



Implantable Medical Devices in Canada

Insights Into High-Volume Procedures and Associated Costs



Canadian Institute for Health Information

Institut canadien d'information sur la santé

Production of this document is made possible by financial contributions from Health Canada and provincial and territorial governments. The views expressed herein do not necessarily represent the views of Health Canada or any provincial or territorial government.

Unless otherwise indicated, this product uses data provided by Canada's provinces and territories.

All rights reserved.

The contents of this publication may be reproduced unaltered, in whole or in part and by any means, solely for non-commercial purposes, provided that the Canadian Institute for Health Information is properly and fully acknowledged as the copyright owner. Any reproduction or use of this publication or its contents for any commercial purpose requires the prior written authorization of the Canadian Institute for Health Information. Reproduction or use that suggests endorsement by, or affiliation with, the Canadian Institute for Health Information is prohibited.

For permission or information, please contact CIHI:

Canadian Institute for Health Information
495 Richmond Road, Suite 600
Ottawa, Ontario K2A 4H6
Phone: 613-241-7860
Fax: 613-241-8120
cihi.ca
copyright@cihi.ca

ISBN 978-1-77109-920-2

© 2020 Canadian Institute for Health Information

How to cite this document:

Canadian Institute for Health Information. *Implantable Medical Devices in Canada: Insights Into High-Volume Procedures and Associated Costs*. Ottawa, ON: CIHI; 2020.

Cette publication est aussi disponible en français sous le titre *Dispositifs médicaux implantables : regard sur les interventions à volume élevé et les coûts connexes au Canada*.

ISBN 978-1-77109-921-9

Table of contents

Acknowledgements	4
Introduction	5
Methods	7
Overall volumes and trends	9
Patient characteristics	13
Variations by province/territory	14
Health system costs	15
Summary and future opportunities	19
Appendix A: Methodological notes	21
Appendix B: Text alternative for figures	26
References	30

Acknowledgements

The Canadian Institute for Health Information (CIHI) wishes to acknowledge and thank the following individuals for their contribution to the development of this report: Michelle Policarpio, Tianhong Cai, Jason Black, Youn Young Choi, Nicholas Gnidziejko and Greg Webster. We also extend our appreciation to the CIHI teams who supported this work — Canadian Joint Replacement Registry (CJRR), Classifications and Terminologies, Financial Standards and Information, and Physician Information — and to other CIHI colleagues who were involved in the development of this report.

CIHI also wishes to thank the following clinicians/stakeholders for providing advice and guidance: Dr. Douglas Lee, ICES and Peter Munk Cardiac Centre of the University Health Network; Dr. Eric Bohm, Concordia Joint Replacement Group, Department of Surgery, University of Manitoba, and CJRR Advisory Committee Chair; Dr. Gavin Wood, Kingston General Hospital and CJRR Advisory Committee Member; and Health Canada. Please note that the content presented in this document does not necessarily reflect the opinions of these clinicians/stakeholders.

Introduction

What is an implantable medical device?

The World Health Organization states that a medical device is any object/device used for medical purposes among humans and does not have the primary intended action by pharmacological, immunological or metabolic means.¹ This definition practically separates a drug or vaccine from a medical device. There are many medical devices in the market today, but those that are surgically or medically inserted into and remain in the human body after the procedure are considered implantable devices.²

Implantable medical devices (IMDs) can help to improve and prolong lives, having a wide range of applications. There are many types of IMDs. For example, cardioverter-defibrillators help to prevent sudden cardiac death, and knee replacement devices help restore functioning and reduce pain. In Canada, medical devices are purchased by hospitals, physicians' offices, laboratories, clinics and patients.³ The demand for IMDs worldwide is influenced by the rising burden of chronic disease, the growing senior population, the use of aesthetic devices, and technological advancements that make new devices possible.⁴

As the number of IMDs in use rises, the safety, efficacy, cost and appropriateness of these devices has garnered greater attention. In December 2018, Health Canada released its *Action Plan on Medical Devices: Continuously Improving Safety, Effectiveness and Quality*, which includes steps to enhance medical device regulation in Canada. The plan outlines strategies to improve how devices are made available for use, to strengthen monitoring of devices and follow-up, and to provide more information to Canadians. It was created to support the continuous improvement of safety and effectiveness of medical devices and patient outcomes, while allowing access to new and innovative technology.⁵

Recognizing the value of data in informing best practices and enabling future research on this emerging topic, *Implantable Medical Devices in Canada: Insights Into High-Volume Procedures and Associated Costs* provides insights into high-volume IMD procedures and associated costs using pan-Canadian hospitalization and day surgery data.

Key findings

- **There were a total of 706,952 hospitalizations and day surgeries during 2018–2019 in Canada related to a set of 12 high-volume, high-cost implantable medical devices (IMDs).**
 - 58.4% of these procedures were cataract lens insertion procedures.
 - The majority of these procedures were performed in outpatient settings (69.4%) compared with inpatient settings (30.6%); this varies by IMD type.
- **A higher proportion of IMD procedures were for seniors and women.**
 - For most IMD procedures, half of patients were age 65 and older.
 - For procedures involving both men and women, a higher proportion of hospitalizations and day surgeries were for women (53%), but there are differences for specific IMDs.
- **5-year trends in age-standardized IMD procedure rates (2014–2015 to 2018–2019) vary by IMD, with some increases and some decreases.**
 - The biggest 5-year percentage changes were for intrauterine devices (an increase of 51%) and for transvaginal mesh implant and tension-free vaginal tape procedures (a 35% decrease). Changes may reflect shifts in patient preferences, care patterns and emerging patient safety evidence.
 - Rates for cataract lens insertion procedures were relatively stable, but they increased for knee and hip replacements (by 9% and 8%, respectively).
- **IMD procedure rates across the country vary, with different procedure rates observed between provinces and territories and by type of IMD.**
 - These variations may be due to population need as well as differences in access and clinical practice patterns.
- **The estimated total hospital cost of the 12 IMD procedures was \$3.7 billion for 2018–2019.**
 - Despite having lower volumes of IMD procedures, higher costs were incurred from inpatient hospitalizations (\$2.8 billion) compared with day surgeries (\$872 million).
- **Future opportunities to better understand the health benefits, system costs and patient safety related to IMDs include**
 - Making individual IMD product information available and linkable to patient-level health data; and
 - Enhancing data capture and reporting, such as those activities outlined in Health Canada’s action plan, to address the increasing demand for IMDs in a way that is both safe and cost-effective.

Methods

Using the Canadian Institute for Health Information's (CIHI's) Hospital Morbidity Database (HMDB) and National Ambulatory Care Reporting System (NACRS), we identified IMD procedures occurring in inpatient or day surgery settings based on relevant Canadian Classification of Health Interventions (CCI) codes. The CCI codes included device implantation and repair procedures but excluded removals and complications directly attributed to the IMDs.

