist between Canadian and U.S. health care structure and curricula, including unmeasured sociodemographic and clinical factors. The decreased odds of “correct” coding after the onset of Covid-19 could be attributed to the greater attention and allocation of resources towards managing the pandemic, rather than addressing other diseases.

E66 coding has many implications in healthcare. Previous literature has found the diagnosis of obesity to be the strongest predictor of the formulation of an obesity plan (29), and that the documentation of overweight and obesity was associated with increased behavioural treatment (30). Without the diagnosis of overweight and obesity, appropriate treatment is unlikely. Thus, it is imperative to acknowledge obesity as a chronic disease and ensure the use of the ICD-10 for overweight and obesity (E66) to facilitate effective treatment.

3.5.1 Strengths and Limitations

This study made use of administrative healthcare data through the CIHI Discharge Abstract Database to assess use of the E66 code across Canada. This dataset provides quality information on administrative, clinical, and demographic information of hospital discharges across Canadian provinces and territories. Despite these strengths, information on hospital discharges in the province of Québec were unavailable. Our analysis also excluded individuals above the age of 64 due to expected changes in body composition and the relationship between body fat and health risk; therefore, the analysis is not representative of the entire Canadian population and may under-represent E66 use.

3.6 Conclusion

Overall, this study offers new insight into the use of the E66 code across Canada. Given the importance of obesity to healthcare service access, delivery, and the management of acute and chronic disease (31), the consistent use of weight and height information within existing electronic medical records systems is critical to assessing broader system and care gaps that may exist across the provinces and territories.

3.7 Tables and Figures

Table 1. Characteristics of sample with E66 diagnosis (n=166,335).

	With BMI (n=35,296)	Without BMI (n=131,039)	p-value
Gender			
Female	22026 (62.40%)	92817 (70.83%)	p<0.05
Male	13270 (37.60%)	38222 (29.17%)	
Age			
20 to 29 years old	4460 (12.64%)	18397 (14.04%)	p<0.05
30 to 39 years old	6114 (17.32%)	31610 (24.12%)	
40 to 49 years old	4651 (13.18%)	25680 (19.60%)	
50 to 59 years old	10826 (30.67%)	34677 (26.46%)	
60 to 64 years old	9245 (26.19%)	20675 (15.78%)	
Income quintile			
1 (lowest)	7926 (22.46%)	31048 (23.69%)	p<0.05
2	6566 (18.60%)	28436 (21.70%)	
3	7251 (20.54%)	26377 (20.13%)	
4	6984 (19.79%)	24920 (19.02%)	
5 (highest)	6569 (18.69%)	20258 (15.46%)	
Area			
Rural/Remote	10061 (28.50%)	36156 (27.59%)	p<0.05
Urban	25235 (71.50%)	94883 (72.41%)	
Ambulance code			
Air ambulance	15 (0.04%)	205 (0.16%)	p<0.05
Any combination (air/ground/water)	97 (0.27%)	788 (0.60%)	
Ground ambulance	4977 (14.10%)	16425 (12.53%)	
Did not arrive by ambulance	30207 (85.58%)	113621 (86.71%)	
Entry code			
Clinic	1860 (5.27%)	12248 (9.35%)	p<0.05
Direct	23107 (65.47%)	90421 (69.00%)	
ED	9775 (27.69%)	26802 (20.45%)	
Day surgery	554 (1.57%)	1568 (1.20%)	
Admission category			
Elective	20947 (59.35%)	92307 (70.44%)	p<0.05
Emergent/Urgent	14349 (40.65%)	38732 (29.56%)	
Significant comorbidity count			
0	29726 (84.22%)	108060 (82.46%)	p<0.05
1	3459 (9.80%)	12689 (9.68%)	
2	1012 (2.87%)	4733 (3.61%)	
3 or more	1099 (3.11%)	5557 (4.24%)	
Comorbidity level			
0: no comorbidity	27747 (78.61%)	78312 (59.76%)	p<0.05
1: 1.25 to 1.5 times more resource intensive	2675 (7.58%)	9574 (7.31%)	
2: 1.5 to 2 times more resource intensive	1385 (3.92%)	5723 (4.37%)	
3: 2 to 3 times more resource intensive	781 (2.21%)	3794 (2.90%)	
4: 3 or greater times more resource intensive	729 (2.07%)	3888 (2.97%)	
Not indicated	1979 (5.61%)	29748 (22.70%)	
Length of stay (days)			
0 to 1	9557 (27.08%)	28190 (21.51%)	p<0.05
2	9995 (28.32%)	30774 (23.48%)	
3	5028 (14.25%)	18814 (14.36%)	
4 to 5	4747 (13.45%)	19979 (15.25%)	
6 or more	5969 (16.91%)	33282 (25.40%)	
Responsibility for payment			
Provincial/territorial responsibility	34633 (98.12%)	126684 (96.68%)	p<0.05
Other	663 (1.88%)	4355 (3.32%)	

Table 2. E66 diagnosis across Canadian provinces and territories.

