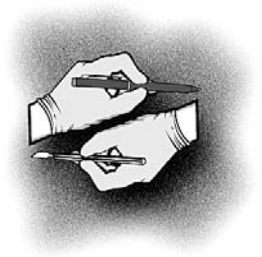

ORIGINAL ARTICLE
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Utilization rates for surgical procedures in rural and urban Canada

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Objective: To investigate whether utilization rates of common surgical procedures are different between urban and rural Canadians in 2 provinces and to examine whether these rates are influenced by the presence and scope of local surgical programs and by the availability of different physician providers.

Methods: Utilization rates for 8 common surgical procedures (appendectomy, carpal tunnel release, closed hip fracture repair, rectal cancer surgery, joint replacement, thyroidectomy, unilateral or bilateral inguinal herniorrhaphy, and cholecystectomy) were identified in rural Alberta and rural Northern Ontario from hospital discharge records. Rural populations were characterized by 3 types of communities, based on availability of local physician and diagnostic resources. Travel time for consultations and surgery were estimated. Age–sex-adjusted rates, their standard errors, and 95% confidence intervals (CIs) were calculated for the purpose of comparisons among residents' locations using the method of direct standardization. To test a possible association between travel times and utilization rates, hierarchical linear and nonlinear modelling was used to analyze a 2-level model, with patients nested within rural hospital catchment areas in the province of Alberta.

Results: Utilization rates for appendectomy, cholecystectomy and carpal tunnel release are significantly greater for rural populations compared with urban in both Alberta and Northern Ontario. Rural Northern Ontario had higher rates of utilization than rural Alberta for carpal tunnel release and cholecystectomy ($p < 0.01$) and closed hip fracture repair ($p < 0.05$). No statistical differences between the provinces were noted for the remaining procedures. No difference in utilization rates was found between the 3 types of rural centres. The modelling found a significant association between travel time and use for only one procedure — carpal tunnel release. Patients who had to travel ≤1 hour had a 13% higher surgery rate.

Conclusion: Rates of utilization were higher in rural areas for procedures where greater surgical variability is known to exist. These higher rural rates were not influenced by either the presence or scope of local surgical programs nor by the differences in providers. There was no difference in rates for procedures where previous research has shown little variability.

Objectif : Déterminer si les taux d'utilisation des interventions chirurgicales courantes sont différents entre les milieux urbains et ruraux dans deux provinces du Canada et si la présence et l'envergure de programmes locaux de chirurgie et la disponibilité de différents médecins prestateurs ont une influence sur ces taux.

Méthodes : On a déterminé, à partir de dossiers de congé d'hôpital, les taux d'utilisation de huit interventions chirurgicales courantes (appendicectomie, libération du nerf médian au niveau du canal carpien, réduction fermée d'une fracture de la hanche, chirurgie pour cancer du rectum, arthroplastie, thyroïdectomie, herniorrhaphie inguinale unilatérale ou bilatérale et cholécystectomie) en milieu rural, en Alberta et dans le nord de l'Ontario. On a caractérisé les populations rurales en fonction de trois types de communauté et de la disponibilité locale d'un médecin et de services de diagnostic. On a estimé le temps de déplacement pour les consultations et l'intervention chirurgicale. On a utilisé la normalisation directe pour calculer les taux corrigés en fonction de l'âge et du sexe, de leur écart type et de leur intervalle de confiance (IC) à 95 % afin d'établir des comparaisons entre les lieux de résidence des patients. Afin de déterminer s'il y a un lien possible entre la durée des déplacements et les taux d'utilisa-

tion, on a utilisé une modélisation linéaire et non linéaire hiérarchique pour analyser un modèle à deux niveaux, les patients étant intégrés à des bassins hospitaliers ruraux en Alberta.