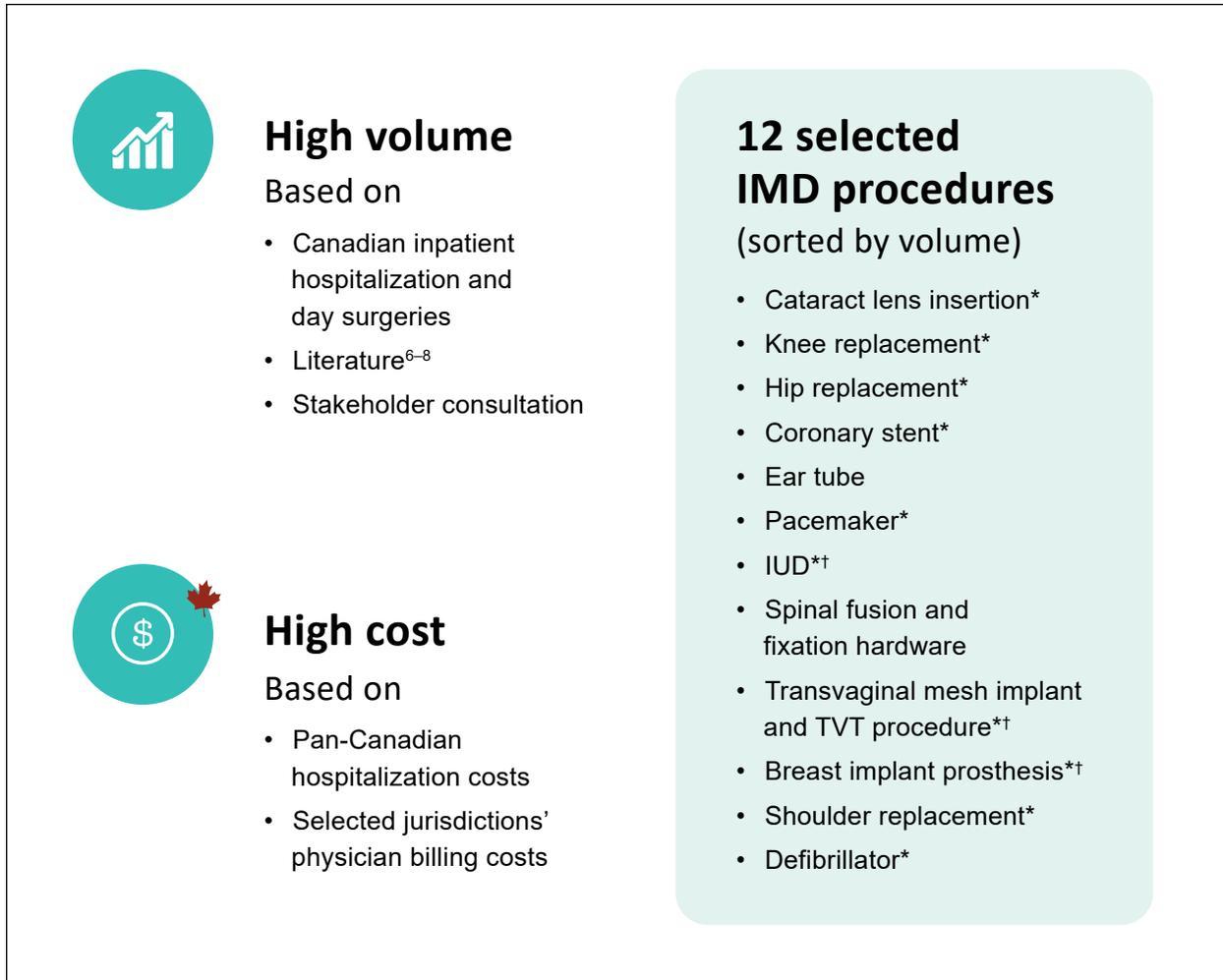
Many IMD procedures across Canada occur outside a hospital setting (such as in a primary care or private health care setting). However, out-of-hospital procedures are not included in this report as pan-Canadian data is not available.

Figure 1 lists the 12 selected IMD procedures as well as the criteria for high volume and high cost. It also shows the approaches taken to identify the 12 high-volume and/or high-cost IMD procedures that are the focus of this report, based on their hospital-related volumes and costs, as well as on literature reviews and stakeholder consultations.

The hospital cost estimates in this report were based on these additional data sources and methodologies: the 2017–2018 Canadian MIS Database (CMDB), the 2018 Case Mix Group+ (CMG+) methodology and CIHI's Patient-Level Physician Billing (PLPB) Repository, which captures data from 5 provinces (Nova Scotia, Ontario, Manitoba, Saskatchewan and Alberta). To estimate the 2018–2019 total and overall costs, the 2017–2018 average costs for each IMD procedure were multiplied by 2018–2019 volumes for the corresponding IMD procedure.

Further details on the methodology and data sources included are provided in [Appendix A](#).

Figure 1 High-volume and high-cost criteria for 12 selected IMD procedures, Canada, 2018–2019



Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Source

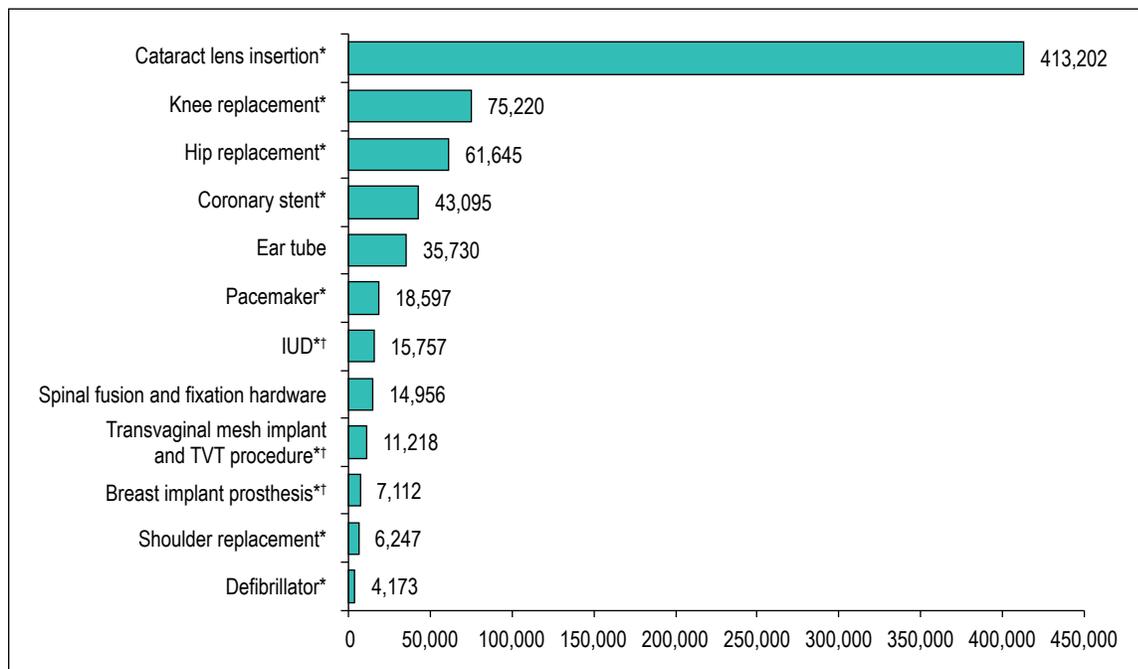
Canadian Institute for Health Information.

Overall volumes and trends

In 2018–2019, there were a total of 706,952 hospitalizations and day surgeries for the 12 selected IMD procedures across Canada. Figure 2 provides the procedure volume for each IMD, sorted by volume.

