A Comparison of the U.S. and Canadian Inpatient Hospital Costs

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Executive Summary

Canada versus U.S. payments for high volume hospital inpatient procedures:

- In 2017, the 19 highest volume hospital inpatient procedures performed in Canada accounted 759,122 procedures (27 percent of the 2,828,495 total) and C$ 3.860 billion in payments (22 percent of the C$ 17.758 billion total). (Table 6e).
    - To compare the payment amounts with U.S. payment rates, we converted the C$ 3.860 in payments for these procedures by Canadian governments to $2.918 billion in U.S. dollars using the end-of-year dollar exchange rate of C$ 0.756 Canadian to $1 U.S.
        - Canadian citizens and residents do not pay for hospital inpatient procedures covered under the Canada Health Act, including the 19 procedures analyzed.
    - Had these procedures been paid at nationwide average Medicare part A rates, $4.475 billion (**153 percent of Canada payment** in U.S. dollars) would have been paid by Medicare and patients, and
    - Had these procedures been paid by commercial insurers that paid for these procedures in North Carolina, $7.790 billion (**270 percent of Canada payment** and 74 percent of Medicare part A payment) would have been paid by commercial insurers and patients.
- In 2017 these same 19 procedures in North Carolina accounted for 130,196 hospital inpatient procedures.
    - Had Medicaid paid for all of these procedures at North Carolina Medicaid rates it would have amounted to $0.606 billion.
    - Had Medicare paid for all of these procedures at North Carolina Medicare rates along with beneficiary copayments it would have amounted to $0.703 billion, or **16 percent greater than Medicaid**, and
    - Had commercial insurers paid for all of these procedures at North Carolina commercial insurance rates along with their beneficiary copayments it would have amounted to $1.363 billion, or **94 percent greater than Medicare**.
    - Both Medicare and commercial insurer **payments were increasing with the amount of tangible capital investment in land, buildings, and equipment of a hospital** while most Medicaid payments showed no effect (Table 6b).
- The 19 highest volume hospital inpatient procedures in Canada used for this analysis included surgery intensive procedures including replacement of a knee or hip, fixing a broken hip or femur, removing a gallbladder, inserting a pacemaker, inserting a stent, and kidney failure; less intensive but none-the less dangerous conditions such as treatment of chronic obstructive pulmonary disorder (COPD), heart failure without a coronary angiogram, pulmonary embolism, and cellulitis; and even less intensive procedures for conditions that generally are not life threatening such as arrhythmia without coronary angiogram, sepsis, lower urinary tract infections, normal newborn birth, birth without anesthetic and non-major obstetric/gynecological intervention, caesarean section with uterine scar but no induction, seizure disorder, depressive episode, and schizophrenia.

Payments to North Carolina hospitals by resource intensity and non-financial capital investment:

- We examined the impact of non-financial capital investment in land, buildings, and fixed and moveable equipment for each hospital in North Carolina on payment rates by type of insurer.
    - The smallest amount of non-financial capital investment was $2 million; the 25th percentile was $43 million; the median amount was $107 million; the 75th percentile amount was $263 million; and the largest amount was $1,919 million.
    - For the 6 highest resource intensive procedures, commercial insurance payments increased with the size of a hospital's non-financial capital investment by $2.98 per $1 million while Medicare payments increased by $2.43 per $1 million.
        - Commercial insurance procedure payments increased 22 percent faster than did Medicare payments as non-financial capital investment increased.
    - For the 4 moderate resource intensive procedures, commercial insurance payments increased with the amount of hospital non-financial capital investment by $2.33 per $1 million while Medicare payments increased by $1.59 per $1 million.
        - Commercial insurance procedure payments increased by 47 percent faster than did Medicare.
    - For the 9 low resource intensive procedures, commercial insurance increased with the amount of hospital non-financial capital by $0.36 per $1 million while Medicare payments increased by $0.98 per $1 million.
        - Commercial insurance procedure payments increased 64 percent *slower* than did Medicare.