	Frequency n (%)
Province	
Newfoundland	11110 (6.68%)
Prince Edward Island	191 (0.11%)
Nova Scotia	1607 (0.97%)
New Brunswick	3645 (2.19%)
Ontario	71560 (43.02%)
Manitoba	51024 (30.68%)
Saskatchewan	5955 (3.58%)
Alberta	13894 (8.35%)
British Columbia	6933 (4.17%)
Northwest Territories, Nunavut & Yukon	416 (0.25%)

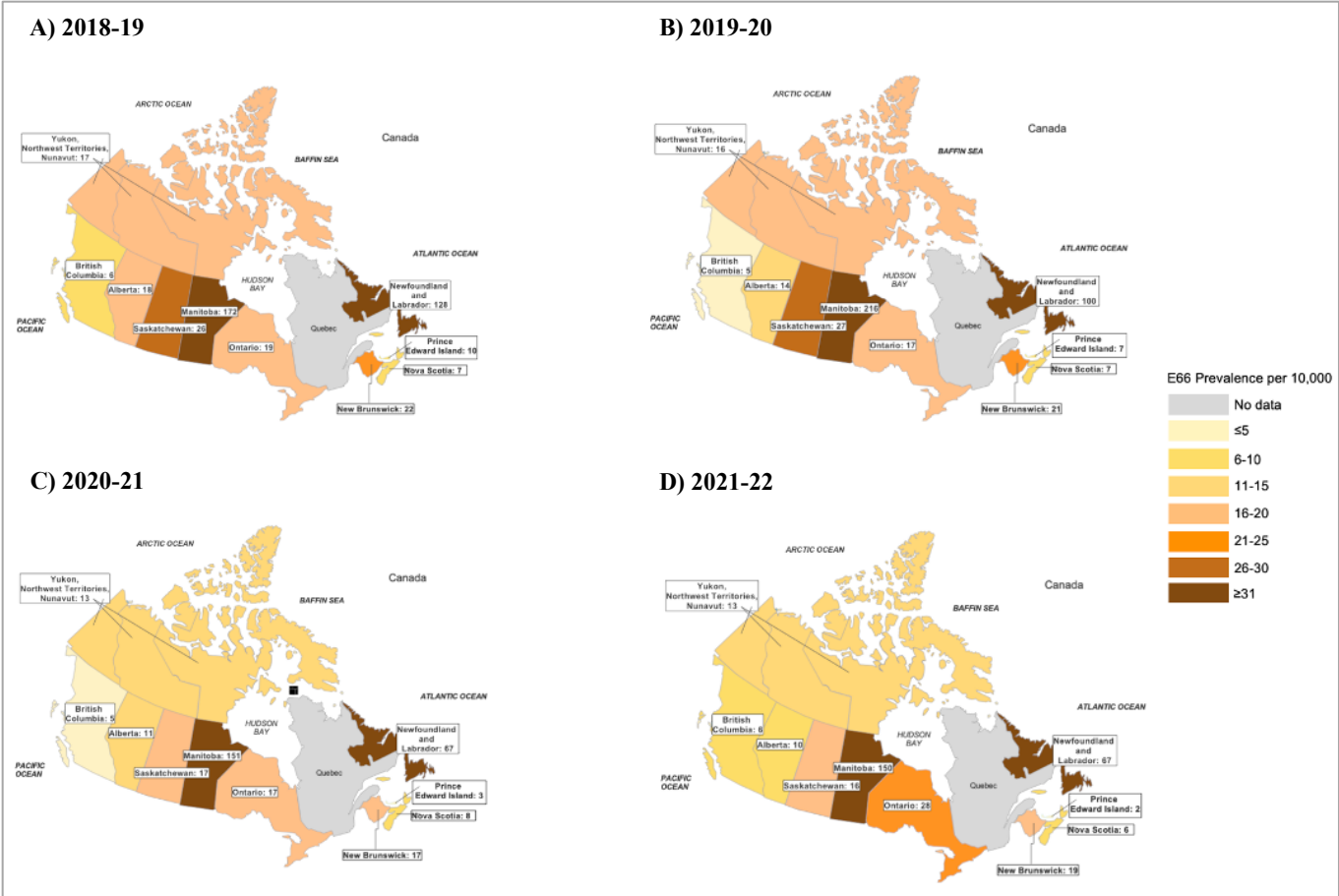


Figure 1. E66 standardized prevalence across Canada, fiscal year 2018-19 through 2021-22. Standardization was done by dividing the absolute value of E66 coding per province/territory for a given year by the population of individuals aged 20-64 in that province/territory for that year. DAD captures data between April 1 to March 31 of a given fiscal year.

Table 3. E66 diagnosis across BMI categories.

E66 diagnosis	
BMI categories	
BMI < 25 kg/m ²	7450
BMI ≥ 25 kg/m ²	27846
	PPV: 78.89%