- Cataract lens insertion was the procedure with the greatest volume (413,202).
- Knee and hip replacements were the second and third most frequently performed procedures (75,220 and 61,645, respectively).
- Coronary stent was the fourth most frequently performed procedure (43,095).
- Cataract lens insertions, knee and hip replacements, and all 3 cardiovascular IMD procedures (coronary stent, pacemaker and defibrillator) were among the 11 most commonly implanted medical devices in the United States.⁶

Figure 2 Selected IMD procedure volumes, Canada, 2018–2019



Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Data may include both primary and revision procedures.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2018–2019, Canadian Institute for Health Information.

In terms of trends over time, Table 1 shows age-standardized rates for the 12 IMD procedures, starting in 2014–2015:

- The largest 5-year age-standardized rate increases were observed for intrauterine device (IUD) procedures (51%) and shoulder (36%), knee (9%) and hip (8%) replacements. The increases in the orthopedic procedures are consistent with trends of an aging population.
- The largest 5-year age-standardized rate decrease was observed for transvaginal mesh implant and tension-free vaginal tape (TVT) procedures (-35%). Recent safety issues related to these IMDs may have contributed to the decrease in rates.⁹

Table 1 Age-standardized rate per 100,000 population for selected IMD procedures, Canada, 2014–2015 to 2018–2019

IMD procedure (sorted by 2018–2019 volume)	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	5-year percentage change (%)
Cataract lens insertion*	1,232	1,220	1,218	1,195	1,219	-1
Knee replacement*	205	208	212	216	224	9
Hip replacement*	172	173	177	180	186	8
Coronary stent*	129	133	137	132	133	3
Ear tube	102	103	105	105	99	-3
Pacemaker*	58	58	57	56	56	-3
IUD*†	75	89	95	104	113	51
Spinal fusion and fixation hardware	37	37	38	38	38	3
Transvaginal mesh implant and TVT procedure*†	116	101	94	85	75	-35
Breast implant prosthesis*†	49	49	50	51	49	0
Shoulder replacement*	14	15	16	17	19	36
Defibrillator*	14	14	14	13	13	-7

Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Numerator may include both primary and revision procedures. The 2011 Canadian reference population was used for age standardization. 5-year percentage change (%) refers to percentage change between 2014–2015 and 2018–2019.

Sources

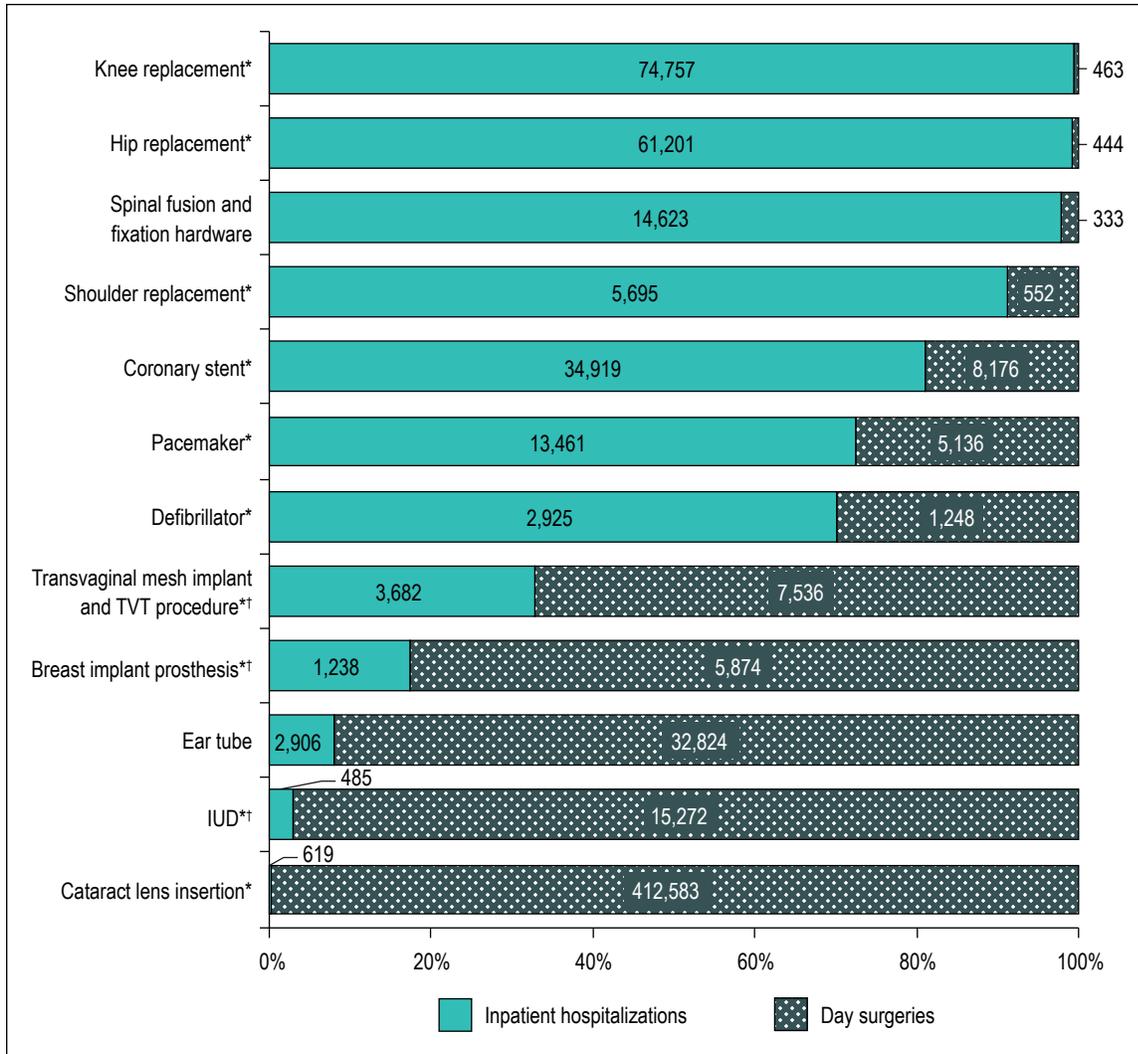
Hospital Morbidity Database and National Ambulatory Care Reporting System, 2014–2015 to 2018–2019, Canadian Institute for Health Information; 2011 Canadian population, Statistics Canada.

A closer look at hospital care settings

Figure 3 shows a breakdown of the 12 selected IMD procedures according to where they were performed (inpatient versus day surgery setting) in 2018–2019, sorted by percentage of inpatient hospitalizations.

- Overall, 69.4% of the IMD procedures were performed in a day surgery setting.
- However, orthopedic IMD procedures (knee, hip and shoulder replacement, and spinal fusion and fixation hardware) and cardiovascular IMD procedures (coronary stent, pacemaker and defibrillator) were performed mostly in inpatient settings.
- Cataract lens insertion procedures were almost exclusively completed in day surgery settings (99.9%) and the vast majority of IUD, ear tube, breast implant prosthesis and transvaginal mesh implant and TVT procedures were also performed as day surgeries.
- Historically, many IMD procedures were performed during inpatient hospitalizations, requiring overnight stays by the patient in hospital. Now, many procedures are performed in outpatient settings, driven by technology advancements, techniques that help reduce complications and support earlier discharges home, and financial incentives for shifting treatments to lower-cost health care settings.¹⁰

Figure 3 Inpatient hospitalizations versus day surgeries for selected IMD procedures, Canada, 2018–2019



Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Data may include both primary and revision procedures.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2018–2019, Canadian Institute for Health Information.