Variation in non-financial capital investment in U.S. hospitals

- We examined the amount of non-financial capital investment in the United States per hospital bed among all hospitals that file reports with CMS for Medicare in 2017. Of the 5,807 hospitals providing useable data 2,924 were non-profit, 1,137 were governmental (Veterans Administration and some state university hospitals), and 1,746 were for-profit.
    - Non-profit hospitals, whether urban or rural, teaching or not teaching, have greater non-financial capital investment per bed than for-profit hospitals.
    - Government hospitals, whether urban or rural, teaching or not teaching, have greater non-financial capital investment per bed than for-profit hospitals with the lone exception that Government urban non-teaching hospitals have similar amounts bed as do for-profit urban teaching hospitals.
    - Non-profit teaching hospitals have similar amounts of non-financial capital investment per bed as do Government teaching hospitals.

I. Health care expenditures and consumption in Canada and the United States

During 2017 national health expenditures in Canada totaled C$ 244 billion, or 11.2 percent of GDP while for the United States expenditures totaled $ 3,487 billion, or 17.9 percent of GDP. For every $1 spent on health care in the U.S. Canada spent C$ 0.625 dollars. So, where did Canada save on health care expenditures relative to the U.S.? To begin to answer this question we compared payments for the 19 most common hospital inpatient procedures in Canada (amounts converted to U.S. dollars) with what Medicare paid for these same procedures in the U.S., and with what commercial insurers paid in North Carolina. Payments for hospital services are the single largest cost element in both the U.S. national health expenditure estimates at 33 percent of total health care spending, and in the Canadian national health expenditure estimates at 27 percent of total health spending.[1] *Overall, for these procedures, Medicare, and its enrollees paid 53 percent more than was paid by Canadian provincial governments, and commercial insurers in North Carolina and their enrollees paid 167 percent more* (Table 6b). Of the 19 procedures Medicare paid less per episode for six, and commercial insurers in North Carolina paid less per episode for two (Table 6a).

This paper does not explain *why* Canadian inpatient procedure costs were so much less than in the U.S. but it does provide some insight into the sources of cost differences between Canada and the U.S. What we can say is that lower costs for Canadian inpatient procedures are not due to fewer hospital beds in Canada as the U.S. and Canada have very similar ratios of persons per hospital bed (Table 4a) although Canadian hospitals utilize their hospital beds at a much higher rate than do U.S. hospitals (Chart 1); or nursing costs as nurses in Canada are paid either the same or more than in the U.S. (Table 10); or capital investment in hospital equipment as Canada and the U.S. invest at very similar rates per hospital bed (Chart 4 – blue line). However, part of the payment disparity could be the result of much lower drug costs in Canada (Table 7), lower laboratory test costs (Table 8), lower capital investment in land and buildings (Chart 4 – orange line), and lower administrative costs (Canada spent 2.9 percent of health expenditures on administration while the U.S. spent 6.7 percent).[2] The contribution of these to the sizeable inpatient payment differential is a topic for further analyses.

The second section of this paper contrasts a fundamental difference between Canada and the U.S. for hospital inpatient procedure payments which is the role of the Canada Health Act in creating universal coverage and requiring provincial governments to be the single-payer for health care services (Table 1). *The Canada Health Act accounts for more than one-third of national health expenditures and exerts a powerful and restraining force on health care expenditures by assigning provincial governments monopsony power over inpatient procedure payments*.

