



# The effect of distance on short-term outcomes in a regionalized, publicly funded bariatric surgery model

Aristithes G. Doumouras<sup>1,2</sup>  · Fady Saleh<sup>1</sup> · Dennis Hong<sup>1,2,3</sup>

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## Abstract

**Background** While high-volume Centers of Excellence (COE) for bariatric surgery may have improved clinical outcomes, their disparate distribution results in longer travel distances for patients. The purpose of this study was to investigate effect of distance from COE on outcomes and readmission.

**Methods** This was a retrospective study of all adults, aged 18 years or older, receiving bariatric surgery from April 2009 to March 2012 in the province of Ontario. Main outcomes included 30-day complication rates and readmission. Multivariable logistic regression was used to examine the impact of distance from patients' primary residence to their bariatric COE on patient outcomes and readmissions.

**Results** Five thousand and seven patients were identified, two-thirds residing within 100 km of a COE with a mean distance of 117.2 km. The majority of patients did not reside within a Local Integrated Health Network (LHIN) that contained a COE, while 18.3% of patients lived in rural areas. Using multivariable adjustment, for every 10 km increase from the COE where surgery was performed, the Odds Ratio (OR) for complications was 1.00 [95% Confidence Interval (CI) 0.99–1.01;  $P=0.747$ ]. Additionally, both residing in a LHIN without a COE, OR 1.10 (95% CI 0.87–1.40;  $P=0.434$ ), and rural status, OR 0.97 (95% CI 0.77–1.23;  $P=0.821$ ) showed no increase in risk of complication. Similarly, further distances did not influence rate of readmission, OR 0.99 (95% CI 0.98–1.00;  $P=0.077$ ) nor did rural status OR 1.31 (95% CI 0.97–1.76;  $P=0.076$ ).

**Conclusion** The COE model, where a few centers in high population areas service a large geographic region, is adequate in ensuring patients that live further away receive appropriate short-term care.

**Keywords** Bariatric surgery · Distance · Regionalization · Outcomes · Complications

Regionalization of care for specialized procedures has the reported benefits of improved outcomes mainly due to the subsequent increase in surgical volume and concentrated expertise. However, there are potential downsides to centralization of health care services which include the increasing

distance between patients and their hospital of treatment [1, 2]. This increase may lead to reduced access to care [3, 4]. Moreover, though the phenomenon of distance bias has been previously reported on, where patients who live further from treatment centers have better long-term outcomes specifically in the medical oncology literature [5, 6], more recent surgical literature has pointed to worse outcomes and a longer length of stay for patients who live further from their treatment center [7–10]. Therefore, though there may be a benefit from regionalization due to volume-based outcomes, certain patients may actually do worse based on the reorganization of resources further from their home.

The creation of the Centers of Excellence (COE) model for healthcare delivery in bariatric surgery has not only increased distances for patients but has been shown to decrease access to health services specifically for patients who live further from their COE [4, 11]. Furthermore, distance may decrease follow-up after bariatric surgery [12–19]

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✉ Dennis Hong  
dennishong70@gmail.com

<sup>1</sup> Division of General Surgery, St. Joseph's Healthcare, Hamilton, ON, Canada

<sup>2</sup> Department of Surgery, McMaster University, Hamilton, ON, Canada

<sup>3</sup> Division of General Surgery, St. Joseph's Healthcare, Room G814, 50 Charlton Avenue East, Hamilton, ON L8N 4A6, Canada

and for similar reasons, patients may be limited in their ability to easily seek early follow-up care for postoperative complications. This may require increased readmission rates in lieu of adequate outpatient care. Therefore, while regionalization can lead to better volume-based outcomes, there may exist a group of patients who suffer from worse health outcomes and differing patterns of health care use based on their proximity to treatment facilities.

In Ontario's universal health care system, publically funded bariatric surgery is offered almost exclusively using the COE model. Within Ontario, a province of 12.8 million people in an area double the size of Texas, ensuring access to care can be difficult and expensive. This study aims to ascertain whether the COE model of healthcare delivery in bariatric surgery creates a subset of patients who suffer from poorer short-term outcomes and inefficient health resource utilization. More specifically, we hypothesize that distance may increase short-term complications and readmissions after bariatric surgery.