Patient characteristics

Table 2 describes the demographic characteristics of patients who underwent at least 1 of the 12 selected IMD procedures, based on reported hospitalizations and day surgeries:

- The median age was 65 or older for 7 of the 12 selected IMD procedures. It is expected that the demand for these procedures will increase, reflecting the needs of a growing senior population.
- Ear tube procedures were more commonly performed in children, with half of the procedures performed in children younger than 3 years old.
- More than half of the procedures for cataract lens insertion and for knee, hip and shoulder replacements were performed on women.
- More males than females underwent cardiovascular-related procedures as well as procedures related to ear tubes, and spinal fusion and fixation hardware.

Table 2 Age/sex characteristics of patients by IMD procedure, Canada, 2018–2019

IMD procedure (sorted by volume)	Median age (interquartile range)	Female (%)
Cataract lens insertion*	72 (66–78)	56
Knee replacement*	68 (62–74)	59
Hip replacement*	70 (62–79)	57
Coronary stent*	66 (58–75)	28
Ear tube	3 (2–6)	41
Pacemaker*	78 (70–84)	42
IUD*†	35 (26–43)	100
Spinal fusion and fixation hardware	60 (48–70)	47
Transvaginal mesh implant and TVT procedure*†	54 (46–65)	100
Breast implant prosthesis*†	48 (38–57)	100
Shoulder replacement*	70 (64–76)	56
Defibrillator*	66 (57–74)	23

Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Data may include both primary and revision procedures.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2018–2019, Canadian Institute for Health Information.

Variations by province/territory

[Table A2 in Appendix A](#) shows age-standardized rates for the 12 selected IMD procedures by patients' jurisdiction of residence.

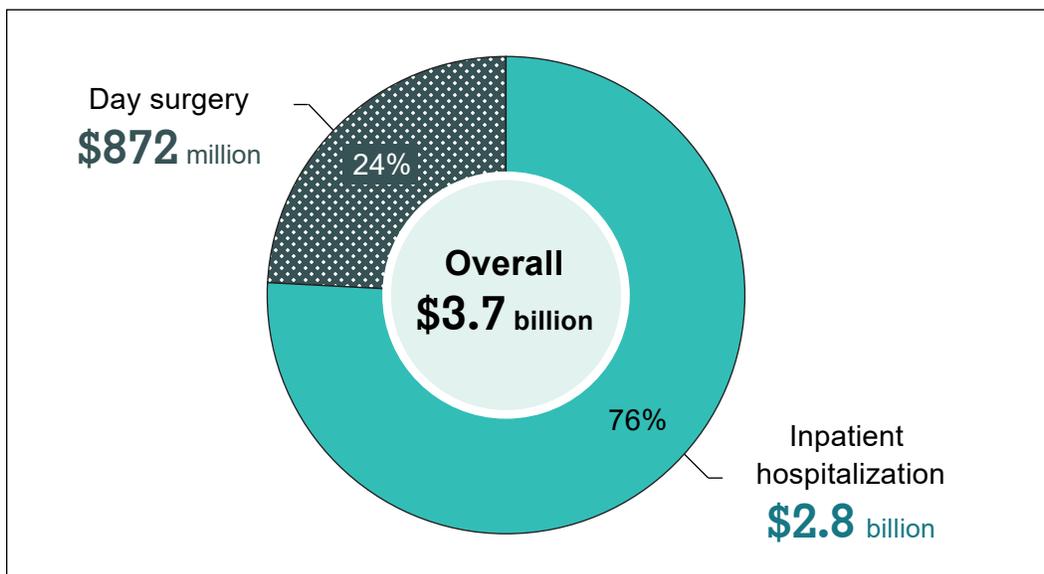
- Higher rates for many IMD procedures were more commonly observed in smaller jurisdictions:
 - The rates for coronary stent, defibrillator, ear tube and transvaginal mesh implant and TVT procedures were highest in Newfoundland and Labrador.
 - The rates for cataract lens insertion and orthopedic procedures (e.g., knee and shoulder replacements; spinal fusion and fixation hardware) were highest in Saskatchewan.
 - The highest rates for hip replacement, pacemaker and IUD procedures were observed in the territories, while New Brunswick had the highest rate for breast implant prosthesis.
- Many of the largest jurisdictions have the lowest procedure rates. For example, Ontario had the lowest rates for defibrillator, transvaginal mesh implant and TVT procedures. The other lowest rates were observed in Alberta (coronary stent and pacemaker), Quebec (hip/knee replacement, IUD) and British Columbia (ear tube). Potential explanations for some of these variations could be the focus of future analyses.

Health system costs

Figure 4 shows both the overall and total estimated costs by care setting for the 12 selected IMD procedures. Total estimated costs were calculated by multiplying 2017–2018 average costs (the most recent costing data available) by the 2018–2019 IMD procedure volumes. The overall estimated hospital cost amounted to approximately \$3.7 billion.

- Total inpatient hospitalization costs were \$2.8 billion and day surgery costs were \$872 million.

Figure 4 Overall and total estimated costs* for IMD procedures, Canada, 2018–2019



Notes

* Overall estimated cost is calculated by adding total estimated costs for hospitalizations and day surgeries.

Total estimated cost is calculated by multiplying the 2017–2018 average cost by the 2018–2019 total volume. Volume includes typical and atypical cases.

IMD: Implantable medical device.

The most recent available costing data is from 2017–2018.

Costs include hospital cost and physician fees and may incorporate both primary and revision procedures. Costs do not include other potential costs for recovery and rehabilitation.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2017–2018 to 2018–2019, Canadian MIS Database, 2017–2018, Case Mix Group+ 2018, Patient-Level Physician Billing Repository, 2017–2018, Canadian Institute for Health Information.

Table 3 provides the estimated overall 2018–2019 hospital cost for each of the 12 selected IMD procedures, alongside the average estimated 2017–2018 costs for each by day surgery and by inpatient hospitalization. Results showed that

- For all IMD procedures, the average cost for inpatient hospitalizations was higher than that for day surgeries.
- Defibrillator procedures had the highest average cost for both hospitalizations (\$37,154) and day surgeries (\$24,443).
- Ear tube procedures had the lowest average cost for both hospitalizations (\$4,924) and day surgeries (\$1,331).

Table 3 Overall and average estimated inpatient hospitalization and day surgery costs for selected IMD procedures, Canada

IMD procedures (sorted by overall estimated costs)	Overall inpatient hospitalization and day surgery estimated costs (2018–2019)	Average inpatient hospitalization cost (2017–2018)‡	Average day surgery cost (2017–2018)
Hip replacement*	\$765,232,702	\$12,453	\$6,962
Knee replacement*	\$724,676,313	\$9,653	\$6,604
Cataract lens insertion*	\$606,047,567	\$8,765	\$1,456
Coronary stent*	\$506,442,494	\$12,805	\$7,254
Spinal fusion and fixation hardware	\$341,126,391	\$23,169	\$7,004
Pacemaker*	\$324,839,553	\$20,443	\$9,668
Defibrillator*	\$139,178,929	\$37,154	\$24,443
Shoulder replacement*	\$71,774,881	\$11,874	\$7,522
Ear tube	\$57,983,541	\$4,924	\$1,331
Transvaginal mesh implant and TVT procedure**†	\$46,656,440	\$7,107	\$2,719
Breast implant prosthesis**†	\$44,419,968	\$12,096	\$5,013
IUD**†	\$28,119,127	\$5,586	\$1,664

Notes

* Includes those age 18 and older.