Résultats : Les taux d'utilisation de l'appendicectomie, de la cholécystectomie et de la libération du nerf médian au canal carpien sont significativement plus élevés dans les populations rurales que dans les populations urbaines, tant en Alberta que dans le nord de l'Ontario. Les milieux ruraux du nord de l'Ontario affichaient des taux plus élevés d'utilisation que ceux de l'Alberta dans le cas de la libération du nerf médian au canal carpien et de la cholécystectomie ($p < 0,01$), ainsi que dans celui de la réduction fermée de fractures de la hanche ($p < 0,05$). On n'a constaté aucune différence statistique entre les provinces pour les autres interventions et aucune différence au niveau des taux d'utilisation entre les trois types de centres ruraux. La modélisation a révélé un lien important entre la durée des déplacements et l'utilisation dans le cas d'une intervention seulement — la libération du nerf médian au niveau du canal carpien. Les patients qui devaient se déplacer moins d'une heure présentaient un taux d'intervention chirurgicale plus élevé de 13 %.

Conclusion : Les taux d'utilisation étaient plus élevés dans les régions rurales dans le cas des interventions où l'on sait qu'il existe une variabilité chirurgicale plus importante. Ni la présence ou l'envergure de programmes locaux de chirurgie, ni les différences entre les prestateurs, n'ont eu d'effet sur ces taux ruraux plus élevés. Les taux d'intervention qui présentaient peu de variabilité selon les recherches antérieures ne montraient aucune différence.

Introduction

The provision of surgical services to rural and remote areas of Canada presents several challenges. First, the provision of smaller, rural, surgical programs is expensive and there is a perception, not documented, that provincial regionalization and restructuring initiatives have seen the closure of many rural surgery programs for financial and administrative reasons. Second, specialist general surgeons have been in short supply (Dr. John Ruedy, Dean of Medicine [1992–99], Dalhousie University: unpublished data, 1998) and there is a lack of consensus on the appropriate role for non-specialist physicians, including family physicians, in the provision of surgical care. There is also a perception that current general surgery training programs prepare their graduates for urban sub-specialty practices rather than for a rural generalist setting. The recommendation that on-call responsibilities should not exceed 1-in-5 requires that services be provided by groups of providers.[1] Third, technological advances such as minimally invasive surgery and the large role of CT scanning in general surgery might encourage the centralization of these services in urban centres.

Surgical services in rural and remote Canada have been provided by physicians with different training backgrounds i) Canadian-certified general surgeons, ii) international medical graduates with an advanced level of surgical training, usually a foreign fellowship, and iii) family physicians with additional postgraduate surgical training who can offer a limited skill set (e.g., appendectomy, herniorrhaphy, cesarean section).[2] Canada's provinces and territories vary in their use of these different providers.[3]

Our research study investigated whether the utilization rates of 8 common surgical procedures are different between urban and rural Canadians. We chose 2 provinces — Alberta and Ontario, specifically Northern Ontario — each with a large geography and significant rural populations, but different approaches to the delivery of surgical services. Northern Ontario relies almost exclusively on Canadian-certified general surgeons, often recruiting and supporting them with Alternative Payment Plans, in surgical groups located in several medium- and large-sized rural centres. Alberta relies on a blend of all 3 physician provider groups, distributed in a significantly larger number of rural surgical programs sometimes located in centres smaller than the rural surgical centres in Northern Ontario.[3]

Our research gave us the opportunity to contrast these systems and to ask whether utilization rates might be affected by these differences. It was also an opportunity to determine if there is an association between utilization rates and either the avail-

ability of local diagnostic and surgical services in rural Canada and/or the distance travelled by rural patients to access these services.

Methods

Data sources

Both Alberta Health and Wellness and the Institute for Clinical Evaluative Sciences (located in Ontario) were partnered with the research team. The following databases were accessed in-house by the respective provincial agencies.

Alberta

- Discharge Abstract Database (DAD): summarizes clinical care provided to each hospital patient admitted for an overnight stay
- Ambulatory Care Classification System: an abstract of the clinical care provided as outpatient services
- Alberta Health Care Insurance Plan: provides patient birth date, sex and postal codes

Ontario

- DAD
- Same Day Surgery (SDS): an abstract of the clinical care provided as outpatient services
- Registered Persons Database: from the Ontario Health Insurance Program, it provided patient age, sex and postal codes