PPV = positive predictive value

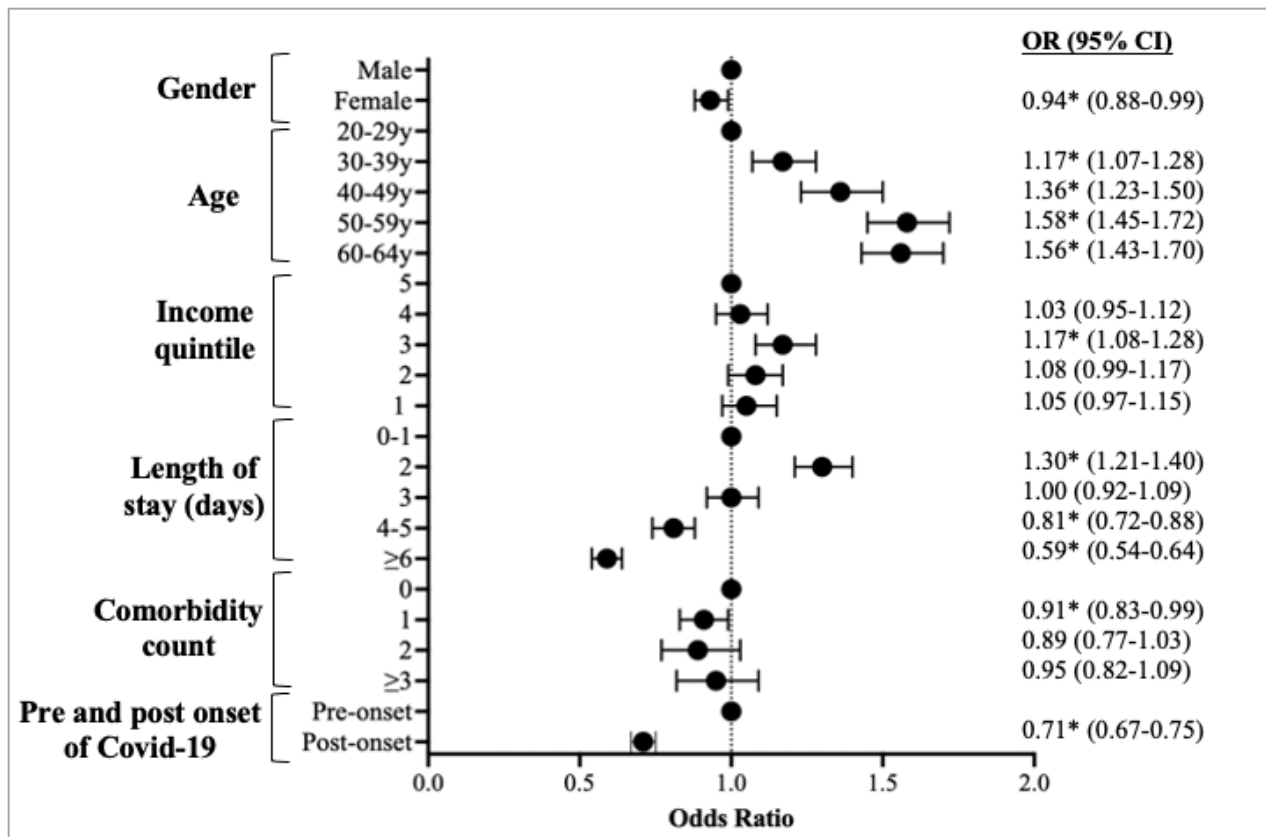


Figure 2. Predictors of correct E66 diagnosis by BMI.

*significance, $p < 0.05$

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Chapter 4.0 Manuscript II

Health Care and Outcomes in Persons with Obesity within Emergency Departments in Ontario, Canada: A Cross-Sectional Analysis of National Ambulatory Care Reporting System (NACRS), 2018-2022

4.1 Abstract

Introduction

Previous literature examining U.S. data has found trauma patients with obesity experience longer wait times, hospital stays, and a higher risk of medical complications and death. Given the difference in healthcare access between countries and the predominate focus of this previous work on blunt trauma injuries, the patterns observed within the U.S. setting may not represent the experience of persons with obesity (PwO) in the Canadian setting.

Aim

The aim of this study was to assess care in PwO (E66 diagnosis) in emergency departments in Ontario.

Methods

This secondary analysis made use of 2018-2022 Canadian Institution for Health Information's (CIHI) National Ambulatory Care Reporting System (NACRS). The sample consisted of 19,862 individuals where 6,474 individuals had an overweight or obesity diagnosis (E66), and 13,388 individuals were controls matched for gender, age and main diagnosis. Logistic regressions were performed to estimate odds of increasing triage levels. Adjusted least squared means of wait times and length of stay in the emergency department were then computed to assess differences across those with E66 and controls.

Results

Individuals with E66 code had longer wait times to physician initial assessment, length of stay in the emergency department and higher triage scores (less urgent). Analyses stratified by triage level revealed that triage level 1 (CTAS 1, most urgent) PwO experienced greater wait time for

physician initial assessment, wait time to inpatient bed, and length of stay in the emergency department relative to controls.

Conclusion

Additional research is needed to confirm the consistency of these findings in other Canadian provinces/territories, and to examine diverse clinical outcomes.

4.2 Introduction

Obesity is a chronic, progressive, and relapsing disease which is characterized by excess body fat that can impair physical, mental, metabolic health as well as quality of life (1). A multitude of health conditions are linked to overweight and obesity, many of which are frequently encountered within the emergency department (ED) setting in Canada.

Literature examining trauma care and outcomes in PwO have shown very similar overall trends: trauma patients with obesity are more likely to experience complications, organ failure, greater length of hospital stay, greater risk of death, and more days on mechanical ventilation (2-8). These patterns have been demonstrated across different healthcare contexts, trauma severity, and research design. In a prospective study of obesity and trauma outcomes in US hospitals, PwO had a more than two-fold increase in risk of admission to the Intensive Care Unit or risk of bloodstream, urinary tract, or respiratory infection, even after adjusting for age and Injury Severity Score (2). As well, a retrospective cohort study of over 140,000 participants in the US found that after adjusting for injury severity and other risk factors, PwO had a significantly higher risk of death and major complications (4). Using a case-control design, Neville et al. observed that although mechanisms and patterns of injury were similar, PwO had a higher incidence of multiple organ failure (13% vs 3%; $P = .02$) and mortality (32% vs 16%; $P = .008$) after admission to a Level 1 trauma center in the U.S. (6). Despite the consistency in findings, research on trauma care and related outcomes in PwO have largely focussed on non-Canadian samples. Moreover, the latest research (3,4) predates important changes to the treatment and management of obesity that have occurred since the recognition of obesity as a “disease”.

Given regional (U.S.-Canada) and temporal differences in healthcare access and population dynamics, results from previous studies using U.S. administrative healthcare data

may not be applicable to Canada today (9). In addition to health system differences in funding for primary care, access to bariatric services, and position stands by governing bodies (e.g. recent Obesity Clinical Practice Guidelines)(10), Canadian and U.S. populations also differ in the sociodemographic patterning of obesity (11). By using 2018-22 CIHI data, we will be able to examine these topics in greater detail within the Canadian healthcare context both prior to, and after the onset of, the COVID-19 pandemic. Given the high rate of obesity (and its comorbidity burden) in Canada, it is essential to examine differences in trauma-related outcomes to better understand future needs for bariatric equipment and specialized care within Canadian hospitals. Thus, this study aims to explore patient care and health outcomes of E66 coded PwO (vs matched controls) attending the emergency departments in Ontario.