† Females only.

‡ Excludes atypical cases (i.e., deaths, sign-outs, transfers and long-stay outliers) and/or those without cost information.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

The most recent costing data available is from 2017–2018.

Data may include both primary and revision procedures.

Costs include hospital costs and physician fees. Costs do not include other potential costs for recovery and rehabilitation.

Overall estimated cost is calculated by adding total estimated costs for hospitalizations and day surgeries. The total estimated cost is calculated by multiplying 2017–2018 average costs for each IMD procedure with the respective 2018–2019 total volumes for each IMD procedure.

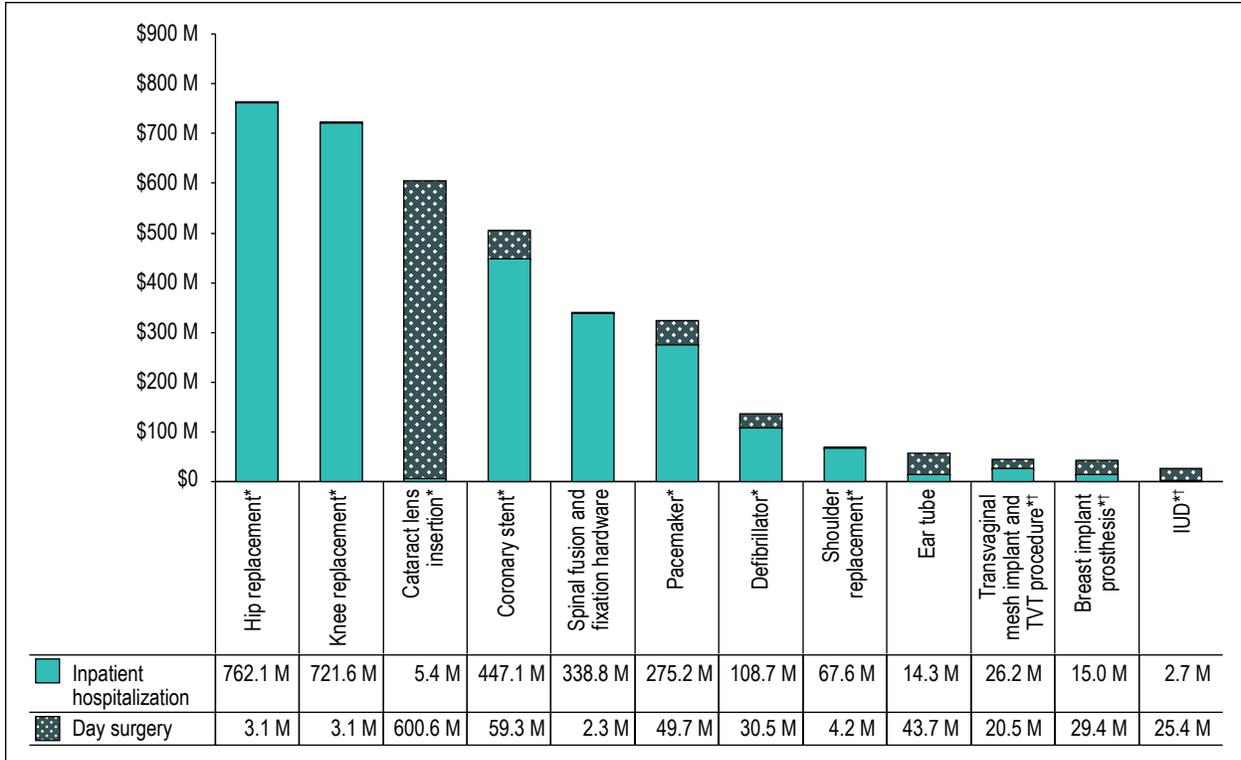
Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2017–2018 to 2018–2019, Canadian MIS Database 2017–2018, Case Mix Group+ 2018, Patient-Level Physician Billing Repository 2017–2018, Canadian Institute for Health Information.

The average inpatient hospitalization and day surgery costs from Table 3 were used to calculate the total estimated costs shown for the 12 selected IMD procedures in Figure 5. This figure demonstrates that, in Canada during 2018–2019,

- Despite lower volumes of procedures in acute inpatient care settings, the majority (76%, or \$2.8 billion) of the overall estimated costs were incurred in these settings due to a higher average cost per procedure.
- Hip and knee replacements combined had the highest total inpatient costs at \$1.5 billion. Cardiovascular-related IMD procedures accounted for \$831 million in inpatient costs.
- Despite a lower average cost per procedure, cataract lens insertion had the highest total day surgery cost — \$600.6 million — due to very high procedure volumes. It also ranked third overall for combined costs among all IMD procedures analyzed.

Figure 5 Total estimated cost of inpatient hospitalizations versus day surgeries for selected IMD procedures, Canada, 2018–2019



Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

M: Million.

TVT: Tension-free vaginal tape.

The most recent available costing data is from 2017–2018.

Data may include both primary and revision procedures.

Total estimated cost is calculated by multiplying the 2017–2018 average cost by the 2018–2019 total volume. Volume includes typical and atypical cases. Costs include hospital costs and physician fees. Costs do not include other potential costs for recovery and rehabilitation.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2017–2018 to 2018–2019, Canadian MIS Database, 2017–2018, Case Mix Group+ 2018, Patient-Level Physician Billing Repository, 2017–2018, Canadian Institute for Health Information.

Summary and future opportunities

Describing the volumes and costs for this set of IMD procedures is an important first step in understanding the current state in Canada. The findings show that, for those devices analyzed, overall higher volumes of IMD procedures occurred in an outpatient setting rather than an inpatient setting, while higher total costs were incurred for inpatient hospitalizations. Variations of IMD procedure rates were observed between provinces and territories and across devices. Results suggest that demand for IMD procedures will continue to increase across Canada due to a growing senior population.

The high-volume and high-cost procedures included in the analyses cover a wide range of devices and patient populations but do not cover all known IMDs, as there is currently no existing comprehensive registry on medical devices or IMDs in Canada. Additionally, while these analyses included 706,952 IMD-related inpatient hospitalizations and day surgeries across Canada in 2018–2019, the volumes may still be underestimated as many IMD procedures are known to take place outside hospitals in settings such as private or public clinics. For example, breast implant prosthesis are often completed outside hospital settings. Similarly, costs may also be underestimated due to the aforementioned limitations in clinic data capture and limitations in available costing data. In order to provide a better picture of these high-volume, high-cost IMD procedures, there is a need to fill information gaps through, for example, the collection of IMD product information using barcode scanning to capture more specific device information, which is needed to measure effectiveness.¹¹

Patient outcomes — such as short- and long-term complications, including death — and costs are highly relevant when assessing the value of IMDs. Some of these outcomes can be tracked at the patient level in CIHI's hospitalization and day surgery databases for some IMD procedures, but data is currently not captured at the level of the device (except for hip and knee replacements). The only known national medical device registry is the Canadian Joint Replacement Registry, managed by CIHI, which contains device-level data and tracks and reports on outcomes such as early revisions for hip and knee replacements.¹² Future work can focus on monitoring outcomes and value for IMDs, particularly on higher-risk devices with higher complication rates.¹³ Patient experience is also of high interest and future work can complement hospitalization and day surgery data on IMDs with [patient-reported experience measures \(PREMs\)](#) and [patient-reported outcome measures \(PROMs\)](#) to determine the impact of these procedures on patients' experiences, health status and quality of life.^{14, 15}