Data extraction criteria

1. Using the DAD and SDS databases the procedures of interest were selected based on the clinical modification of the *International Classification of Diseases*, 9th revision (ICD-9-CM) databases (Appendix 1).
2. Only one unique procedure per person was included. If more than 1 of the **same** procedure was found for the **same** individual (e.g., 2 carpal tunnel releases, 2 closed hip fracture repairs) only the first surgical procedure record and its attendant information were included.
3. A resident with a non-urban postal code was defined as a non-urban resident. A non-urban postal code was defined as a place 60 min in travel time from a tertiary care centre, or 30 min in travel time from a regional centre (60:30 rule).
4. Age–sex-adjusted rates, their standard errors, and 95% confidence intervals (CIs)[1] were calculated for the purpose of comparisons among residents' locations using the method of direct standardization. The standard population for the adjusted rates was the population of Alberta on Sept. 30, 1999 (the mid-point of the study period). In Alberta, the population used in age–sex-region specific rates was from the Alberta Health Care Insurance Plan registry database. In Ontario, the population was from the intercensal estimates using the 1996 census data.
5. T-square statistics developed by Carriere and Roos[4] were computed for comparing rates, and 95% CIs were provided in the tables.

Level of surgical services

1. Hospital catchment areas

All of the acute care hospitals in Alberta and Northern Ontario were assigned unique hospital catchment areas. This allowed each patient undergoing a procedure to be mapped by postal code to the hospital where she or he resided, regardless of where he or she actually received the surgical care. For a detailed description of this methodology the reader is referred to the companion paper by Ellehoj and colleagues (p. 187).[5]

2. Surgical services

Service characteristics for each acute care facility were used to characterize hospital catchment area polygon residents into 5 levels of surgical service categories: Metropolitan, Regional, Rural A, Rural B and Rural C.

i) Metropolitan catchment areas

A Metropolitan centre includes at least 1 tertiary care facility associated with a local medical school. In Alberta, these are in Edmonton and Calgary. At the time of the study, Northern Ontario did not have a tertiary care centre with a local medical school. We used London, Ont., in Southwestern Ontario as our reference Metropolitan population for Northern Ontario. All hospitals within a 60-min drivetime of the Academic Health Sciences Centres are included in the Metropolitan catchment area.

ii) Regional catchment areas

Regional catchment area residents have local access to all of the study procedures and to a full comple-

ment of diagnostic technologies associated with these procedures (fluoroscopy, endoscopy, ultrasound, electromylography). The only exception is the Northern Lights Regional Health Centre in Fort McMurray, Alta., where joint replacement and repair of closed hip fracture are not offered locally.

Alberta's Regional centres are Fort McMurray, Grande Prairie, Red Deer, Lethbridge and Medicine Hat. Northern Ontario's Regional centres are Thunder Bay, Sault Ste. Marie, Sudbury, North Bay and Timmins. All hospitals within a 30-min drive of these facilities are included within a Regional catchment area.

iii) Rural A, rural B and rural C

A Rural facility represented all acute care facilities outside the Regional and Metropolitan centres. The defining characteristic was the provision of most or all of the local medical services by family physicians.

The definitions of the 3 rural facility groupings: Rural A (RA), Rural B (RB) and Rural C (RC) were based on a survey completed in Western Canada between May and September of 2000.[6] This survey was sent by mail or email to the facility administrator or a member of the surgical staff of all the rural acute care facilities providing surgical services in Manitoba, Saskatchewan, Alberta and British Columbia. (These facilities were defined as having provided at least one appendectomy or cesarean section during the 1996/97 fiscal year in the DAD file.) The survey respondent was asked to describe the type of surgery performed in the facility, available diagnostic services, and physician availability and training. Based on these responses the definitions of RA, RB and RC were created (Appendix 2).

In Northern Ontario, similar hospital service characteristics were collected by a telephone survey to the rural facilities that provided local surgical services.

iv) Travel time

A set of procedure-specific travel webs was created that anticipated the most likely referral centre for consultation, diagnostic testing and surgery for each of the rural facilities in both provinces. In most instances this represented the closest referral facility by road access. When the anticipated referral centre was not obvious, a telephone survey completed the travel web.

For some procedures — appendectomy, closed hip fracture repair — patients only travel once. For other procedures, rural patients might travel 2 (joint replacement) or 3 times (carpal tunnel release), depending on the local services available. Our travel time variable became the destination specific travel time multiplied by the number of expected trips.

Ethics approval was received from the Community Research Ethics Board of Alberta (Protocol 0410).