4.3 Methods

4.3.1 Study Design and Data Source

This study is a secondary analysis of anonymized data accessed through the Graduate Student Data Access Program ([GSDAP](#)) of the Canadian Institute for Health Information (CIHI). CIHI is an independent not-for-profit that provides data architecture, analysis, and reports of routinely collected healthcare data in Canada ([CIHI](#)). This study will use data derived from the CIHI National Ambulatory Care Reporting System (NACRS), representing serial presentations for all hospital emergency department admissions.

4.3.2 Study Sample and Setting

The study sample will be derived from April 1, 2018 to March 31, 2022 CIHI NACRS Ontario emergency department visits, which includes administrative, clinical, and demographic

information of hospital emergency department visits. NACRS captures data every fiscal year from April 1 to March 31; data for this study pooled cycles 2018-19, 2019-20, 2020-21, and 2021-22. The sample consists of 32,675 individuals aged 20 to 64 years old of any gender/sex. Duplicate records, any records relating to therapeutic abortions, cadaveric donors, and stillbirths are excluded. The cohort is selected using a case-control method, where cases have an overweight/obesity diagnosis (n=18,770 with ICD-10 E66) and controls were matched for age, gender/sex, and main diagnosis (n=13,905). In 6% of the control where the main diagnosis of controls was unavailable, matching was done with age and gender/sex only. The final sample excluded those with no income data (n=774) or triage level (n=12,454), resulting in a final analytic sample of 19,862 (n=13,388 controls, n=6474 cases).

4.3.3 Variables

Socio-demographic characteristics included gender/sex, age, income, area (urban or remote). Gender/sex categories include male and female. Age was dichotomized as 20 to 44 and 45 to 64 years old. Income was assessed by patient income quintiles based on census data of annual income [1 (lowest) to 5 (highest)]. A diagnosis of overweight/obesity was defined as one of eight E66 codes: E66.0 Obesity due to excess calories, E66.1 Drug induced obesity, E66.2 Extreme obesity with alveolar hypoventilation, E66.3 Overweight, E66.8 Other obesity (morbid obesity), and; E66.9 Obesity, unspecified. Health service-related variables included the Canadian Triage and Acuity Scale (CTAS; 1: severely ill, requires resuscitation, 2: requires emergent care and rapid medical intervention, 3: requires urgent care, 4: requires less-urgent care, 5: requires non-urgent care) (12), length of stay in ED (hours), wait time to inpatient bed (hours), wait time to

physician initial assessment (hours), and responsibility for payment (provincial/territorial responsibility, other).

4.3.4 Data analysis

Characteristics of the sample were compared between cases and controls using chi-square analysis for categorical variables (gender, age, income quintile, area, triage level, and responsibility for payment). Mean differences in wait time to physician initial assessment, wait time to inpatient bed, and length of stay between cases and controls was assessed by paired t-test. To assess the relationship between E66 and health and healthcare-related outcomes, a series of linear analyses were conducted with adjustment for possible confounders. For categorical variables, a series of ordinal logistic regression models were used to estimate the odds of increasing triage level in cases relative to controls (Model 1: unadjusted; Model 2: adjusted for gender and age, and; Model 3: adjusted for gender, age, responsibility for payment, income, and area). The relationship between continuous outcomes (wait times and length of stay) with E66 cases and controls was then assessed using adjusted least squared means (Model 1: adjusted for gender and age, and; Model 2: adjusted for gender, age, responsibility for payment, income, area, and triage level). Sensitivity analyses were stratified into pre- and post-onset of Covid-19 years (April 1, 2018 to March 31, 2020 versus April 1, 2020 to March 31, 2022), and cycle years by group interactions were assessed.

4.4 Results

Table 1 shows the characteristics of individuals with E66 and matched controls, with p-values from chi-square analysis. Overall, a majority of the sample were 45 to 64 years of age (controls:

65.4%; cases: 62.0%), had lower income (Quintile 1, controls: 27.5%; cases: 35.1%), were largely from urban regions (controls: 83.8%; cases: 77.0%), and comprised of level 3 triage emergency department visits (controls: 46.8%; cases: 47.0%).

Figure 1 shows the results of paired t-tests comparing individuals with E66 and controls across wait time to physician initial assessment, wait time for inpatient bed, and length of stay. While average wait time for physician initial assessment (controls: 1.49 ± 1.42 (SD) hours, cases: 1.54 ± 1.50 hours) and length of stay (controls: 6.09 ± 8.07 hours, cases: 7.91 ± 9.31 hours) were significantly higher in those with E66 than controls, no difference in wait time for inpatient bed was observed (controls: 7.96 ± 12.04 hours, cases: 8.42 ± 14.45 hours). Further stratification by CTAS level (**Figure 2**) yielded discrepant findings in that wait times and length of stay in the emergency department were greater in those with E66 than controls for CTAS 1. Furthermore, the average length of stay was significantly higher in those with E66 than controls across all CTAS levels, with the biggest difference observed in CTAS 3. When these relationships were compared in the pre- and post-onset of Covid-19 years (April 1, 2018 to March 31, 2020 versus April 1, 2020 to March 31, 2022, **Figure 3**), wait time to physician initial assessment was higher in those with E66 relative to controls only after the onset of Covid-19 (controls: 1.44 ± 1.42 hours, cases: 1.53 ± 1.53 hours, $P < 0.05$), where the average wait time dropped for controls after the onset of Covid-19 (pre-onset: 1.55 ± 1.41 hours, post-onset: 1.44 ± 1.42 hours, $P < 0.05$). The average length of stay was also higher in those with E66 relative to controls both pre- and post-onset of Covid-19, where the average increased in those with E66 post-onset of Covid-19 (pre-onset; controls: 6.04 ± 7.95 hours, cases: 7.55 ± 9.54 hours, post-onset; controls: 6.14 ± 8.17 hours, cases: 8.29 ± 9.04 hours). Finally, wait time for inpatient bed in those with E66 dropped post-onset of Covid-19 (pre-onset: 9.25 ± 16.0 hours, post-onset: 7.67 ± 12.8 hours).