The third section compares the Canadian and U.S. populations by health care coverage, age and mortality (Tables 2 and 3). The only persons who lack universal health care coverage in Canada are

[1] Micah Hartman, Anne B. Martin, Joseph Benson, Aaron Catlin and the National Health Expenditure Accounts Team, *National Health Care Spending in 2018: Growth Driven by Acceleration in Medicare and Private Insurance Spending (Exhibit 2),* Health Affairs 39, No. 1 (2020). Canadian Institute for Health Information, *National Health Expenditure Trends, 1975 to 2019*: Data Tables – Series C, Ottawa, ON: CIHI; 2019.
[2] Ibid p.5

tourists and new immigrants who have not yet obtained resident status, amounting to approximately 1 percent of the population. Canadians are older and live significantly longer than Americans on average.

The fourth section compares hospitals by number, size, and non-financial capital investment (Table 4a and Charts 1, 2, and 4). Canada has a greater proportion of very small hospitals with 25 or fewer beds *and* very large hospitals with over 1,000 beds than in the U.S. but overall a very similar number of persons per hospital bed. Canada has many fewer teaching hospital beds at less than one-third compared with more than one-half in the U.S. (Table 4a). However, Canada and the U.S. invest similar amounts in hospital equipment on a per bed basis. Canada, on the other hand investments much less in land and buildings than in the U.S. This section also compares physicians by number and utilization between the two countries (Table 4b and Chart 3). Canada has many more general practice physicians but many fewer specialist physicians than in the U.S. Perhaps as a result of more general practice physicians, Canadians *visit doctors much more frequently* than Americans (Table 4b).

The fourth section also examines how hospital investment in land, buildings, and equipment – non-financial capex - in the United States is distributed among the three main types of hospitals – non-profits which mostly have an academic or religious order affiliation, non-profits that are governmental because they have a municipal/regional government affiliation or because they have a state university affiliation, and for-profits. This section tests and rejects the hypothesis that the amount of non-financial capex is independent of these affiliations *with for-profit hospitals convincingly investing less in land, buildings, and equipment* than for-profit hospitals (Table 5, blue shaded areas). This finding deserves further analyses.

The fifth section provides the central findings of our analysis and compares hospital inpatient costs between Canada, the United States, and North Carolina by the type of payor for the 19 highest volume procedures in Canada (Tables 6a, 6b, and 6c). We use actual payments for procedures from the Canada Institute for Health Information for Canada for Canada, CMS for Medicare nationwide for the U.S., and the North Carolina Department of Health and Human Services for payments received by hospitals in North Carolina from Medicaid, Medicare, and commercial insurers. This section uses least median squares estimation procedures and shows a strong positive relationship in North Carolina between the amount of non-financial capital investment in land, buildings, and equipment for each hospital and the payments received for procedures.

The sixth section graphically compares the range of payments for each of the 19 procedures between Canada, and Medicaid, Medicare, and commercial insurers in North Carolina (Charts 5, 6, and 7). Each chart shows the range for payments by each type of payer between the 25th percentile (low) and 75th percentile (high) of payments. Table 6d explores a potential data limitation of the analysis - whether the variability in the payment data shown in these charts might be the result of data aggregation rather than a true reflection of the variability in payments across hospitals. We present evidence that supports the view that data aggregation might not be the reason that the variability in Canadian payments for procedures is much less than for Medicaid, Medicare, or commercial insurers in North Carolina. However, we admit that hospital level payment data for Canadian hospitals would be preferable to conclusively resolve this possibility. Table 6f explores the downward impact on our estimates of payments by commercial insurers in North Carolina from deliberately excluding DRG procedures that have complications or co-morbidities when comparing with Canadian CMG procedure codes and payments.

The seventh section also includes four tables that provide supporting information for the analysis comparing prescription drug costs and laboratory tests costs and physician and nursing costs between Canada and the U.S. As is commonly understood, Canadians pay much less for drugs and laboratory tests, both highly commoditized inputs to health care, than people in the United States pay.

The eighth section provides a brief conclusion and the ninth section describes the least median squares algorithm R code used for estimation.

II. Health care payment methods in Canada and the United States

Health care costs are a universal fact of life, but there are many differences in how countries pay for health care. The U.S. and Canada both rely upon private hospitals and physicians to provide the great majority of health care but pay for health care services in very different ways.