Results

1. Between-province comparison of utilization rates

Rural Northern Ontario had higher rates of utilization than rural Alberta for carpal tunnel release and cholecystectomy ($p < 0.01$) as well as closed hip fracture repair ($p < 0.05$). No statistical differences between the provinces were noted in the remaining areas (Table 1).

In a comparison of urban areas, Northern Ontario had higher rates for several procedures, including carpal tunnel release, closed hip fracture repair, joint replacement, unilateral or bilateral inguinal herniorrhaphy, and cholecystectomy ($p < 0.01$). Urban Alberta had higher rates only for thyroidectomy ($p < 0.05$). There was no statistical difference in urban areas for appendectomy (Table 2).

3. Within-province comparison of rural and urban populations

Appendectomy, cholecystectomy and carpal tunnel release utilization rates are significantly greater for rural populations in both Alberta and Northern Ontario ($p < 0.01$). In Alberta the rural utilization rates for joint replacement are higher in rural areas ($p < 0.01$). In Northern Ontario there were no differences between the rural and urban populations for joint replacement (Table 2).

For closed hip fracture repair, rectal cancer surgery, thyroidectomy, and unilateral or bilateral inguinal herniorrhaphy there are no differences in the utilization rates between rural and urban populations within a province (Table 2).

2. Within-province comparison of different local surgical service levels

In Alberta, differences in rates based on local surgical services were identified for 5 procedures: appendectomy, carpal tunnel release, joint replacement, cholecystectomy (all $p < 0.01$) and unilateral or bilateral inguinal herniorrhaphy ($p < 0.05$). For

these procedures utilization rates were significantly lower in at least 1 of the urban centres (i.e., either Edmonton or Calgary). There were no differences between the different rural areas (RA, RB, RC) or regional centres. (Table 3).

In Ontario, carpal tunnel release and cholecystectomy rates were lower in the urban centre ($p < 0.01$). London, Ont., also had lower utilization rates for appendectomy and for unilateral or bilateral inguinal herniorrhaphy ($p < 0.05$). Similar to Alberta, there were no statistically significant differences in utilization rates between the 3 types of rural communities or in comparison to the regional centres in Northern Ontario (Table 4).

Using an F-test of the Alberta and Ontario T-squared statistics, we tested how the variation in utilization rates among the populations residing in Rural, Regional and Metropolitan service centres

Table 1. Utilization rates* (and standard deviations) by rural and urban residence: interprovincial comparison

Procedure, age limit in years	Rural			Urban		
	Alberta	Northern Ontario	T^2	Alberta	Northern Ontario	T^2
Appendectomy, ≥ 5	1.20 (1.12–1.29)	1.24 (1.12–1.37)	0.23	1.07 (1.02–1.11)	1.00 (0.94–1.07)	2.40
Carpal tunnel release, ≥ 20	1.39 (1.28–1.50)	1.95 (1.78–2.13)	30.42†	0.83 (0.78–0.87)	1.47 (1.39–1.55)	213.47†
Closed hip fracture repair, ≥ 50	1.44 (1.27–1.63)	1.81 (1.54–2.12)	4.79‡	1.46 (1.36–1.57)	1.73 (1.59–1.87)	9.49†
Rectal cancer surgery, ≥ 50	0.42 (0.33–0.53)	0.45 (0.34–0.60)	0.17	0.44 (0.39–0.50)	0.48 (0.41–0.56)	0.50
Joint replacement, ≥ 40	3.36 (3.15–3.58)	3.21 (2.94–3.51)	0.61	2.90 (2.80–3.02)	3.53 (3.38–3.69)	42.09†
Thyroidectomy, no age limit	0.36 (0.30–0.43)	0.27 (0.20–0.35)	3.17	0.34 (0.31–0.38)	0.29 (0.25–0.33)	4.05‡
Unilateral or bilateral inguinal herniorrhaphy, ≥ 20	1.93 (1.81–2.06)	2.07 (1.90–2.26)	1.73	1.88 (1.82–1.95)	2.27 (2.17–2.38)	41.80†
Cholecystectomy, ≥ 20	3.62 (3.44–3.80)	4.39 (4.13–4.66)	23.35†	2.98 (2.89–3.06)	3.30 (3.17–3.42)	18.23†

SD = standard deviation
*No. of procedures per 1000 population.
†$p < 0.01$
‡$p < 0.05$.
Note: 99.17% confidence intervals for rates (overall $\alpha = 0.05$).