## Materials and methods

This was a retrospective cohort study in which the principle objective was to determine whether increasing distance from a bariatric COE was associated with increased short-term overall complication and readmission rates. This study was approved by the research ethics board of St. Joseph's Hospital, Hamilton, Ontario.

### Setting and population

The Ontario Bariatric Network (OBN) manages the publicly funded regionalized bariatric care system within Ontario. At the time of this study, it comprises four bariatric COEs which performed Roux-en-Y gastric bypass (RYGB) and longitudinal sleeve gastrectomy (SG). Referrals for bariatric surgery in Ontario are centralized within the OBN and distributed to centers based on geographic proximity. Despite Ontario's large size, approximately 70% of the population lives in a small area in Southern Ontario, known as the Golden Horseshoe, which contains three of the four COE consisting of seven of the eight hospitals within these COEs. The OBN also serves as an entity for bariatric education which is directed to all primary care physicians within Ontario, regardless of region.

### Patient population

This study included patients who received RYGB or SG within the province of Ontario for the purposes of weight loss between April 2009 and March 2012. Patients were greater

than 18 years of age and were selected for surgery based on NIH criteria [20].

### Data sources

Patient demographics, co-morbidities, operations, and outcome data were derived from the Canadian Institute for Health Information (CIHI) Hospital Morbidity Database and Discharge Abstract Database. These data included all potential admissions and readmissions within Ontario for the time period. These data contained information on patient administrative health regions, defined as Local Health Integration Networks (LHINs). There are 14 LHINs in Ontario roughly divided on the basis of population that directly administer the region's health care resource allocation.

### Exposures and outcome

The primary exposure for this study was distance from patients' home to the COE where their surgery was performed. Patient forward sortation areas were used as a proxy for home address. These are neighborhood size units utilized by Canada's postal system and are represented by the first three characters of a patient's postal code. The locations of Ontario's hospitals were derived from Desktop Mapping Technologies Incorporated's Enhanced Points Of Interest File. Distances were calculated using the straight-line distance between the patient neighborhood centroid and the COE where they received care.

The main outcomes of interest in this study were short-term overall complication rate and readmissions. Complications had to have occurred during index hospital admission or during a readmission within 30 days of index procedure. Complications are outlined in Table 1 and include specific surgical and medical complications. In addition, the CIHI database allows for identification of general complications that are defined by CIHI as an identified adverse event which extended length of stay by 24 h or required a separate, unplanned procedure. This represents a composite outcome that is determined by the CIHI during the initial data collection process and therefore is the most comprehensive outcome afforded by the dataset. Hospital readmissions were included if they occurred within 30 days of the index procedure. Readmissions to any hospital in Ontario were included within this study.

In addition to distance, rural status of a patient's neighborhood was examined as a predictor of overall complications and readmission. Rurality was derived from the patients' postal codes as, in Canada, each postal code is defined as being either rural or urban. Also, whether a patient lived and consequently had surgery within a LHIN that contained a COE (as compared to traveling outside of their LHIN to have

**Table 1** Baseline complication types

Surgical complications
Anastomotic leak
Hemorrhage
Postoperative ileus
Wound infection
Death
Medical complications
Cardiac (myocardial infarction, heart failure, arrest)
Respiratory (pneumonia, respiratory failure)
Thrombotic complication (DVT, stroke)
UTI
Renal failure
ICU admission
General complications <sup>a</sup>

<sup>a</sup>Non-specific code in CIHI database which identified adverse events not specifically mentioned above that extended length of stay by 24 h or required a separate, unplanned procedure

surgery) was also examined to determine if an association existed with the outcomes of interest.

