Outcomes of Pediatric Appendicitis
An International Comparison of the United States and Canada

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The United States and Canada have very different health care delivery systems. The United States has a multipayer system consisting of a large number of private insurers and multiple public programs. In 2011, 48.6 million people in the United States, including approximately 9 million children, were uninsured, representing 15.7% of the population.

Canada provides universal, publicly funded, single-payer health insurance to all citizens and legal residents. Wait times for evaluation and treatment are influenced by age and US insurance status. These differences are relevant to health policy decisions in both nations.

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Several previous studies have looked at outcome differences between the United States and Canada for a variety of diseases, both acute and chronic. A systematic review of 38 studies showed that most favored Canada or showed no differences between the 2 countries. Most of these studies analyzed adult diseases or combined adult and pediatric populations. To our knowledge, no previous studies have specifically looked at pediatric surgical outcomes.

Appendicitis is the most common pediatric surgical emergency, and appendectomy is the most common urgent pediatric surgical operation. The outcomes of appendicitis are largely dependent on the severity of the disease at presenta-
tion. Perforated appendicitis is associated with prolonged hospital stay and higher rates of postoperative complications. Previous studies from the United States have shown that hospital-level characteristics and patient-level factors, such as socioeconomic status, insurance status, and race, influence the outcomes of children with appendicitis. More recent studies have shown that the effects of race and socioeconomic status vanish when equal access to care is provided.

In Canada, all children are insured in a single-payer system, which theoretically provides equal access. We performed the first population-based international comparison of pediatric appendicitis outcomes between the 2 countries, to our knowledge. Our hypothesis was that outcomes are better in Canada vs the United States.

Methods

Data Source

This study was approved by the McGill University Faculty of Medicine institutional review board (A12-E75-11B). Population-based databases were used in this study. US data were obtained from the Kids’ Inpatient Database (KID), a part of the Healthcare Cost and Utilization Project. The Kids’ Inpatient Database is a national database of pediatric inpatient admissions from more than 2000 US hospitals. Data are gathered every 3 years. Data were coded using the International Classification of Diseases, Ninth Revision. Kids’ Inpatient Database data for 2006 and 2009 were accessed after approval of the standard research application.

Canadian data for 2004 to 2010 were obtained from the Discharge Abstract Database (DAD), managed by the Canadian Institute for Health Information (CIHI). The Discharge Abstract Database contains mandatory discharge data from all hospitals in Canada, except those in Quebec. Data were coded using International Classification of Diseases, Tenth Revision, Canada. The CIHI released the data after institutional review board approval was submitted.

Both databases also contain patient demographics and hospital characteristics.

Study Population

All patients younger than 18 years with a valid procedure code for appendectomy were candidates for the study population. Patients had to have 1 of the following 3 procedure codes: (1) appendectomy (KID 4701 or 4709 or CIHI 1.NV.89.DA or 1.NV.89.LA), (2) drainage of appendiceal abscess (KID 472 or CIHI 1.NV.52) AND secondary code of (1), or (3) abdominal or pelvic drainage (KID 4591 or CIHI 1.OT.52 or LSO.52) AND secondary code of (1) or (2). Patients with no primary or secondary procedure code of appendectomy, patients who had incidental appendectomy, and patients with an elective admission or unrelated primary diagnostic code were excluded.

Demographic data gathered for all patients included age and sex. Insurance status for US patients was classified as public (Medicare or Medicaid), private, or uninsured (self-pay or no charge).

Outcomes

The main outcome measures were the normal appendix rate, the perforated appendix rate, and the total length of hospital stay. The normal appendix rate was defined as an appendectomy procedure code in combination with a diagnostic code other than appendicitis. The perforated appendix rate was defined as a procedure code of appendectomy and a primary diagnostic code of acute appendicitis with peritonitis or abcess. Neither database provided reliable information on postoperative complications such as abscess, phlegmon, wound infection, or readmission. Secondary procedures (eg, abscess drainage) were recorded in both databases without specification of whether they occurred at the same time or subsequent to the primary procedure.

Statistical Analysis

Both databases were downloaded to an SPSS 20.0 for Windows file (IBM SPSS). Pearson χ² test was used for comparison of nominal data. Independent-samples t test and 1-way analysis of variance (ANOVA) were used for comparison of continuous variables between 2 and 3 categories, respectively. If the 1-way ANOVA test was significant, a post hoc Bonferroni test for multiple comparisons was subsequently performed to determine where the significance exists. An overall analysis of the US and Canadian cohorts was performed. Subanalyses by age group (0-5, 6-11, and 12-17 years) and US insurance status were performed.