Table 2. Utilization rates* (and standard deviations) by province: rural and urban comparison

Procedure, age limit in years	Alberta			Northern Ontario		
	Rural	Urban	T^2	Rural	Urban	T^2
Appendectomy, ≥ 5	1.20 (1.12–1.29)	1.07 (1.02–1.11)	8.17†	1.24 (1.12–1.37)	1.00 (0.94-1.07)	12.09†
Carpal tunnel release, ≥ 20	1.39 (1.28–1.50)	0.83 (0.78–0.87)	116.25†	1.95 (1.78–2.13)	1.47 (1.39–1.55)	27.12†
Closed hip fracture repair, ≥ 50	1.44 (1.27–1.63)	1.46 (1.36–1.57)	0.03	1.81 (1.54–2.12)	1.73 (1.59–1.87)	0.25
Rectal cancer surgery, ≥ 50	0.42 (0.33–0.53)	0.44 (0.39–0.50)	0.19	0.45 (0.34–0.60)	0.48 (0.41–0.56)	0.11
Joint replacement, ≥ 40	3.36 (3.15–3.58)	2.90 (2.80–3.02)	14.53†	3.21 (2.94–3.51)	3.53 (3.38–3.69)	3.44
Thyroidectomy, no age limit	0.36 (0.30–0.43)	0.34 (0.31–0.38)	0.13	0.27 (0.20–0.35)	0.29 (0.25–0.33)	0.29
Unilateral or bilateral inguinal herniorrhaphy, ≥ 20	1.93 (1.81–2.06)	1.88 (1.82–1.95)	0.38	2.07 (1.90–2.26)	2.27 (2.17–2.38)	3.60
Cholecystectomy, ≥ 20	3.62 (3.44–3.80)	2.98 (2.89–3.06)	45.66†	4.39 (4.13–4.66)	3.30 (3.17–3.42)	61.82†

SD = standard deviation
*No. of procedures per 1000 population.
†$p < 0.01$
Note: 99.17% confidence intervals for rates (overall $\alpha = 0.05$).

differed between the provinces. There were no significant differences between the provinces for any of the 8 procedures.

5. Modelling of rural care delivery

Hierarchical linear and nonlinear modelling (HLM 5.05) was used to analyze a 2-level model with patients nested within hospital catchment areas. Because our principal interest was to test the possible association between travel times and utilization rates, we restricted the model to include only the rural population. We tested the modelling exercise using only the Alberta population. At the patient level, age and sex were included as independent variables. At the community level, travel time and level of surgical service (RA, RB, RC) were included. We chose a significance test of $p < 0.01$ because of multiple associations.

For carpal tunnel release the utilization rate was significantly associated with travel time. Patients who travel ≤1 hour had a 13% higher surgery rate. No significant associations between travel time and utilization rates were found for the other 7 procedures.

Discussion

Much of the analytical framework in the literature derives from Wennberg and Gittelsohn, who hypothesized that variation in surgical rates would be inversely correlated with the accuracy of diagnosis and the efficacy of surgical treatment for any particular morbid condition.[7,8] If there are significant challenges with diagnosis (appendectomy) or discretion in the use of surgical treatment (hysterectomy, tonsillectomy, carpal tunnel release), then greater variation in surgical rates are expected. When the diagnosis is easily made and the appropriateness of surgical therapy is established (cancer surgery, closed hip fracture repair, hernia repair) little variation in surgical rates is anticipated.

Our results for the variation in utilization rates are similar to the international and Canadian literature.[9–15] Both appendectomy and cholecystectomy rates have generally shown significant variability but less so than the extremes of hysterectomy and tonsillectomy.

In the Canadian literature 2 consistent findings emerge.[12–15] First, the utilization rates for the procedures studied are significantly higher among rural populations. Second, the lowest utilization rates are found in Metropolitan centres with teaching hospitals. Our own results are similar for those procedures where differences in utilization rates are found.