Table 2 shows the result of the ordinal logistic regressions for triage levels (CTAS) across those with E66 and controls. In fully adjusted models, individuals coded as an E66 case were at 35% greater odds of having a higher triage level compared to controls (OR=1.35, 95% CI 1.28-1.43). Similarly, **Table 3** shows the results of least adjusted squared means hours for wait time to physician initial assessment, wait time for inpatient bed, and length of stay in the emergency department across those with E66 and controls. In fully adjusted models, those with E66 code had higher wait time to physician initial assessment (control: 1.21±0.03 (SE) hours, case: 1.28±0.03 hours, $p<0.05$) and length of stay (control: 3.72±0.20 hours, case: 7.06±0.21 hours, $p<0.05$) relative to controls. Wait time to inpatient bed was not significantly different between those with E66 and controls (control: 6.57±0.79 hours, case: 7.19±0.79 hours, $p=0.09$).

4.5 Discussion

This study adds to existing literature on health and healthcare disparities for PwO by examining emergency department presentations from April 1, 2018 to March 31, 2022 in Ontario, using CIHI NACRS. Overall, this study found that PwO had a longer wait time to physician initial assessment, length of stay, and higher triage level in Ontario emergency departments when compared to controls that were matched for gender, age, and main diagnosis. In analyses stratified by CTAS level, the difference in wait times and length of stay between PwO and controls was generally consistent across CTAS levels, where CTAS 1 showed the greatest disparities where PwO experienced both greater wait times and length of stay in the emergency department relative to controls. For most measures, patterns of care were relatively unchanged in the pre- vs post-onset of Covid-19, aside from higher wait time for initial assessment relative to controls we observed post-onset of Covid-19.

In the present study, average length of stay was greater in PwO, relative to matched controls. Previous literature examining trauma care and outcomes in PwO have shown similar overall trends, where PwO were more likely to experience complications, organ failure, greater length of hospital stays, greater risk of death, and more days on mechanical ventilation (2-8). PwO also have a higher susceptibility to infections during their hospital stays (13,14), highlighting the need to reduce exposure and risk of infection within this population. Most recently, however, a U.S. observational cohort study from 2018 to 2020 found that PwO had shorter wait times relative to patients with normal weight (15). This is in contrast to the present study which found that overall, PwO experienced longer wait times for physician initial assessment. These differences may be due in part to inter-country differences in sociodemographic characteristics of the ED data in the Lichen et al. (Mayo Clinic (U.S)) and our sample (Ontario, Canada). Moreover, these studies also differed in the operationalization of “obesity”: whereas Lichen et al. defined obesity by BMI, the present study defined PwO as those with an E66 diagnosis.

Our finding that wait time for initial assessment was lower in controls, and wait time for inpatient bed was lower in PwO from pre- to post-onset of Covid-19 may be explained by the decline in visits to Canadian Emergency Departments during Covid-19 (36.9% decline, and 66% of expected volume) (16,17). PwO also had higher CTAS scores overall, indicating that their cases were considered of a lower priority than their matched controls despite matching diagnosis type. This is notable, as PwO would be expected to have lower CTAS scores (higher priority/more urgent) as they often have related comorbidities (18), and higher risk of serious diseases and health conditions (19-21). Higher CTAS scores (lower priority) could partially account for their extended wait times for initial assessment; however, the reason for PwO (E66

diagnosis) experiencing longer wait times for initial assessment relative to matched controls after the onset of Covid-19 remains unclear. Longer wait times in emergency departments are correlated with poorer clinical outcomes (22,23) and increased risk of mortality (24-26). Given that PwO experience prolonged wait times for initial assessment and wait time to an inpatient bed in CTAS level 1, PwO are a priority for interventions aimed at reducing ED wait times.

Longer wait times and length of stay in E66 cases could also be due higher triage scores amongst PwO, meaning that (on average) they represented less urgent cases that had to wait longer for treatment and had a longer wait time in the emergency department. Interestingly, however, stratified analyses revealed that the greatest disparity in E66 cases and controls was in CTAS 1 (highest priority), where wait times (for initial assessment and inpatient bed) and length of stay in the emergency department were consistently higher for PwO. Although PwO had relatively higher CTAS scores, even when they had the same CTAS score as controls, they experienced longer wait times and length of stay. Individuals with a CTAS level 1 have life threatening conditions requiring immediate intervention (12); the fact that PwO have longer wait times could account for previous literature indicating worse outcomes in PwO (2-8). Finally, the average 4 minute longer wait times for physician initial assessment, and average 3 hour longer length of stay in the emergency department in PwO, could also be accounted for by the greater difficulty in patient management in the emergency department for PwO. Of note, higher BMI has been strongly correlated with difficulty finding anatomical landmarks, venous pressure measurement, physical examination, patient positioning, and procedures (27), which could have delayed assessment and care. These findings further highlight the need for a bariatric friendly healthcare system with specialized bariatric equipment (28) to better assess and care for PwO.