## Statistical analysis

Descriptive statistics were used to describe the patient population. Patient demographic data were compared using the Chi-square statistic for categorical variables and the Student's *t* test for continuous variables. Multivariable logistic regression was used to control for confounding in order to determine the extent to which the aforementioned exposures were associated with short-term overall complications and readmissions. Clinically relevant predictors entered in the model included procedure type, age, gender, baseline comorbidities, the different COEs, distance from COE, rural status, and whether a COE was within a patient's LHIN (vs not). Distance from COE was utilized as a continuous variable within the model and presented on a per 10 km basis for simplicity rather than per km. The outcomes of complications and readmission were binary variables. Marginal analysis was used to look at the adjusted relationship between both outcomes and distances. Odds Ratios (OR) with 95% confidence intervals (CI) were reported. Statistical significance was set at  $P < 0.05$ . Stata software was used for data analysis (StataCorp. 2013. *Stata Statistical Software: Release 12.1*. College Station, TX: StataCorp LP).

## Results

The population baseline characteristics are detailed in Table 2. There were a total of 5007 patients who underwent either a RYGB (91.7%) or an SG (8.3%), with almost 99%

performed laparoscopically. Approximately two-thirds of the patients lived within 100 km of the COE where surgery was performed. The mean distance from patient residence to the COE where bariatric surgery occurred was 117.2 km (standard deviation 168.5 km, data not displayed). The majority of patients were female (81.9%), which differed slightly between patients within and beyond 100 km, but was statistically significant ( $P = 0.047$ ). Co-morbidities differed between those within 100 km of their COE and above 100 km. Generally, the patients greater than 100 km away were older (44.5 vs 44.4 years;  $P = 0.022$ ), and had higher rates of hypertension, hyperlipidemia, obstructive sleep apnea, and gastroesophageal reflux disease ( $P < 0.05$ ). While the rates were also higher for diabetes, renal failure, coronary artery disease, and chronic obstructive pulmonary disease, they were not statistically significant. Overall complication rates were 11.7% in the cohort and readmission rates were 6.1%.

Table 3 outlines the univariate analysis of the exposures of interest and both the overall complication and readmission rates. With every 10-km increase in distance a patient lived from their COE, there was no increase in complication (OR 1.00,  $P = 0.213$ ). Having a COE within the patient's home LHIN was associated with a higher complication rate, OR 1.30 (95% CI 1.09–1.55;  $P = 0.004$ ). Patients from neighborhoods classified as rural had higher complications rates, OR 1.14 (95% CI 0.91–1.41) but was not statistically significant,  $P = 0.251$ . There was a statistically significant decreased rate of readmission with increased distance from a COE, but this amounted to just a 1% decrease in the odds of readmission for every 10-km increase in distance, OR 0.99 ( $P = 0.043$ ). Both having a COE within the patient's home LHIN and coming from a neighborhood classified as rural had higher rates of readmission but were not significant ( $P > 0.05$ ).

Figures 1 and 2 show the relationships between distance and the outcomes. The scatter plots display weighted markers based on the number of patients within each 50 km interval. The scatter plots are fitted with a line. Both plots demonstrate a decrease in events over distance, although as discussed above, overall complications in non-significant while readmission reaches significance.

Table 4 details the multivariable analysis. After adjustment, there appears to be no association between the odds of complications and increased distance, OR 1.00 (95% CI 0.99–1.01;  $P = 0.747$ ). Having a COE within a patient's LHIN, OR 1.10 (95% CI 0.87–1.40), and residing within a rural area, OR 0.97 (95% CI 0.77–1.23) do not appear to be significantly predictive of overall complications,  $P = 0.434$  and  $P = 0.821$ , respectively. Similarly, readmission rate does not appear to be associated with distance from the COE, with an odds ratio remaining 0.99 (95% CI 0.98–1.00) though not reaching significance,  $P = 0.077$ . While living within a LHIN that contains a COE is not associated with