Some authors suggest that higher utilization

Table 3. Utilization rates* (and standard deviations) by service level of residence, in Alberta

Procedure, age limit in years	Rural†			Regional‡	Metropolitan§		T^2
	RA	RB	RC		Edmonton	Calgary	
Appendectomy, ≥ 5	1.11 (0.90–1.37)	1.27 (1.10–1.46)	1.21 (1.02–1.43)	1.25 (1.10–1.42)	1.13 (1.04–1.23)	0.91 (0.83–1.00)	43.94¶
Carpal tunnel release, ≥ 20	1.42 (1.15–1.76)	1.43 (1.22–1.68)	1.34 (1.11–1.61)	1.11 (0.95–1.30)	0.83 (0.74–0.92)	0.70 (0.62–0.79)	161.34¶
Closed hip fracture repair, ≥ 50	1.28 (0.91–1.81)	1.54 (1.20–1.98)	1.40 (1.06–1.85)	1.40 (1.10–1.77)	1.57 (1.35–1.82)	1.40 (1.21–1.63)	3.76
Rectal cancer surgery, ≥ 50	0.41 (0.22–0.76)	0.40 (0.25–0.66)	0.40 (0.23–0.68)	0.39 (0.24–0.61)	0.44 (0.34–0.58)	0.47 (0.37–0.61)	1.69
Joint replacement, ≥ 40	3.25 (2.74–3.86)	3.32 (2.91–3.80)	3.43 (2.98–3.95)	3.35 (2.97–3.78)	2.65 (2.43–2.88)	2.99 (2.77–3.23)	32.48¶
Thyroidectomy, no age limit	0.36 (0.23–0.57)	0.35 (0.24–0.50)	0.35 (0.23–0.53)	0.40 (0.29–0.53)	0.30 (0.24–0.36)	0.38 (0.31–0.45)	6.71
Unilateral or bilateral inguinal herniorrhaphy, ≥ 20	2.07 (1.74–2.46)	1.91 (1.68–2.19)	1.96 (1.69–2.28)	2.12 (1.90–2.38)	1.86 (1.72–2.00)	1.78 (1.65–1.92)	14.24**
Cholecystectomy, ≥ 20	3.45 (3.00–3.95)	3.64 (3.30–4.02)	3.62 (3.23–4.06)	3.86 (3.55–4.20)	2.82 (2.66–2.99)	2.82 (2.65–2.99)	117.75¶

SD = standard deviation
*No. of procedures per 1000 population.
†All acute care facilities outside the Regional and Metropolitan centres.
‡See Methods section for a description of Regional.
§Includes at least 1 tertiary care facility associated with a local medical school.
¶ $p < 0.01$
** $p < 0.05$.
Note: 99.17% confidence intervals for rates (overall $\alpha = 0.05$).

rates in rural populations represent inappropriate or unnecessary surgery.[12–15] It is equally plausible that urban populations might have restricted access to common low-complexity procedures. These procedures compete in large teaching hospitals with complex province-wide surgical services. It is possible that access is better for certain procedures in rural areas.

Appendectomy, unlike cholecystectomy and carpal tunnel release, is not a discretionary procedure. However, there are several reasons why appendectomy rates may be higher in rural areas. Diagnostic imaging services such as ultrasound and CT scanning are typically less available in rural hospitals, so accurate diagnosis is more difficult. Another traditional management strategy to cope with the challenge of diagnosing appendicitis is to observe the patient over a period of time. However, for the subset of rural patients without local surgical services, and who have travelled a significant distance to an urban hospital, the opportunity to ask the family to wait, out of hospital, for any significant period of time is restricted by issues of accommodation and expense. Similarly, transfer from a rural hospital to an urban setting for diagnostic testing puts the patient at greater risk in some instances (e.g., possible appendicitis).

International literature on rates of urban versus rural joint replacement were reviewed. In Great Britain there is some evidence that osteoarthritis of the hip has a significantly greater incidence in rural populations than in urban ones (101.3/100 000 v. 77.6/100 000).[16,17] The intuitive explanation is the cumulative mechanical stresses on the joint from the more physical occupations in rural areas. In this light, the higher rates for joint replacement in rural Alberta seem appropriate. In addition, Alberta has moved to regionalize orthopedic programs. If this change improves access for rural populations, then higher utilization rates are an expected outcome. This may also explain why higher rates were not seen in rural Northern Ontario, where regionalization of orthopedic services has not occurred.