Results

Study Cohorts

A total of 41,492 Canadian and 78,625 US patients met the inclusion criteria (Figure). Age was available for all patients. Five US patients were missing sex codes. One hundred twenty-eight Canadian patients did not have length of hospital stay information reported and were excluded from that outcome analysis. Two thousand nine hundred fifty-five US patients with an insurance status of “other,” “missing,” or “invalid” were excluded from the insurance subanalysis. The demographics of the study population are shown in Table 1 and were quite similar between both countries. Within the US cohort, 57% of patients had private insurance, 33% had public insurance, 6% had no insurance, and 4% had missing or invalid insurance codes.

Overall Comparison

Canadian children had an approximately 50% higher rate of normal appendix (6.3% vs 4.3%; P < .001) and a slightly higher rate of perforated appendicitis (27.3% vs 26.7%; P = .04). The Canadian perforated appendicitis rate fell in the middle between privately insured (24.1%) and publicly insured or noninsured US patients (30.4% and 31.2%, respectively). The hospital stay was nearly identical in Canada (mean [SD], 2.8 [3.1] days) and the United States (mean [SD], 2.7 [3.0] days), despite statistical significance (P < .001).

Subanalyses

The influence of age and US insurance status on outcomes is shown in Table 2. The normal appendix rate was higher in

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Canada for all age groups regardless of US insurance status. In the youngest age group, a significantly lower perforated appendicitis rate (47.7%) was seen in Canadian children vs US children in all 3 insurance categories. The difference was particularly pronounced when compared with US children with public (54.6%) or no insurance (61.4%). In the oldest age groups, the perforated appendicitis rate in Canada (24.7%) was approximately 20% higher than in privately insured US patients (20.6%) but similar to publicly insured (23.7%) or noninsured (25.1%) US patients. In the middle age group, the Canadian perforated appendicitis rate (29.2%) was approximately 10% higher than privately insured US children (26.5%) but lower than publicly insured (31.4%) or noninsured US patients (36.0%).

The proportion of children with perforated appendicitis in Canada who had more than 1 appendicitis-related procedure was significantly lower than in the United States (0.37% vs 0.71%; P < .001). As mentioned earlier, it was not possible to delineate whether the second procedure represented treatment of the primary disease (eg, drainage of abscess before or during appendectomy) or a complication (eg, drainage of postoperative abscess). In addition, the very low rate of secondary procedures for perforated appendicitis in both databases raises questions about the validity of this statistic. Laparoscopic appendectomy rates were higher in the United States than in Canada for all groups: 0 to 5 years, 43.0% vs 28.8%; 6 to 11 years, 54.5% vs 38.7%; and 12 to 17 years, 67.8% vs 53.5%

Hospital Stay
Hospital stay for the entire Canadian cohort fell in the middle range between privately insured and publicly or noninsured US patients (Table 3). However, the differences were influenced by severity of appendicitis. In Canada, hospital stay was longer after nonperforated appendicitis (mean [SD], 2.0 [1.2] vs 1.7 [1.2] days; P < .001) and shorter after perforated appendicitis (mean [SD], 4.8 [3.6] vs 5.3 [3.7] days; P < .001). When analyzed by US insurance status, the difference in hospital stay between Canadian and US patients remained significant for all 3 insurance categories.

Discussion
Canada and the United States have dramatically different health care delivery systems despite the general similarities in the standards of care used to treat most diseases. The large body of research literature on the negative effects of noninsurance and underinsurance in the United States is paralleled by Canadian literature on the effects of waiting lists and resource restrictions. Several previous studies have compared American and Canadian outcomes of multiple diseases and procedures. Very few have included pediatric populations or specifically investigated pediatric outcomes. Better outcomes were identified in Canadian children with end-stage renal disease, as well as asthma. Low socioeconomic status was found to have a much more severe negative effect on birth outcomes in the United States vs Canada. To our knowledge, our study is the first to compare outcomes of a pediatric surgical disease between the 2 nations.

A health care system can improve medical outcomes in 2 ways. The first is to allow entry into the system when the disease is at an earlier stage, potentially decreasing morbidity. The second is to provide better treatment that directly impacts outcomes. Both of these can influence the outcomes of pediatric appendicitis, an ideal disease for investigating health care system effects. It is the most common surgical emergency in children. Postoperative complications and overall morbidity are directly related to the stage of appendicitis at presentation and treatment. The Montreal Children's Hospital has consistently reported perforation rates less than 20%. Those rates are almost 50% lower than found in reports from large American urban hospitals, including one by one of us (S.E.). This motivated us to investigate whether these differences are also seen on national levels.