Canada

Under the Canada Health Act, all citizens and permanent residents are eligible for health care coverage.[3] *This universal coverage has no premiums, deductibles, or copays for doctor office visits, hospital visits, and laboratory work related to those visits.* Coverage is portable across all of Canada regardless of the province of residency. This single-payer system is funded chiefly through provincial income taxes and is administered by each provincial government. Provincial governments funded healthcare with approximately C$ 122 billion in 2017. In addition, each provincial and territorial government receives from the federal government a Canadian Health Transfer to pay for services required under the Canada Health Act. The Canadian Health Transfer is funded through federal income taxes. In 2017 this transfer totaled C$ 37 billion, or about 15 percent of the C$ 244 billion of health expenditures in Canada. An additional C$ 12 billion of funding came from other public sector sources. In total, public funding amounted to C$ 172 billion, or 70 percent of total health expenditures. The remaining 30 percent, or C$ 72 billion, came from private sources through employer provided insurance (12%), private insurance from other sources (3%), and out-of-pocket spending (15%).[4]

In 2017, Canadian health expenditures amounted to C$ 6,701 per person or 11.2 percent of GDP while in the U.S. the amount was $10,742 or 17.9 percent of GDP.[5] Each province sets the range of fees that will be paid and services to be provided by physicians, hospitals, and laboratory services consistent with the Canada Health Act. Each province administers health care in their province and pays hospitals, physicians, and laboratories for services provided.[6] In the United States the closest analog to this single-payer no premiums, no deductibles, no copayments system of health care services and payments is

[3] Permanent residence in Canada varies from province to province. In Ontario the process typically takes about 45 days, https://settlement.org/ontario/immigration-citizenship/permanent-residence/permanent-resident-pr-status/frequently-asked-questions-about-the-permanent-resident-card/, while in British Columbia it takes at least 6 months, https://www2.gov.bc.ca/gov/content/health/health-drug-coverage/msp/bc-residents/eligibility-and-enrolment/are-you-eligible.

[4] Canadian Institute for Health Information. *National Health Expenditure Trends, 1975 to 2019*: Data Tables – Series C, Ottawa, ON: CIHI; 2019.

[5] Canadian Institute for Health Information. *National Health Expenditure Trends. 1975 to 2019*: Data Tables – Series C, Ottawa, ON: CIHI; 2019.

[6] This system finances 98 percent of all expenditures for physician services and 90 percent of all hospital expenditures for care. Canadian Institute for Health Information. *National Health Expenditure Trends, 1975 to 2018*. Ottawa, ON: CIHI; 2018.

Medicaid.[7] In Canada this system covers approximately 99 percent of the population, or 36 million, while in the United States Medicaid covers approximately 23 percent of the population, or 74 million, half of whom are children. The single payer system in Canada accounts for 39 percent of the C$ 244 billion in national health expenditures, while in the U.S. Medicaid accounts for 17 percent of the $3,487 billion in national health expenditures.

Canada's universal coverage does not cover all health care services. Prescription drugs (not used during hospital procedures), vision, dental, hearing and long-term care coverage is determined and paid for separately under each province or territory government. The absence of universal prescription drug coverage is unique among all countries with universal health care coverage.[8] However, the pan-Canadian Pharmaceutical Alliance negotiates jointly for provinces and territories brand name prescription drug prices, and the pan-Canadian Pharmaceutical Alliance Generics Initiative negotiates prices for generic drugs. All drugs that come through the national drug review process – either the pan-Canadian Drug Review or the pan-Canadian Oncology Drug Review – are subject to price negotiation through these alliances.[9] Therefore, *while there is no universal coverage for payment of prescription drugs, there is a single government entity negotiating prices nationwide and as a result, the prices of generic and brand drugs are significantly lower in Canada than in the U.S.* Canadians, in 2017, had more choice among brand name drugs (1,381 versus 1,100 in the U.S.), and a higher percentage of prescription drugs consumed in Canada are brand name drugs than in the U.S. (30 percent versus 10 percent). Table 7 compares branded drug spending for the top 20 drugs by expenditure for Medicare part D at Medicare, Veterans Administration, and Canadian prices.