As technology advances, there is an opportunity to improve medical device performance and for innovation to make new IMDs available. For example, left ventricular assist devices have opened new possibilities for treating patients with heart failure, potentially increasing the chances of survival and decreasing complications, including death.¹⁶

Future strategies, such as implementing the capture of barcoded information on medical devices and collecting linkable, patient-level product information, could help to fill in data gaps. Enhanced monitoring and reporting on the quality and patient safety of IMDs, including activities described in Health Canada's action plan on medical devices, will play a key role going forward. By filling in data gaps and expanding analyses on IMDs into different areas, there will be additional opportunities to ensure that timely, relevant and cost-effective information is available on current and future IMDs. From exploring procedure outcomes and expanding the list of devices to understanding patient-reported measures, CIHI's data holdings are a rich source of information that can be leveraged to identify system improvement opportunities and inform best practices in Canada.

Appendix A: Methodological notes

Data sources

Inpatient hospitalization and day surgeries

Inpatient hospitalization data was obtained from CIHI's national Discharge Abstract Database (DAD) and Hospital Morbidity Database (HMDB). Day surgeries were sourced from the DAD, HMDB and National Ambulatory Care Reporting System (NACRS). Data was based on the fiscal year of discharge (the DAD and HMDB) and registration (NACRS).

Cost information

The most recent costing data available (2017–2018) was taken from the Canadian MIS Database (CMDB) and Patient-Level Physician Billing (PLPB) Repository. The CMDB includes hospital costs from all provinces and territories except Quebec and Nunavut. Quebec financial and statistical data is mapped to similar accounts to allow the calculation of various indicators. The PLPB Repository receives physician fee information from Nova Scotia, Ontario, Manitoba, Saskatchewan and Alberta. Costing information was also sourced from the 2018 Case Mix Group+ (CMG+) methodology.

Calculations

Age-standardized rate was based on crude rates and the application of population weights for each age group. The 2011 Canadian reference population was used for age standardization. Results were presented by patients' jurisdiction of residence, rather than by the province or territory of the facility where the treatment occurred.

Average hospital cost was calculated by averaging the estimated cost of inpatient hospitalizations and day surgeries. Atypical cases (i.e., deaths, sign-outs, transfers and long-stay outliers) were excluded in the calculation. The estimated cost of a clinical case in the DAD-HMDB and NACRS input file is determined by multiplying the Cost of a Standard Hospital Stay (CSHS) provincial/territorial indicator by the Resource Intensity Weight (RIW) of the case. The estimates include the costs incurred by the hospital in providing services and exclude physician compensation, since physicians are normally paid directly by the jurisdiction. Hospital costs include labour, nursing and allied health professionals, pharmacy (drugs), supplies, medical imaging and laboratory, as well as indirect (overhead) costs. Cases with an invalid RIW value or CSHS indicator do not have an estimated cost. Further information on the hospital costing methodology is available in [Cost of a Standard Hospital Stay: Appendices to Indicator Library](#).¹⁷

Average physician cost was calculated using the sum of physician costs divided by the number of inpatient hospitalizations and day surgeries included. Atypical cases were excluded from the calculation.

Clinical information from the DAD and NACRS was linked to the physician claims data to calculate physician-related costs. Physician claims that fell outside the clinical stay (admission to discharge date [DAD], registration to disposition date [NACRS]) were excluded. Following the data linkage, each case was tested to determine if the expected activity was captured in the claims data and appropriate to include in the physician cost calculation. Any cases that did not contain the expected physician activity were excluded. For the category of intrauterine device (IUD), there was no specific activity required within the claims data. For cataract lens insertion and coronary stent, each case required at least one claim for a surgical procedure. For all other categories, each case required at least one claim for a surgical procedure and a claim for anesthesia. Physician costs are the sum of all claims within the clinical stay for the cases that met the outlined criteria above.

Average cost was calculated by adding the average hospital cost and average physician cost. The calculation for the average physician cost was based on the assumption that all other provinces and territories have physician fee information similar to that of the 5 provinces that submit to the PLPB Repository — namely, Nova Scotia, Ontario, Manitoba, Saskatchewan and Alberta.

Total estimated cost is calculated by multiplying the average cost for typical cases from 2017–2018 by the total volume from 2018–2019. The total estimated cost includes both hospital and physician fees. Volume includes typical and atypical cases. This calculation was based on the assumptions that the population is similar in the physician and hospital costing data and that costs would be similar from 2017–2018 to 2018–2019.

Overall estimated cost was calculated by adding the total estimated cost for hospitalization and day surgeries. The overall estimated cost includes both hospital and physician fees.

Table A1 Definitions of 12 selected IMD procedures by CCI codes, version 2018, Canada

IMD procedures	CCI codes, version 2018
Breast implant prosthesis	1YM79DAPM; 1YM79LAPM; 1YM79LAPMA; 1YM79LAPME; 1YM79LAPMG; 1YM80DAPM; 1YM80LAPM; 1YM80LAPMA; 1YM80LAPME; 1YM80LAPMF; 1YM80LAPMG; 1YM80LAPMK; 1YM88LAPM; 1YM88LAPME; 1YM88LAPMF; 1YM88LAPMG; 1YM88LAPMK; 1YM90LAPM; 1YM90LAPME; 1YM90LAPMF; 1YM90LAPMG; 1YM90LAPMK; 1YM92LAPME; 1YM92LAPMF; 1YM92LAPMG; 1YM92LAPMK; 1YM92TRPME; 1YM92TRPMF; 1YM92TRPMG; 1YM92TRPMK; 1YM92TRTPE; 1YM92TRTPF; 1YM92TRTPG; 1YM92TRTPK; 1YM92WPPME; 1YM92WPPMF; 1YM92WPPMG; 1YM92WPPMK
Cataract lens insertion	1CL53LAFE; 1CL53LALM; 1CL53LALN; 1CL53LALO; 1CL53LALP; 1CL53LALR; 1CL89NVLR; 1CL89VOLM; 1CL89VOLN; 1CL89VOLP; 1CL89VRLR; 1CL89NPLM; 1CL89NPLN; 1CL89NPLP; 1CL89NVLP; 1CL89VRLM; 1CL89VRLN; 1CL89VRLP
Coronary stent	1IJ50GQNR; 1IJ50GQOA; 1IJ50GQOB; 1IJ50GQOE
Defibrillator	1HZ53HNFS; 1HZ53GRFS; 1HZ53GRFU; 1HZ53LAFS; 1HZ53LAFU; 1HZ53SYFS; 1HZ53SYFU
Ear tube	1DF53JATS
Hip replacement	1SQ53LAPM; 1SQ53LAPMA; 1SQ53LAPMK; 1SQ53LAPMN; 1SQ53LAPMQ; 1SQ53LAPN; 1SQ53LAPNA; 1SQ53LAPNK; 1SQ53LAPNN; 1SQ53LAPNQ; 1VA53LAPM; 1VA53LAPMA; 1VA53LAPMK; 1VA53LAPMN; 1VA53LAPMQ; 1VA53LAPN; 1VA53LAPNA; 1VA53LAPNK; 1VA53LAPNN; 1VA53LAPNQ; 1VA53LASLN (with attribute = R); 1VA53LLPM; 1VA53LLPMA; 1VA53LLPMK; 1VA53LLPMN; 1VA53LLPMQ; 1VA53LLPN; 1VA53LLPNA; 1VA53LLPNK; 1VA53LLPNN; 1VA53LLPNQ; 1VA53LLSLN (with attribute = R)
IUD	1RM53CABH
Knee replacement	1VG53LAPM; 1VG53LAPMA; 1VG53LAPMK; 1VG53LAPMN; 1VG53LAPMQ; 1VG53LAPN; 1VG53LAPNA; 1VG53LAPNK; 1VG53LAPNN; 1VG53LAPNQ; 1VG53LAPP; 1VG53LAPPA; 1VG53LAPPK; 1VG53LAPPN; 1VG53LAPPQ; 1VG53LAPR; 1VG53LASLN (with attribute = R); 1VP53LAPM; 1VP53LAPMN; 1VP53LAPN; 1VP53LAPNN
Pacemaker	1HZ53GRFR; 1HZ53GRNK; 1HZ53GRNL; 1HZ53GRNM; 1HZ53LAFR; 1HZ53LANK; 1HZ53LANL; 1HZ53LANM; 1HZ53QANK; 1HZ53QANL; 1HZ53QANM; 1HZ53SYFR
Shoulder replacement	1TA53LAPM; 1TA53LAPMA; 1TA53LAPMK; 1TA53LAPMN; 1TA53LAPMQ; 1TA53LAPN; 1TA53LAPNA; 1TA53LAPNK; 1TA53LAPNN; 1TA53LAPNQ; 1TA53LAPQ; 1TA53LAPQA; 1TA53LAPQK; 1TA53LAPQN; 1TA53LAPQQ; 1TA53LASLN (with attribute = R)