We found a significant association between the obligation to travel for care and a diminished utilization rate for carpal tunnel release, based on Alberta data. That travel should be associated with surgery in carpal tunnel morbidity, but not in the other procedures, is not surprising. Carpal tunnel release represents the most discretionary of the studied surgeries, and there are acceptable alternative medical therapies (e.g., orthotics, steroids, physiotherapy, rest).

Furthermore, whereas the equipment for diag-

Table 4. Utilization rates* (and standard deviations) by service level of residence, in Northern Ontario

Procedure, age limit in years	Rural†			Regional‡	Metropolitan§	T^2
	RA	RB	RC		London, Ont.¶	
Appendectomy, ≥ 5	1.35 (1.09–1.67)	1.11 (0.77–1.59)	1.13 (0.87–1.48)	1.02 (0.90–1.15)	1.02 (0.92–1.14)	10.06**
Carpal tunnel release, ≥ 20	1.80 (1.46–2.22)	1.81 (1.32–2.48)	1.85 (1.47–2.32)	1.80 (1.63–1.99)	1.30 (1.17–1.44)	44.31††
Closed hip fracture repair, ≥ 50	1.72 (1.23–2.41)	1.68 (0.92–3.06)	2.24 (1.58–3.16)	1.82 (1.56–2.13)	1.64 (1.43–1.88)	5.28
Rectal cancer surgery, ≥ 50	0.29 (0.13–0.65)	0.44 (0.17–1.17)	0.56 (0.29–1.07)	0.51 (0.38–0.68)	0.44 (0.33–0.58)	3.74
Joint replacement, ≥ 40	2.76 (2.23–3.40)	3.45 (2.56–4.66)	3.34 (2.70–4.14)	3.51 (3.21–3.83)	3.57 (3.31–3.85)	9.30
Thyroidectomy, no age limit	0.24 (0.13–0.45)	0.22 (0.08–0.60)	0.23 (0.11–0.47)	0.31 (0.24–0.40)	0.28 (0.22–0.35)	2.35
Unilateral or bilateral inguinal herniorrhaphy, ≥ 20	2.15 (1.78–2.59)	1.80 (1.32–2.45)	1.97 (1.59–2.45)	2.14 (1.96–2.34)	2.39 (2.22–2.57)	12.55**
Cholecystectomy, ≥ 20	4.50 (3.94–5.14)	5.55 (4.61–6.67)	4.05 (3.46–4.73)	3.48 (3.25–3.74)	3.20 (3.00–3.41)	82.68††

SD = standard deviation
*No. of procedures per 1000 population.
†All acute care facilities outside the Regional and Metropolitan centres.
‡See Methods section for a description of Regional.
§Includes at least 1 tertiary care facility associated with a local medical school.
¶At the time of the study, Northern Ontario did not have a tertiary care centre with a local medical school; therefore, London, Ont., in Southwestern Ontario was used as reference.
**$p < 0.05$
††$p < 0.01$
Notes: 99.17% confidence intervals for rates (overall $\alpha = 0.05$). The Bonferri method[5] was used to calculate confidence intervals for multiple comparisons.

nosing all of the procedures for which we found variation in utilization rates is potentially available in many rural surgical programs (e.g., ultrasound for appendicitis or cholecystitis), the electromylogram testing for carpal tunnel entrapment is available only in Regional or Metropolitan centres. This then presents travel issues.

The lack of significant association between utilization and the presence or absence of local surgical programs in rural communities (i.e., RA v. RB v. RC) in either province is reassuring.

Limitations

Our data on utilization rates included only those procedures performed within the province of residence. Where patients travelled out of province, those procedures were not included in our database. This is a particular problem in Northern Ontario, where referral to Winnipeg, Manitoba, for major surgery occurs on a regular basis. Utilization rates for these procedures by Northern Ontario residents will be underestimated.

Rates were standardized for age and sex but these do not necessarily capture underlying differences in need among the population. Furthermore, levels of utilization are not linked to assessment of outcomes. Future work might assess outcomes such as complication rates, length of stay and patient satisfaction. Additional work might also consider a cost–benefit analysis of different surgical systems.