4.5.1 Strengths and Limitations

Taken together, this study provides new insight into care outcome experiences of PwO within in ED in Ontario. Among the strengths of our analysis is our use of administrative health care data within a publicly funded universal healthcare system (i.e. “Medicare”) (29), which decreases risk of response bias differences across income groups. Indeed, the CIHI dataset used for the current analysis is based on includes data from ED visits within Ontario hospitals (2018-19: n=178; 2019-20: n=178; 2020-21: n=180, and; 2021-22: n=179 facilities) over a four year period. Second, PwO is defined as having an ICD-10 diagnosis of overweight and obesity (E66) by a physician during the ED encounter. By using E66 instead of BMI, the focus is on overweight and obesity-related health risk rather than weight alone, as BMI fails to account for variation in body composition and health risk by age, sex, and ethnicity (30). Notwithstanding these study strengths, the study sample consists of ED visits in Ontario only, which may not generalize to the broader Canadian population or other jurisdictions. Cases were defined using an E66 diagnosis, however it is possible individuals with obesity were missed due to a lack of diagnosis, and potential inclusion as a control which may have biased our results towards the null. As well, it is unclear how an E66 diagnosis was made, and whether the physician used measures such as BMI, waist circumference, comprehensive history, physical examinations, and so on. Furthermore, E66 cases were matched on gender, age, and main diagnosis only, as further matching was not statistically feasible. Instead, analyses were adjusted for possible confounders (i.e. responsibly for payment, income, and area (rural/remote or urban)).

4.6 Conclusion

This study demonstrates longer average wait times for initial assessment, length of stay, and triage scores for PwO relative to controls matched for gender, age, and main diagnosis in emergency departments in Ontario. Future research is necessary to confirm the consistency of these findings in other Canadian provinces/territories, and with diverse clinical outcomes.

4.7 Tables and Figures

Table 1. Characteristics of E66 cases and controls.

	Controls (n=13,388)	E66 Cases (n=6 474)	p-value
Gender			
Female	7325 (54.71%)	3491 (53.92%)	
Male	6063 (45.29%)	2983 (46.08%)	p=0.29
Age			
20 to 44 years old	4632 (34.60%)	2462 (38.03%)	
45 to 64 years old	8756 (65.40%)	4012 (61.97%)	p<0.05
Income quintile			
1	3677 (27.46%)	2274 (35.13%)	
2	2850 (21.29%)	1383 (21.36%)	
3	2529 (18.89%)	1160 (17.92%)	
4	2329 (17.40%)	958 (14.80%)	
5	2003 (14.96%)	699 (10.80%)	p<0.05
Area			
Rural/Remote	2170 (16.21%)	1487 (22.97%)	
Urban	11,218 (83.79%)	4987 (77.03%)	p<0.05
Triage level			
1	414 (3.09%)	237 (3.66%)	
2	3783 (28.26%)	2070 (31.97%)	
3	6261 (46.77%)	3040 (46.96%)	
4	2284 (17.06%)	869 (13.42%)	
5	646 (4.83%)	258 (3.99%)	p<0.05
Responsibility for payment			
Provincial/territorial responsibility	12,867 (96.11%)	6196 (95.71%)	
Other	521 (3.89%)	278 (4.29%)	p=0.17

WTPIA = wait time to physician initial assessment

WTIB – wait time to inpatient bed

LOS = length of stay

Continuous variables (WTPIA, WTIB, LOS) displayed as mean ± SD (hours)

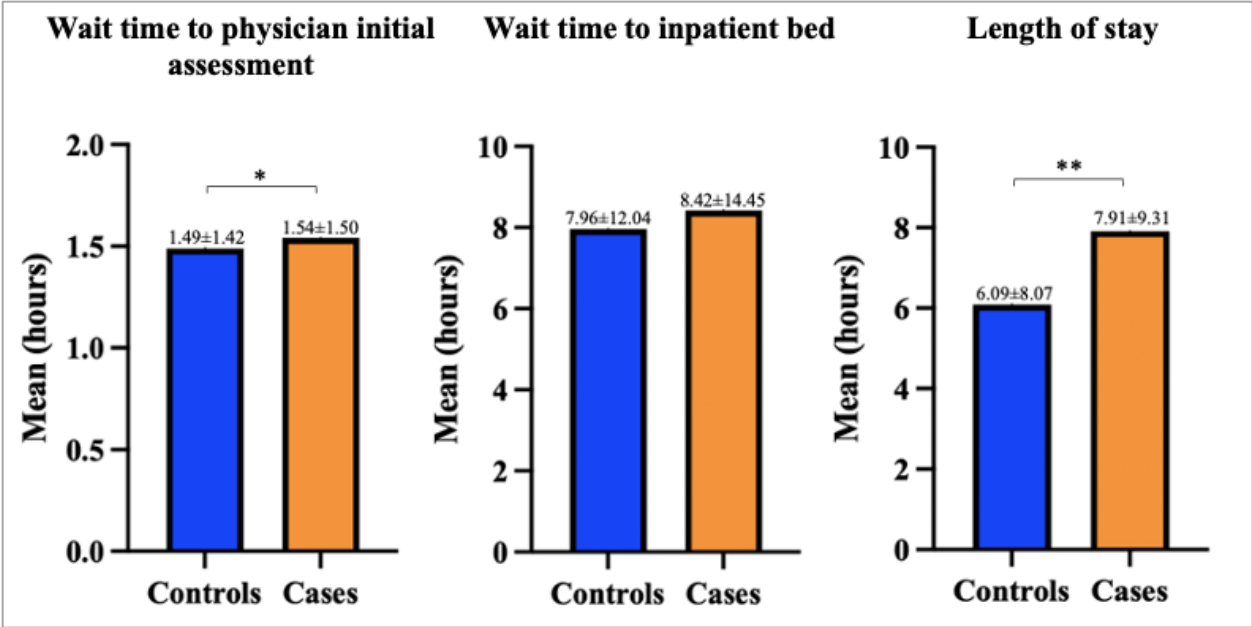


Figure 1. Mean wait time to a physician’s initial assessment, inpatient bed, and overall length of stay in the emergency department between cases (E66 PwO) and controls.