IMD procedures	CCI codes, version 2018
Spinal fusion and fixation hardware	1SC75LLGXA; 1SC75LLNWA; 1SC75LLKDA; 1SC75PFGXA; 1SC75PFNWA; 1SC75PFKDA; 1SC75PFTCA; 1SC75LNGXA; 1SC75LNNWA; 1SC75LNKDA; 1SC75LNTCA; 1SC75ERGXA; 1SC75ERNWA; 1SC75ERKDA; 1SC75LLGXQ; 1SC75LLNWQ; 1SC75LLKDQ; 1SC75PFGXQ; 1SC75PFNWQ; 1SC75PFKDQ; 1SC75PFTCQ; 1SC75LNGXQ; 1SC75LNNWQ; 1SC75LNKDQ; 1SC75LNTCQ; 1SC75ERGXQ; 1SC75ERNWQ; 1SC75ERKDQ; 1SC75LLGXK; 1SC75LLNWK; 1SC75LLKDK; 1SC75PFGXK; 1SC75PFNWK; 1SC75PFKDK; 1SC75PFTCK; 1SC75LNGXK; 1SC75LNNWK; 1SC75LNKDK; 1SC75LNTCK; 1SC75ERGXK; 1SC75ERNWK; 1SC75ERKDK; 1SC75LLGXN; 1SC75LLNWN; 1SC75LLKDN; 1SC75PFGXN; 1SC75PFNWN; 1SC75PFKDN; 1SC75PFTCN; 1SC75LNGXN; 1SC75LNNWN; 1SC75LNKDN; 1SC75LNTCN; 1SC75ERGXN; 1SC75ERNWN; 1SC75ERKDN; 1SC75LLGXL; 1SC75LLNWL; 1SC75LLKDL; 1SC75PFGXL; 1SC75PFNWL; 1SC75PFKDL; 1SC75PFTCL; 1SC75LNGXL; 1SC75LNNWL; 1SC75LNKDL; 1SC75LNTCL; 1SC75ERGXL; 1SC75ERNWL; 1SC75ERKDL; 1SC74LLGX; 1SC74PFGX; 1SC74LLTC; 1SC74PFTC; 1SC74LLNW; 1SC74PFNW; 1SC74LLKD; 1SC74PFKD; 1SC74LLMK; 1SC74PFMK; 1SC74HAMK
Transvaginal mesh implant and TVT procedure	1RS74CRXXN; 1RS74DAXXN; 1RS74LAXXN; 1PL74CRXXN; 1PL74ALXXN; 1PL74AFXXN; 1PL74LAXXN; 1PL74DAXXN

Notes

CCI: Canadian Classification of Health Interventions.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Table includes CCI codes, version 2018, which were used for the most recent available data. Codes used for previous years were not shown in this table.

Source

Canadian Classification of Health Interventions, version 2018, Canadian Institute for Health Information.

Table A2 Age-standardized rate per 100,000 population for high-volume IMD procedures, by patients' jurisdiction of residence, Canada, 2018–2019

IMD procedures (sorted by volume)	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T., N.W.T. and Nun.	Canada
Cataract lens insertion*	1,175	1,517	1,259	1,465	1,268	1,072	1,063	1,548	1,321	1,374	1,528	1,219
Knee replacement*	216	236	256	237	161	251	251	280	216	241	227	224
Hip replacement*	200	197	214	184	144	194	204	218	201	207	219	186
Coronary stent*	249	175	125	205	131	112	218	190	76	169	116	133
Ear tube	214	146	131	180	171	88	50	107	44	42	93	99
Pacemaker*	80	70	49	78	59	46	57	69	46	71	92	56
IUD*†	279	54	106	233	34	97	188	167	171	164	350	113
Spinal fusion and fixation hardware	47	46	29	69	33	35	38	88	49	34	39	38
Transvaginal mesh implant and TVT procedure*†	147	117	67	76	91	63	74	73	77	68	131	75
Breast implant prosthesis*†	60	23	39	77	47	49	30	42	50	54	13	49
Shoulder replacement*	8	18	18	19	15	21	21	29	17	18	8	19
Defibrillator*	24	13	11	19	13	11	15	12	13	14	14	13

Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Numerator may include both primary and revision procedures.

Results are presented by patients' jurisdiction of residence, rather than by the province/territory of the facility where the treatment occurred.

The 2011 Canadian reference population was used for age standardization.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2018–2019, Canadian Institute for Health Information; 2011 Canadian population, Statistics Canada.

Appendix B: Text alternative for figures

Text alternative for Figure 1: High-volume and high-cost criteria for 12 selected IMD procedures, Canada, 2018–2019

These are the approaches taken to identify the 12 high-volume and/or high-cost implantable medical device (IMD) procedures.

The selection of high-volume procedures was based on Canadian inpatient hospitalizations and day surgeries, literature reviews and stakeholder consultation. The selection of high-cost procedures was based on pan-Canadian hospitalization costs and selected jurisdictions' physician billing costs. The 12 selected IMD procedures (sorted from highest to lowest volume) were as follows: cataract lens insertion,* knee replacement,* hip replacement,* coronary stent,* ear tube, pacemaker,* intrauterine device (IUD),*† spinal fusion and fixation hardware, transvaginal mesh implant and tension-free vaginal tape (TVT) procedure,*† breast implant prosthesis,*† shoulder replacement* and defibrillator.*

Notes

* Includes those age 18 and older.

† Females only.

Source

Canadian Institute for Health Information.