Health care disparities in the United States are influenced by multiple patient-related factors such as race, socioeconomic status, and insurance status. These disparities were evident when pediatric appendicitis outcomes were studied.
Table 1. Demographics of Study Populations

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Canada (n = 41,492)</th>
<th>United States (n = 78,625)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean (SD)</td>
<td>12.3 (3.5)</td>
<td>11.5 (3.9)</td>
</tr>
<tr>
<td>Male</td>
<td>24,453 (58.9)</td>
<td>47,285 (60.1)</td>
</tr>
</tbody>
</table>

Moreover, recent work by Lee and colleagues6-7 in Southern California has shown that disparities due to race and socioeconomic status disappear in systems that provide equal access, such as the Kaiser Permanente health care maintenance organization. Reports from other similar US health care environments, such as the Department of Defense hospitals, have shown perforation rates similar to those we reported from Montreal, Quebec, Canada.3,14,18 We therefore hypothesized that the Canadian system, a single-payer universal insurance system, would produce superior outcomes when compared with the American system.

The perforation rate is perhaps the major outcome directly reflective of the health care system. Although statistically significant because of the large number of individuals in the study, the difference in perforation rate between the United States and Canada, just over 25% in both countries, was not clinically significant. However, the differences widened when insurance status was taken into account, with the Canadian perforation rate lying almost exactly in the middle between privately insured and publicly insured or uninsured US patients. This may temper the argument that access is the sole determinant of outcomes. For example, Bratu et al19 analyzed 20 years of data for pediatric appendicitis in Manitoba, Canada, and found that lower rural or urban socioeconomic status and northern area of residence were significantly associated with a higher perforation rate. Our group has recently shown that perforation rates are much higher in native Canadian patients, who typically have to be transported very far distances from Canada’s north.20

A population-based study from Ontario, Canada, also showed that children in rural locations were more likely to have perforated appendicitis or normal appendix at surgery.21 However, unlike results of US studies, socioeconomic status did not have an impact on outcomes.21

Perforation rates were lower in Canadian patients than in publicly insured or uninsured US patients in all 3 age groups. This advantage was more pronounced in the youngest age group, children 5 years and younger, where the Canadian perforation rate was lower than that of all 3 US insurance categories. The effect may be mediated by the greater access of the youngest Canadian children to tertiary pediatric care. In our cohort, 45.5% of children in the 0- to 5-year age group were treated at children’s hospitals vs 30.2% and 20.6% for the 6 to 11 years and 12 to 17 years age groups, respectively. Similar data could not be extracted from KID. Pediatric subspecialty care, as well as greater hospital experience, has been shown to result in variable benefits in the treatment of pediatric appendicitis, particularly in the youngest children.5,22-25

Table 2. Perforated Appendicitis and Normal Appendix Rates Reported by Age Group and Insurance Status

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Perforated Appendicitis</th>
<th>Normal Appendix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 0-5 y</td>
<td>Canada 47.7</td>
<td>10.3</td>
</tr>
<tr>
<td>US All</td>
<td>52.3</td>
<td>6.7</td>
</tr>
<tr>
<td>Private</td>
<td>48.6</td>
<td>7.8</td>
</tr>
<tr>
<td>Public</td>
<td>54.6</td>
<td>5.9</td>
</tr>
<tr>
<td>No insurance</td>
<td>61.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Age 6-11 y</td>
<td>Canada 29.2</td>
<td>5.1</td>
</tr>
<tr>
<td>US All</td>
<td>29.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Private</td>
<td>26.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Public</td>
<td>31.4</td>
<td>3.6</td>
</tr>
<tr>
<td>No insurance</td>
<td>36.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Age 12-17 y</td>
<td>Canada 24.7</td>
<td>6.6</td>
</tr>
<tr>
<td>US All</td>
<td>21.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Private</td>
<td>20.6</td>
<td>4.5</td>
</tr>
<tr>
<td>Public</td>
<td>23.7</td>
<td>4.7</td>
</tr>
<tr>
<td>No insurance</td>
<td>25.1</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Abbreviation: US, United States. All differences between groups were statistically significant (P < .001), as determined by 1-way analysis of variance with Bonferroni tests.