Case: PwO, Controls: matched for age, gender/sex, and main diagnosis

*significance p<0.05

**significance p<0.01

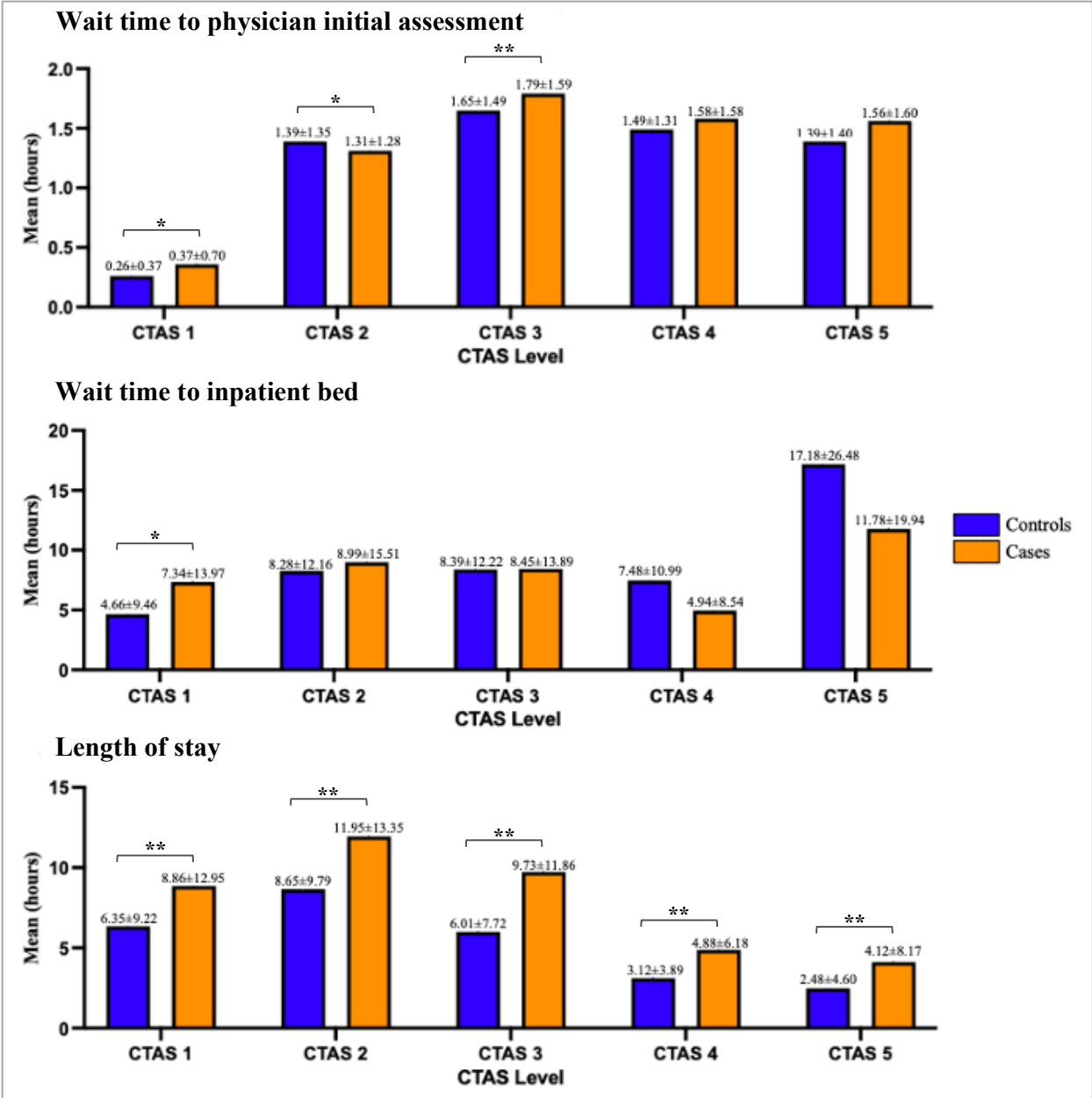


Figure 2. Mean wait time to a physician’s initial assessment, inpatient bed, and overall length of stay in the emergency department between cases (E66 PwO) and controls across Canadian Triage and Acuity Scale.

CTAS = Canadian Triage and Acuity Scale
 Case: PwO, Controls: matched for age, gender/sex, and main diagnosis
 *significance p<0.05
 **significance p<0.01