Text alternative for Figure 2: Selected IMD procedure volumes, Canada, 2018–2019

Implantable medical device procedures (sorted by volume)	Number
Cataract lens insertion*	413,202
Knee replacement*	75,220
Hip replacement*	61,645
Coronary stent*	43,095
Ear tube	35,730
Pacemaker*	18,597
IUD*†	15,757
Spinal fusion and fixation hardware	14,956
Transvaginal mesh implant and TVT procedure**†	11,218
Breast implant prosthesis**†	7,112
Shoulder replacement*	6,247
Defibrillator*	4,173

Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Data may include both primary and revision procedures.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2018–2019, Canadian Institute for Health Information.

Text alternative for Figure 3: Inpatient hospitalizations versus day surgeries for selected IMD procedures, Canada, 2018–2019

Implantable medical device procedures (sorted by percentage of inpatient hospitalizations)	Inpatient hospitalizations		Day surgeries	
	Number	Percentage of total volume	Number	Percentage of total volume
Knee replacement*	74,757	99.4%	463	0.6%
Hip replacement*	61,201	99.3%	444	0.7%
Spinal fusion and fixation hardware	14,623	97.8%	333	2.2%
Shoulder replacement*	5,695	91.2%	552	8.8%
Coronary stent*	34,919	81.0%	8,176	19.0%
Pacemaker*	13,461	72.4%	5,136	27.6%
Defibrillator*	2,925	70.1%	1,248	29.9%
Transvaginal mesh implant and TVT procedure*†	3,682	32.8%	7,536	67.2%
Breast implant prosthesis*†	1,238	17.4%	5,874	82.6%
Ear tube	2,906	8.1%	32,824	91.9%
IUD*†	485	3.1%	15,272	96.9%
Cataract lens insertion*	619	0.1%	412,583	99.9%

Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

Data may include both primary and revision procedures.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2018–2019, Canadian Institute for Health Information.

Text alternative for Figure 4: Overall and total estimated costs* for IMD procedures, Canada, 2018–2019

Care setting	Total estimated cost	Percentage of overall estimated cost
Inpatient hospitalization	\$2.8 billion	76%
Day surgery	\$872 million	24%
Overall estimated cost	\$3.7 billion	100%

Notes

* Overall estimated cost is calculated by adding total estimated costs for hospitalizations and day surgeries. Total estimated cost is calculated by multiplying the 2017–2018 average cost by the 2018–2019 total volume. Volume includes typical and atypical cases.

IMD: Implantable medical device.

The most recent available costing data is from 2017–2018.

Costs include hospital cost and physician fees and may incorporate both primary and revision procedures. Costs do not include other potential costs for recovery and rehabilitation.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2017–2018 to 2018–2019, Canadian MIS Database, 2017–2018, Case Mix Group+ 2018, Patient-Level Physician Billing Repository, 2017–2018, Canadian Institute for Health Information.

Text alternative for Figure 5: Total estimated cost of inpatient hospitalizations versus day surgeries for selected IMD procedures, Canada, 2018–2019

Implantable medical device procedures	Total estimated cost of inpatient hospitalization	Total estimated cost of day surgery
Hip replacement*	\$762.1 million	\$3.1 million
Knee replacement*	\$721.6 million	\$3.1 million
Cataract lens insertion*	\$5.4 million	\$600.6 million
Coronary stent*	\$447.1 million	\$59.3 million
Spinal fusion and fixation hardware	\$338.8 million	\$2.3 million
Pacemaker*	\$275.2 million	\$49.7 million
Defibrillator*	\$108.7 million	\$30.5 million
Shoulder replacement*	\$67.6 million	\$4.2 million
Ear tube	\$14.3 million	\$43.7 million
Transvaginal mesh implant and TVT procedure**†	\$26.2 million	\$20.5 million
Breast implant prosthesis**†	\$15.0 million	\$29.4 million
IUD**†	\$2.7 million	\$25.4 million

Notes

* Includes those age 18 and older.

† Females only.

IMD: Implantable medical device.

IUD: Intrauterine device.

TVT: Tension-free vaginal tape.

The most recent available costing data is from 2017–2018.

Data may include both primary and revision procedures.

Total estimated cost is calculated by multiplying the 2017–2018 average cost by the 2018–2019 total volume. Volume includes typical and atypical cases. Costs include hospital costs and physician fees. Costs do not include other potential costs for recovery and rehabilitation.

Sources

Hospital Morbidity Database and National Ambulatory Care Reporting System, 2017–2018 to 2018–2019, Canadian MIS Database, 2017–2018, Case Mix Group+ 2018, Patient-Level Physician Billing Repository, 2017–2018, Canadian Institute for Health Information.

References

1. World Health Organization. [Medical device — Full definition](#). Accessed October 29, 2019.
2. Brown SL, Bright RA, Tavis DR, eds. [Medical Device Epidemiology and Surveillance](#). 2007.
3. Government of Canada. [Medical devices: Industry profile](#). Accessed November 27, 2019.
4. Research and Markets. [Implantable Medical Devices Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019–2024](#). 2019.
5. Health Canada. [Health Canada’s Action Plan on Medical Devices: Continuously Improving Safety, Effectiveness and Quality](#). 2018.
6. 24/7 Wall St. [The 11 most implanted medical devices in America](#). *Business Insider*. July 2011.
7. Kuder M, Gelman A, Zenilman J. [Prevalence of implanted medical devices in medicine inpatients](#). *Journal of Patient Safety*. September 2018.
8. Meng E, Sheybani R. [Insight: Implantable medical devices](#). *Lab on a Chip*. September 2014.
9. Health Canada. [Summary safety review — Surgical mesh products made from non-absorbable synthetic \(polypropylene\) material that are used for the transvaginal repair of pelvic organ prolapse \(POP\) — Health Canada](#). Accessed January 8, 2020.
10. Deloitte. [Growth in outpatient care: The role of quality and value incentives](#). *Deloitte Insights*. August 2018.
11. Lind K.; AARP Public Policy Institute. [Understanding the market for implantable medical devices](#). *Insight on the Issues*. August 2017.
12. Canadian Institute for Health Information. [Canadian Joint Replacement Registry \(CJRR\)](#). Accessed December 3, 2019.
13. Zhang S, et al. [Recalls of cardiac implants in the last decade: What lessons can we learn?](#). *PLoS One*. May 2015.
14. Hadibhai S, Lacroix J, Leeb K.; Canadian Institute for Health Information. [Developing the first pan-Canadian acute care patient experiences survey](#). *Patient Experience Journal*. 2018.
15. Canadian Institute for Health Information. [Patient-reported outcome measures \(PROMs\)](#). Accessed December 3, 2019.

16. Kilic A. [The future of left ventricular assist devices](#). *Journal of Thoracic Disease*. December 2015.
17. Canadian Institute for Health Information. [Cost of a Standard Hospital Stay: Appendices to Indicator Library — Methodology Notes](#). 2019.

**CIHI Ottawa**

495 Richmond Road
Suite 600
Ottawa, Ont.
K2A 4H6
613-241-7860

CIHI Toronto

4110 Yonge Street
Suite 300
Toronto, Ont.
M2P 2B7
416-481-2002

CIHI Victoria

880 Douglas Street
Suite 600
Victoria, B.C.
V8W 2B7
250-220-4100

CIHI Montréal

1010 Sherbrooke Street West
Suite 602
Montréal, Que.
H3A 2R7
514-842-2226

cihi.ca

21589-0120