**Table 2** Baseline characteristics

Variable	Total	< 100 km <sup>a</sup>	> 100 km <sup>a</sup>	P-value
<i>N</i>	5007	3386 (67.6)	1621 (32.4)	N/A
<b>Procedure</b>				
Laparoscopy	4952 (98.9)	3347 (98.9)	1605 (99.0)	0.601
Roux-en-Y	4591 (91.7)	3093 (91.4)	1498 (92.4)	0.201
SG	416 (8.3)	293 (8.7)	123 (7.6)	
<b>Co-morbidities</b>				
Female sex	4100 (81.9)	2798 (82.6)	1302 (80.3)	0.047
Mean age (years) ( $\pm$ SD)	44.6 (10.3)	44.4 (10.2)	45.1 (10.6)	0.022
Diabetes mellitus	1483 (29.6)	974 (28.8)	509 (31.4)	0.056
Hypertension	1363 (27.2)	852 (25.2)	511 (31.5)	<0.001
Hyperlipidemia	175 (3.5)	101 (3.0)	74 (4.6)	0.004
Obstructive sleep apnea	1545 (30.9)	1010 (29.8)	535 (33.0)	0.023
Gastro-esophageal reflux	328 (6.6)	188 (5.6)	140 (8.6)	<0.001
Chronic kidney disease	38 (0.8)	24 (0.7)	14 (0.9)	0.555
Coronary artery disease	74 (1.5)	45 (1.3)	29 (1.8)	0.207
COPD	27 (0.5)	16 (0.5)	11 (0.7)	0.352
<b>Location</b>				
LHIN with COE <sup>b</sup>	1815 (36.3)	1792 (52.9)	23 (1.42)	<0.001
Rural <sup>c</sup>	915 (18.3)	411 (12.1)	504 (31.1)	<0.001
<b>Outcome</b>				
Overall complications	585 (11.7)	416 (12.3)	169 (10.43)	0.055
Readmission	305 (6.1)	224 (6.6)	81 (5.0)	0.025

Numbers represent *N* (%) unless otherwise indicated

SD standard deviation, COPD chronic obstructive pulmonary disease, COE Center of Excellence, LHIN local health integrated network

<sup>a</sup>Distance from the Center of Excellence where patient had surgery

<sup>b</sup>Patient resides in LHIN that contains a COE

<sup>c</sup>Patient resides in a neighborhood classified as rural

**Table 3** Univariate rate for complications and readmissions

	Overall complications <i>N</i> = 585 (11.7%)			Readmission <i>N</i> = 305 (6.1%)		
	Unadjusted OR	95% CI	P-value	Unadjusted OR	95% CI	P-value
Distance (per 10 km)	1.00	0.99–1.00	0.213	0.99	0.98–1.00	0.043
LHIN with COE <sup>a</sup>	1.30	1.09–1.55	0.004	1.10	0.87–1.40	0.429
Rural <sup>b</sup>	1.14	0.91–1.41	0.251	1.25	0.94–1.66	0.117

COE Center of Excellence, LHIN local health integrated network

<sup>a</sup>Patient resides in LHIN that contains a COE

<sup>b</sup>Patient resides in a neighborhood classified as rural

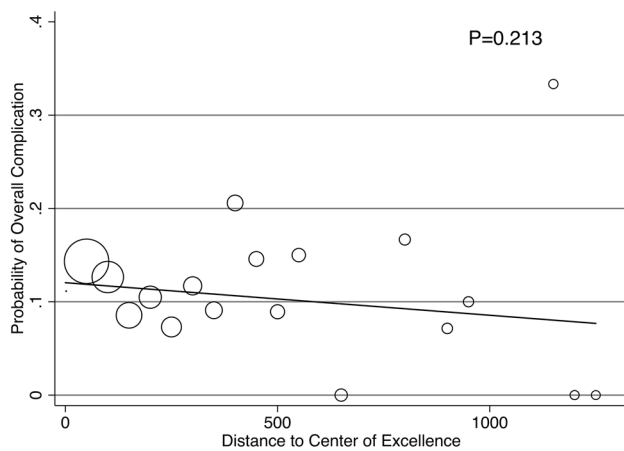
readmission, OR 1.00 (95% CI 0.73–1.37;  $P=0.996$ ), living within a rural neighborhood trends towards significance, OR 1.31 (95% CI 0.97–1.76;  $P=0.076$ ).