Drug pricing in Canada is a monopsony market with the federal government, through the drug price review committees effectively acting as a "single buyer" in terms of establishing market prices, even though the two-thirds of all drug spending is through private parties, and mostly through individuals. In contrast, drug pricing in the U.S. under Medicare part D is an oligopoly market with pharmaceutical companies and pharmaceutical benefits managers effectively acting as "few sellers" in terms of establishing market prices. CMS is a price-taker under Medicare part D. We are puzzled as to why the Veterans Administration, which has the authority to negotiate drug prices and thus act as a "single buyer" still ends up paying 150 percent more than Canadian's do (Table 7).

A leading challenge for Canada is how to pay for prescription drugs, which are not covered under the Canada Health Act. In two provinces, Quebec and British Columbia, Canadians are required to purchase insurance for prescription drug coverage either through a government insurance plan with monthly premiums and copays or private insurance, while for the other provinces and territories limited prescription drug coverage is provided through combinations of insurance and means-tested

[7] Medicaid is a state administered health care system partially funded by the federal government that must comply with federal Medicaid rules.

[8] Prescription drug coverage in Canada varies by province, with most providing some type of catastrophic prescription drug coverage based upon income. The absence of a nationwide prescription drug coverage program was to be addressed by the Advisory Council on the Implementation of National Pharmacare, which has yet to provide recommendations. Jaden Brandt, Brenna Shearer, and Steven G. Morgan, "Prescription drug coverage in Canada: a review of the economic, policy and political considerations for universal pharmacare", *Journal of Pharmaceutical Policy and Practice*, (2018)11:28.

[9] Canadian Institute for Health Information. *National Prescription Drug Utilization Information System Database – Plan Information Document, July 14 2017*. Ottawa, ON: CIHI; 2017.

deductibles after which catastrophic coverage is provided. Because means-tested amounts established under provincial plans can be large, between 3 and 20 percent of income varying by province, many Canadians purchase insurance for prescription drug coverage, generally through their employers. About two-thirds of Canadians use private insurance to help pay for prescription drugs. This results in roughly one-in-five Canadians reporting no coverage for prescription drugs.[10]

Each province offers and funds, to varying degrees, services not covered under the Canada Health Act. In addition to prescription drugs (outside of hospitals), these include nursing care (outside of hospitals) and assisted living, vision, dental, hearing, and ambulance costs. Provinces often cover these services free-of-charge or for reduced copays for children, and on a means-tested basis for the adult population. Provincial funding comes through income taxes, government insurance premiums, and individual out-of-pocket payments. As with prescription drugs, roughly two-thirds of Canadians purchase private health insurance, generally through employers, to cover the costs of vision, dental, hearing, prescription drugs, long-term care, and additional health care services. The range of these services varies widely with the particular needs of the province. For example, the Atlantic provinces of Newfoundland and Labrador, Nova Scotia, New Brunswick, and Prince Edward Island have older populations and a greater need for assisted living services than the other provinces and territories. These provinces have more extensive government supported assisted living. The three territories – Yukon, Northwest Territory, and Nunavut - owing to their younger populations provide more extensive dentistry for children.