Our attempts to build a model using a measure of local surgical services and travel time had several weaknesses. The model was based only on Alberta data, which reduced our sample size. We relied on survey data to assign our RA/RB/RC designation of "local surgical services." Even with perfect accuracy in our response, it is possible that this designation might have changed during the 4- year study period. Furthermore, our travel webs were *anticipated* referral patterns based on survey data rather than *actual* patient travel. Most of our survey respondents were quite frank that several referral possibilities were considered for each patient, and the final choice reflected bed availability, wait lists, weather, and patient and physician preferences. It is possible that a travel variable built on actual travel obligations might be a more powerful explanatory variable in our model.

Our original research interest represented an inquiry into whether rural patients might have restricted access to common surgical procedures. Consequently, our modelling exercise included issues such as local services and travel that might influence rural access. Now that it is clear that rural utilization rates for some procedures are actually higher, it is regrettable that we did not make any effort in our model to ask why urban residents might have diminished access to these procedures — for example, restricted access to family physicians, restricted supply of generalist general surgeons, or longer surgical wait lists.

Conclusions

Cholecystectomy, carpal tunnel release, appendectomy and joint replacement were performed at higher rates in rural Northern Ontario and Alberta populations than urban. This variation is consistent with previous findings. For other procedures — unilateral or bilateral inguinal herniorrhaphy, closed hip fracture repair, cancer (rectal cancer surgery and thyroidectomy), where utilization rates are known to show little variation, the rates for rural and urban residents are similar.

For one procedure, carpal tunnel release, we found an association between longer travel times and diminished utilization rates. One hour of travel time was associated with a 13% decrease in utilization ($p < 0.01$). For the remaining 7 procedures there was no significant association between travel time and utilization.

We found no significant association between utilization and the presence and scope of surgical services available locally to rural communities.

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Appendix 1. Discharge Abstract Database (CAD) and Same Day Surgery (SDS) database ICD-9-CM procedure extraction criteria

	Selection criteria, based on DAD or SDS data	
Procedure	ICD-9-CM code	Inclusion / Exclusion
Unilateral or bilateral inguinal herniorrhaphy	53.00 through 53.17	In the primary procedure code field
Appendectomy	47.01, 47.09	In the primary procedure code field
Carpal tunnel release	04.43	In the primary procedure code field
Cholecystectomy	51.22, 51.23	In the primary procedure code field
Thyroidectomy	06.2, 06.31, 06.39, 06.4	In the primary procedure code field
Rectal cancer surgery	48.62, 48.63, 48.5	In the primary procedure code field ***and*** that have an ICD-9-CM code of 154.0 or 154.1 in ***any one*** of 16 diagnostic code fields
Closed hip fracture repair	820.00, 820.01, 820.02, 820.03, 820.09, 820.20, 820.21, 820.22, 820.8	In the ***first*** diagnosis field. ***Exclude*** any cases in which a 78.55, 79.25 or 79.35 is ***not*** found in the first procedure code field of that record.
Joint replacement*	81.51, 81.52, 81.54	In the primary procedure code field

ICD-9-CM = Clinical modification of the *International Classification of Diseases*, 9th rev.
*Primary hip and knee replacement.

Appendix 2. Definition of the Rural (RA, RB and RC) surgical service levels

Rural surgical service level	Definition
Rural A	Those who reside in a polygon in which surgical services are provided by at least one resident certified general surgeon (FRCS) who is living in the community with his/her principal practice at the local hospital. Rural A surgical programs offer all of the procedures of interest with the exception of primary hip and knee replacement and closed reduction of a hip fracture. They also have x-ray, fluoroscopy, ultrasound and endoscopy capability.
Rural B	Those who reside in a polygon in which surgical services are provided by at least one local GP-surgeon or one itinerant (resides outside the hospital catchment area) certified general surgeon (FRCS) and one or more GP-surgeons. Rural B surgical programs do not offer surgical services that are usually restricted to specialist general surgeons, i.e., primary hip and knee replacement, closed reduction of a hip fracture, rectal cancer surgery, cholecystectomy or thyroidectomy. They have x-ray, fluoroscopy, endoscopy, ultrasound and minimal endoscopy capability.
Rural C	Those who reside in a polygon in which no surgical services are provided — there is no resident or itinerant provider with both privileges and procedures that include either cesarean section or appendectomy. In terms of diagnostic capability Rural C facilities usually only have x-ray.