Figures 3 and 4 display the marginal analysis of the multivariable models. Over units of distance, each patient is run through the model to give the average effect on complication rates (Fig. 3) and readmission rates (Fig. 4). The shaded area represents the 95% CI. Figure 3 illustrates a slight increase over distance of the probability of complications with very

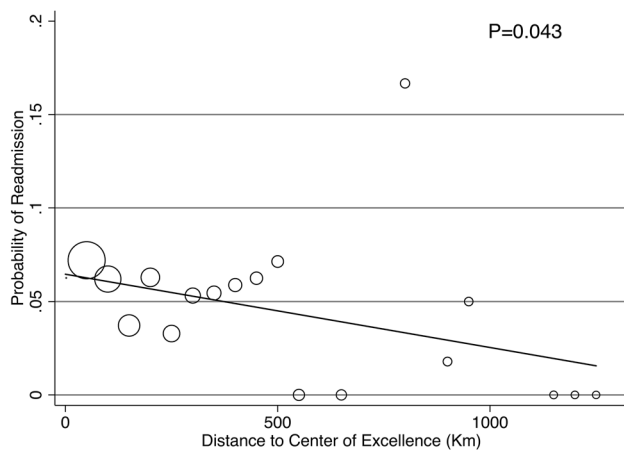
wide CIs. Figure 4 demonstrates a declining readmission rate with distance.

## Discussion

This study is unique in that it is the first to assess the effect of distance on short-term outcomes and readmissions in bariatric surgery. Our data show that distance from a COE



**Fig. 1** Probability of overall complication versus distance from COE



**Fig. 2** Probability of readmission versus distance from COE

did not result in worsened short-term outcomes for bariatric surgery patients or higher readmission rates. Specifically, the OR for complications for every 10-km increase in distance from the COE where patients had bariatric surgery was 1.00 ( $P=0.747$ ) while for readmission, OR 0.99 ( $P=0.077$ ).

Additionally, patients living in a LHIN with a COE within its boundaries had no effect on complication or readmission rates. Finally, patients living in rural areas also did not suffer increased complications, but trended towards higher readmission rates, OR 1.31 (95% CI 0.97–1.76;  $P=0.076$ ).

There is an abundance of evidence suggesting that regionalization of bariatric surgery, with the resultant high volume status and designation as a COE, improves patient outcomes [21–28]. Improved outcomes include a reduction in overall complications, death, and reoperation [26–28]. While the majority of evidence points to this positive effect of centralization, a number of studies do call into question whether this ‘volume-outcome hypothesis’ is in fact true, citing poor study design and lack of appropriate controls for comparison and suggesting that perhaps centralization is just one part in a number of initiatives improve outcomes [29–31]. These include technical changes over time, surgeon experience, policy changes, and improved technologies. In addition to improved outcomes, costs also appear to be lower [24, 26, 27, 32]. The implementation of a center of excellence model in bariatric surgery has led to an increased distance to treatment facilities as well as a decreased delivery of bariatric surgery for patients who live further from regionalized centers [4, 11]. The effect of this increased distance and unequal distribution on short-term outcomes had not been previously explored in bariatric surgery. Previous medical literature related to oncologic outcomes actually found that patients coming from further away had improved outcomes, a poorly understood phenomenon [5, 6]. More recent findings in the surgical literature found that patients who lived further from their treatment facility had poorer outcomes [7, 8]. However, the latter study by Chou et al. found that readmission was not affected by distance, similar to this study [8]. Additionally, the first orthopedic surgery study that examined the effect of distance on complications after reorganization to a COE model for total joint arthroplasties also found no effect of distance on rates of complications [33].

This study is important from a policy perspective. With bariatric surgery comparatively new in Ontario and Canada

**Table 4** Adjusted OR for overall complications and readmission

	Overall complications			Readmission		
	Adjusted OR <sup>a</sup>	95% CI	<i>P</i> -value	Adjusted OR <sup>a</sup>	95% CI	<i>P</i> -value
Distance (per 10 km)	1.00	0.99–1.01	0.747	0.99	0.98–1.00	0.077
LHIN with COE <sup>b</sup>	1.10	0.87–1.40	0.434	1.00	0.73–1.37	0.996
Rural <sup>c</sup>	0.97	0.77–1.23	0.821	1.31	0.97–1.76	0.076