The consistently higher normal appendix rate in Canada is somewhat difficult to explain. Unlike the United States, the use of computed tomography (CT) scan for the diagnosis of pediatric appendicitis in Canada is rare. Ultrasonography, which is less sensitive and specific than CT, is the modality of choice for patients with equivocal disease. However, multiple studies have shown no improvement in the perforation or normal appendix rates with the use of CT scan.26-28 However, a possible benefit of CT scan in reducing the normal appendix rate may become apparent in a large population-based study such as this one. Unfortunately, imaging data in both databases are quite incomplete and cannot be used to infer any conclusions. In any case, decreasing the normal appendix rate by 1% to 2% may be outweighed by the radiation risk and cost of CT scans.

In comparison with the United States, duration of hospital stay was longer for Canadian patients with nonperforated appendicitis and shorter for Canadian patients with perforated appendicitis. Daily use review is nonexistent in Canadian hospitals. Therefore, there may be less pressure to discharge patients soon after appendectomy. On the other hand, the shorter hospital stay after perforated disease may be due to the wider use of treatment algorithms in Canadian centers.
These clinical pathways have been shown to decrease hospital stay.3-16 US surveys have reported significant variability in the treatment of appendicitis between surgeons.39,30 Chen et al29 reported that only 17% of American pediatric surgeons used formal clinical practice guidelines when treating pediatric appendicitis. A longer hospital stay after perforated appendicitis may also be a surrogate for an increased complication rate.

Like all population-based studies, ours has its limitations. Appendicitis outcomes are typically evaluated by assessment of the normal appendectomy rate, the perforation rate, hospital stay, readmissions, and infectious complications, including intra-abdominal abscess, phlegmon, or wound infection. Unfortunately, both KID and DAD do not provide adequate data on readmissions. There are also no direct data on postoperative complications. The only surrogate for that is a secondary procedure during the same admission, but the rate of these procedures in both databases appears extremely low and therefore unreliable. The time frame determined by KID and CIHI did not allow us to compare identical years. However, this is unlikely to have significantly affected outcomes, since the treatment of appendicitis has changed little during the 6-year period from 2004 to 2010. The databases are only as accurate as the coders entering the data. Miscoding can occur anywhere from the physician completing the discharge summary to the institutional medical archives department to the receiving database organization. We trust that the large number of patients should have diluted any miscoding. Both KID and DAD code their databases on a per-visit, instead of per-patient, basis. Thus, it was not possible for us to determine if patients returned for any related complications or secondary procedures related to their initial hospital visit. Readmission rates would have been an important outcome to study. Finally, multiple other factors such as race, operative technique, or place of residence may have affected outcomes. However, the purpose of the study was to report differences in outcomes between the 2 countries, not to analyze the determinants of each country.

### Conclusions

We have reported the first international comparison of outcomes of a common pediatric surgical disease between the United States and Canada, to our knowledge. Our hypothesis that pediatric appendicitis outcomes are superior in Canada was disproven. Perforation rates in Canadian children generally fall in the middle of the range between privately insured and publicly or uninsured US children. The youngest Canadian children appear to have better outcomes than their US counterparts. The rate of misdiagnosis is higher in Canada, but hospital stay after perforated appendicitis is shorter. These findings have important implications for health care policy and delivery.

### Table 3. Length of Hospital Stay by Country of Origin and US Insurance Status

<table>
<thead>
<tr>
<th>Patients</th>
<th>Canada</th>
<th>All</th>
<th>US</th>
<th>Private</th>
<th>Public</th>
<th>No Insurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>2.8 (3.1)</td>
<td>2.7 (3.0)</td>
<td>2.48 (2.6)</td>
<td>3.1 (3.5)</td>
<td>2.93 (3.0)</td>
<td></td>
</tr>
<tr>
<td>Nonperforated appendicitis</td>
<td>2.0 (1.2)</td>
<td>1.7 (1.2)</td>
<td>1.6 (1.1)</td>
<td>1.82 (1.3)</td>
<td>1.77 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Perforated appendicitis</td>
<td>4.8 (3.6)</td>
<td>5.3 (3.7)</td>
<td>5.06 (3.5)</td>
<td>5.71 (3.9)</td>
<td>5.58 (3.7)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: US, United States.

*All differences between groups were statistically significant (P < .001), as determined by 1-way analysis of variance with Bonferroni tests.

### Additional Contributions

We thank Elise Mok, PhD, and Xun Zhang, PhD, of the Montreal Children’s Hospital Clinical Research Center for providing assistance with statistical analysis.

### References


Outcomes of Pediatric Appendicitis

Original Investigation

Research