Under the Canada Health Act each provincial health care system providing for universal coverage is required to be publicly administered.[11] This creates a single province-wide health care payment network in each province covering most health care services. However, the great majority of health care providers – physicians' groups, hospitals, and laboratories – are privately owned. When a resident of one province or territory uses health care services in another province or territory, the services are out-of-network and payment is made according to agreements among the provinces. For health care services provided under the universal care system – physician office visits, hospital visits, and attendant laboratory services – the Canada Health Act *requires portability across provinces* of covered services. However, because the provinces and territories cover to varying degrees health services not covered by universal care such as prescription drugs, assisted living, dental and vision, it is possible for shortfalls in reimbursement to occur leaving the individual liable for payment. Similarly with Medicaid in the U.S., each state determines the full range of services to be provided as long as basic Medicaid services are covered. When a Medicaid enrollee in one-state receives health care services in another state, the extent of Medicaid coverage will depend upon whether the services are required to be covered by Medicaid or whether they are more state-specific, and the agreement for reimbursement between the two states.

The United States

In the U.S. Medicaid is, like Canada's universal coverage under the Canada Health Act, also a single-payer system without premiums, deductibles (there are some de minimis deductibles), or copays; Medicare is a dual-payer system with premiums, deductibles, and copays where the government and

[10] Brandt, Shearer, and Morgan, 2018.

[11] Jay Makarenko, "Canada's Health Care System: An Overview of Public and Private Participation", Mapleleafweb, October 22, 2010. https://www.mapleleafweb.com/features/canada-s-health-care-system-overview-public-and-private-participation.html

the beneficiary share payment; and commercial insurance is typically a three-payer system where commercial insurers, employers, and beneficiaries share payment.[12]

Unlike Canada's universal coverage for doctors' office and hospital services, Medicaid coverage varies from state to state through means-tested eligibility rules and the level of services and availability of service providers. About 70 percent of physicians accept Medicaid where as in Canada all physicians participate in the universal health care coverage.[13] About 74 million persons are enrolled in Medicaid because they are in households with incomes less than 133 percent of the federal poverty level or in states that expanded Medicaid coverage under the Affordable Care Act, are younger than 65 years of age, or have a disability under the Social Security Act.[14] Half of these enrollees are children. Importantly, as with health care provided under the Canada Health Act, when a person receives inpatient hospital care covered through Medicaid, they will leave the hospital without a medical bill.

Medicare is "almost" universal health care coverage for persons over the age of 65 so long as during their lifetime they paid Medicare taxes for at least 10 years.[15] Unlike universal coverage under the Canada Health Act or Medicaid, patients covered by Medicare generally pay premiums, deductibles, and copayments for covered health care services. Medicare is a complex system with different "Parts" covering different health care services, each with its own set of premiums, deductibles, and copayments. Medicare part A covers hospital, skilled nursing care (like Canada), and hospice care but has a per benefit period deductible of $1,316 (in 2017) in addition to an increasing coinsurance amount depending upon the length of a hospital stay. Medicare part B covers doctor office visits and laboratory work on a fee-for-service basis (like Canada), but also has premiums and cost-sharing with an annual deductible amount of $185 followed by a general rule of 80 percent paid by Medicare and 20 percent paid by the patient (unlike Canada). Medicare has significant cost-sharing with patients, including daily hospital inpatient copayments at a rate of $341 per day for days 61 through 90 in a hospital.[16] Unlike health care provided under the Canada Health Act or through Medicaid, when a person receives inpatient hospital care covered through Medicare they will leave the hospital with a medical bill.

Like Canada's universal coverage, Medicare part B does not cover vision, dental, prescription drugs, long-term care, or assisted living. Medicare part B and universal health care services covered under the Canada Health Act both operate under a fee-for-service payment mechanism administered by governments, and as a result, data detailing expenditures is generally available. Both Medicare part B and Canadian provinces publish fee schedules and payments for health care services. Data on payments for health care services paid by private insurance is mostly not available, and as private insurers take on more of both Medicaid and Medicare through managed care arrangements, more Medicare data for covered health care services is becoming hidden behind a veil of business method confidentiality. *Under*

[12] Large employers mostly self-insure their employee health care plans rather than provide commercial insurance, and are more similar to Medicare's dual-payer system.