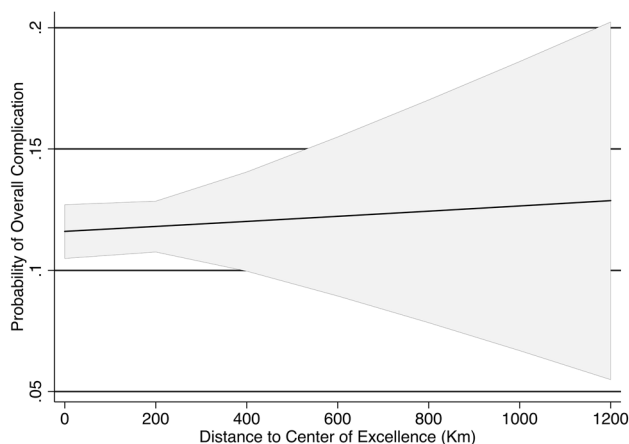
COE Center of Excellence, LHIN local health integrated network

<sup>a</sup>Adjusted for procedure type, sex, age, diabetes, hypertension, hyperlipidemia, sleep apnea, gastroesophageal reflux, chronic kidney disease, coronary artery disease, chronic obstructive pulmonary disease, residence with a LHIN containing a center of excellence, rural status, and center of excellence

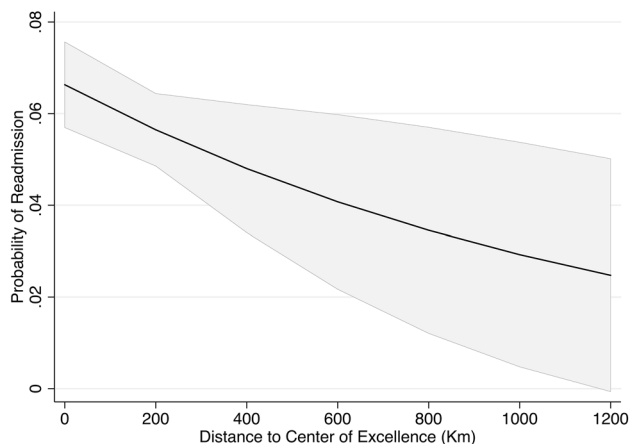
<sup>b</sup>Patient resides in LHIN that contains a COE

<sup>c</sup>Patient resides in a neighborhood classified as rural





**Fig. 3** Adjusted probability of overall complication versus distance from COE



**Fig. 4** Adjusted probability of readmission versus distance from COE

as a whole, it is incumbent upon policy makers to make evidence-based decisions on resource allocation and evaluate the COE strategy currently employed to service its populace. Despite Ontario's large size, compounded by the fact that approximately 70% of the population within the Golden Horseshoe and the remainder dispersed over a vast landmass, it appears distance from COE did not have any negative effect on complication rates or need for re-hospitalization in a bariatric regionalized care system. This is important, as a reverse distance bias would have been problematic for policy makers. As it stands, from an outcomes perspective, there should continue to be concern based on the increased distance for patients created by regionalization. Bariatric surgery poses a unique patient population and previous studies have demonstrated high variation in the knowledge, familiarity, and comfort level of primary care providers in dealing with bariatric surgery and morbidly obese patients [34, 35].

This study has several limitations. CIHI is an administrative database and is subject to response bias and measurement error [36, 37]. The administrative character of the database also limits our ability to adjust for all clinically relevant variables. Despite controlling for COE in our multivariable analysis, there remained heterogeneity between surgeon practices which could not be adjusted for, though all centers met criteria for OBN center of excellence designation. We also did not have capture emergency or outpatient visits and thus we used readmission as our health utilization proxy. Additionally, the findings of the study applied to Ontario specifically and our findings may not be entirely generalizable to different health systems. Finally, a number of initiatives as part of the roll out of the Ontario Bariatric Network included education to primary care physicians and local hospitals to ensure quality care that could not be accounted for in our analysis. However, these campaigns were for all of Ontario and not for specific areas and therefore we do not believe would have a great impact on the analysis.

Despite the fact that increased distance to COEs is a consequence of regionalization of bariatric surgery, our study found no short-term impact of distance on complications or readmission. Considering the benefits to outcomes of high volume regionalized centers, the data in this study affirm the viability of this model as a method for healthcare delivery.

### Compliance with ethical standards

**Disclosures** Drs. Aristithes Doumouras, Fady Saleh, Dennis Hong have no conflicts of interest or financial ties to disclose.

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