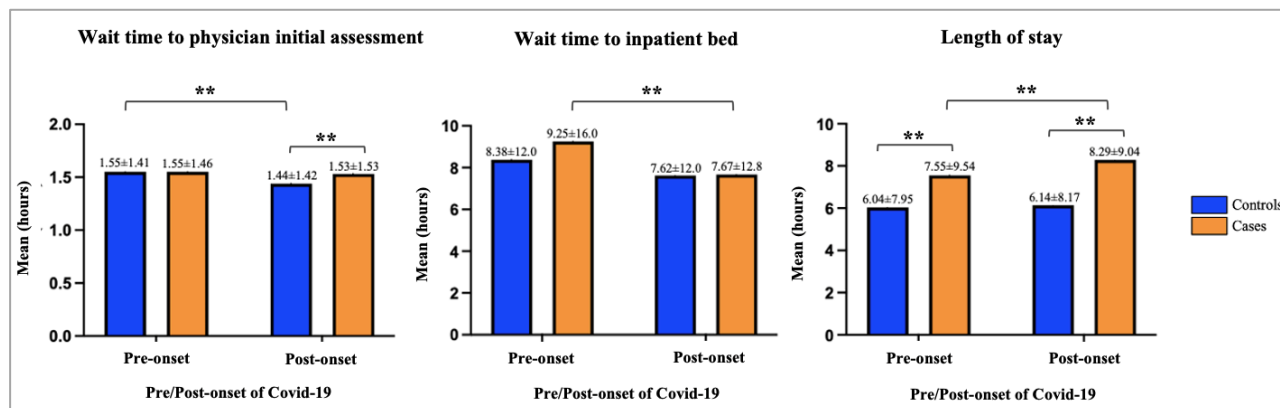


Figure 3. Mean wait time to a physician’s initial assessment, inpatient bed, and length of stay in the emergency department between cases (E66 PwO) and controls across time, examining pre- and post-onset of Covid-19 years.

Case: PwO, Controls: matched for age, gender/sex, and main diagnosis

**significance p<0.01

Table 2. Odds of increasing triage levels (CTAS) across cases (E66 PwO) and controls (n=19,862).

	Unadjusted OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Control	1.00 (ref)	1.00 (ref)	1.00 (ref)
Case (E66)	1.25* (1.18-1.32)	1.26* (1.19-1.33)	1.35* (1.28-1.43)

Case: PwO, Controls: matched for age, gender/sex, and main diagnosis

Model 1 adjusted for gender and age.

Model 2 adjusted for gender, age, responsibility for payment, income, area.

OR = odds ratio (95% CI).

*significance, p<0.05.

Table 3. Results of least squared adjusted means hours to wait times and length of stay in the emergency department across cases (E66 PwO) and controls.

	Control	Unadjusted Case (E66)	p-value	Control	Model 1 Case (E66)	p-value	Control	Model 2 Case (E66)	p-value
WTPIA (n=18,483)	1.49±0.01	1.54±0.02	0.03	1.48 ± 0.01	1.53 ± 0.02	0.03	1.21 ± 0.03	1.28 ± 0.03	0.002
WTIB (n=5436)	7.99±0.25	8.44±0.26	0.22	7.78 ± 0.28	8.29 ± 0.27	0.16	6.57 ± 0.79	7.19 ± 0.79	0.09
LOS (n=19,773)	6.10±0.08	9.53±0.12	<0.0001	5.83 ± 0.05	9.31± 0.12	<0.0001	3.72 ± 0.20	7.06 ± 0.21	<0.0001

Values as Mean ± SE (hours)

Case: PwO, Controls: matched for age, gender/sex, and main diagnosis

Model 1 adjusted for gender and age.

Model 2 adjusted for gender, age, responsibility for payment, income, area, triage level.

WTPIA = wait time to physician initial assessment

WTIB = wait time to inpatient bed

LOS = length of stay

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Chapter 5.0 General Conclusion

The Canadian Clinical Practice Guidelines highlight the importance of obesity diagnosis and shift towards patient-centred health outcomes (1,2). Thus, the studies presented in this thesis aimed at examining diagnosis of obesity through E66 use, and patient care and outcomes within the Canadian context in the two-year prior to, and immediately following the onset of Covid-19 (2018-2022). The first study found regional variation, but uniformly low E66 use across Canada. Predictors of correct E66 coding by BMI were gender, age, income, and length of stay. The second study showed that individuals with E66 code had higher wait times to physician initial assessment, emergency department length of stay and CTAS scores relative to controls that were matched for gender, age, and main diagnosis.

Diagnosis of obesity (E66 use) is the practice of acknowledging obesity as a disease. Diagnosis of obesity can have several implications such as helping reduce stigma and bias associated with obesity, and providing awareness of its severity, which facilitates interventions and treatment. If PwO are not “diagnosed”, physicians cannot offer treatment or refer patients to a specialist for care. Coding for overweight and obesity using the ICD (E66) is also essential for data capture and comparisons in at least two ways. First, using administrative (E66) data may help to assess care and outcomes for PwO, as they have been shown to more frequently visit primary care and emergency departments, with higher hospitalization rates (3). Second, the use of E66 data in the context of access to care and outcomes for PwO may also allow for a better understanding of health system needs for bariatric equipment and specialized care. In study 2 we found longer wait times and length of stay with higher CTAS for PwO compared to controls matched for sex, age, and main diagnosis. When patients enter the emergency department they

are triaged (using CTAS) based on the severity of their condition so that healthcare workers can prioritize patient care requirements (4).

Despite the many strengths of these analyses, results must be interpreted with caution. Although the use of ICD-10 code alongside administrative hospital records was a major strength of this thesis, it is not possible to know exactly when the E66 diagnosis was made by the physician. This poses a limitation for study one as it is unclear if certain medical factors assessed were predictors of E66. For study two, physicians assess patients after they are triaged, meaning that CTAS scores were assigned before E66 was captured. It is therefore not possible to know if patients received E66 code at initial assessment or sometime after. BMI information (weight and height) were also not captured for all patients, therefore limiting the analytic sample of study 1. Moreover, within the first study, relatively few individuals (n=50) had BMI information and no E66 code, which meant that it was not possible to assess BMI as a predictor of E66 coding. Finally, the extent to which patients *with* BMI information may be a potential source of bias, as they it may have been collected for the purpose of adjusting medications or as a contraindication for surgery.

To conclude, the present studies add to the literature by examining E66 use across Canada, and PwO care and outcomes in emergency departments from the years 2018 to 2022. Future research with more complete administrative data information is needed to inform how E66 use could improve healthcare services for PwO.

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