[13] https://www.kff.org/medicaid/issue-brief/data-note-a-large-majority-of-physicians-participate-in-medicaid/#

[14] https://www.medicaid.gov/medicaid/eligibility/index.html

[15] In 2017, Medicare covered 93.7 percent of the population over the age of 65. Of the 51.08 million persons age 65 and older, 3.2 million were not covered by Medicare because they were not eligible. (Berchick, Edward R., Emily Hood, and Jessica C. Barnett, Current Population Reports, P60-264, *Health Insurance Coverage in the United States: 2017*, U.S. Government Printing Office, Washington D.C., 2018.)

[16] https://www.medicare.gov/your-medicare-costs/medicare-costs-at-a-glance

the Canada Health Act, private insurers are prevented from paying for covered health care services. This legal structure reinforces each provincial government's monopsony power to set hospital procedure payments.

After 1997 Medicare added part C to allow private insurance companies to enroll Medicare eligible persons into managed health care plans. Today these plans are called Managed Medicare and approximately one-third of the 64 million Medicare enrollees use Medicare managed care rather than the fee-for-service model under Medicare part B. Medicare managed care plans can offer coverage for a broader range of services than Medicare part B as long as the plan also covers Medicare procedures. These plans manage medical costs by negotiating bundles of health care services with service providers – physician offices, hospitals, and laboratories – to achieve cost savings. Beginning in 2006, Medicare again expanded by adding part D to cover prescription drugs. However, under title 42 section 1395 of the U.S. Code, Medicare part D plans are legally prevented from negotiating drug prices for their beneficiaries. Medicare, one of the largest purchasers of health care services on the planet, is a price taker for prescription drugs. Within the federal government, the Veterans Administration is allowed to negotiate drug prices but can only manage a 20 percent discount to Medicare part D which is far less than the 70 percent discount achieved in Canada (See Table 7).

Table 1 below summarizes major payment features for health care in Canada and in the U.S. The shaded box in the upper left corner of the table identifies single-payer systems in Canada under the Canada Health Act and in the United States under Medicaid. Two key features of both are that 1) the provincial governments in Canada and the state governments in the U.S. set prices for procedures and these prices cannot be enhanced through private insurance, and 2) patients do not pay premiums, copays, or deductibles. Each of the remaining payment forms – Medicare, Managed Medicare, and private insurance in the U.S. and Provincial plans in Canada – require patient specific payments for prescription drugs, assisted living, dental and vision services when those services are consumed. In 2017 Canadians paid for 15 percent of health care services out-of-pocket while in the United States 18 percent of health care services were paid out-of-pocket.[17]

[17] Canadian Institute for Health Information. *National Health Expenditure Trends. 1975 to 2018*. Ottawa, ON: CIHI; 2018. Total private spending in Canada amounted to 30 percent of national health expenditures, with individuals paying 15 percent; employers paying 12 percent; and other private parties, such as unions, paying 3 percent.

Table 1. Comparison of primary payment methods for health care in Canada and the United States, 2017. Dashed line means no coverage. Single payer networks in shaded area.

Are there individual premiums, deductibles, or co-pays, for basic health care services provided?						
Country:	**Canada**		**U.S.**			
Coverage geography:	**Nationwide**	**Provinces and Territories**	**States**	**Nationwide**	**Private networks**	**Private networks**
Payer:	**Federal**	**Provinces and Territories (1)**	**Medicaid (2)**	**Medicare (3)**	**Medicare (3)**	**Private**
Hospital:						
Premium	none	none	none	none	none	yes
Deductible	none	none	none	yes	yes	yes
Co-pay	none	none	none	yes	yes	yes
Doctor's office:						
Premium	none	none	none	yes	yes	yes
Deductible	none	none	none	yes	yes	yes
Co-pay	none	none	none	yes	yes	yes
Prescription drugs (4):						
Premium	-	some yes, most none	none	yes	yes	yes
Deductible	-	yes, means-tested	none	yes	yes	yes
Co-pay	-	yes, means-tested	yes, means-tested	yes	yes	yes
Assisted living (5):						
Premium	-	none	-	-	-	yes
Deductible	-	none	-	-	-	yes
Co-pay	-	yes, means-tested	-	-	-	yes
financial assistance	-	-	yes, means-tested	-	-	-
Dental:						
Premium	-	none	none	-	yes	yes
Deductible	-	yes, means-tested	none	-	yes	yes
Co-pay	-	yes, means-tested	yes	-	yes	yes
Vision:						
Premium	-	none	none	-	yes	yes
Deductible	-	yes, means-tested	none	-	yes	yes
Co-pay	-	yes, means tested	yes	-	yes	yes

(1) Provinces and Territories fund assisted living and charge on a daily rate that is means-tested.

(2) Some states have begun to charge small co-payments at the time of service, but these are tightly limited under Medicaid rules. Almost all states that provide dental and vision under Medicaid charge co-pays.

(3) Medicare part A covering hospital costs does not have a premium, but does have annual deductibles and co-pays.

(4) British Columbia and Quebec provinces mandate prescription drug coverage through insurance, either through government or privately. The general approach to paying for prescription drugs, assisted living, dental, and vision services by provinces and territories is to provide universal coverage for children for basic services, and means-tested coverage for adults.

(5) In most, but not all, states, Medicaid can provide financial assistance to a beneficiary for assisted living expenses. Medicaid cannot directly pay an assisted living facility. In Canada, provincial governments contract with assisted living facilities and directly pay facilities for eligible persons.

Sources:

Canadian Institute for Health Information, National Prescription Drug Utilization Information System Database - Plan Information Document, July 14, 2017. Ottawa, ON: CIHI; 2017.

Shaw, Jodi L., and Judy W. Farmer, An Environmental Scan of publicly financed dental care in Canada: 2015 Update. Report prepared for the Public Health Agency of Canada, 2015.

Unlike Canada's single payer system which only applies to physician office visits, hospital procedures, and attendant laboratory tests, Medicaid extends coverage for prescription drugs, assisted living, dental and vision health care services. In Canada, each province creates and administers its own suite of coverage for these health services.

III. A comparison of populations between Canada and the United States

The populations of Canada and the United States have a similar urban/rural distribution with approximately 80 percent living in urban areas. Canada's large urban areas are centered around Toronto (with 5.4 million persons), Montreal (with 3.5 million persons), Vancouver (with 2.2 million persons) Calgary (with 1.2 million persons), Edmonton and Ottawa (each with 1.0 million persons).[18]

But Canada has an older population than the U.S, and because of universal health care coverage, a far smaller portion of its population lacks health care coverage as table two shows. If anything, an older population should mean higher health care costs per-capita, rather than Canada's lower health care cost per capita, because it is axiomatic in health care that older persons consume more health care than younger persons. Canadians also live on average three-years longer than do persons in the U.S., as seen in table three.

Table 2. Age profile of Canada and the United States and number of uninsured in 2017.

Country	Number of People	Age Distribution (1) (2)				Number Uninsured	Percent Uninsured (3)
		0-19 years	20-39 years	40-64 years	65+ years		
Canada	36,543,321	21.9%	27.1%	34.3%	16.8%	~360,000	1.0%
United States	325,147,121	25.2%	27.2%	31.9%	15.6%	28,287,800	8.7%

Sources:
(1)U.S. age distribution from U.S. Census Bureau.
U.S. Census Bureau, 2013, 2016, and 2017 1-Year American Community Surveys.
(2)Canadian age profile from https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501.
(3)Canada uninsured rate from www.health4all.ca/get-the-facts/canadas-uninsured.html.

Table 3. Percent of population with healthcare coverage, life expectancy, and age adjusted death rate for Canada and the U.S., 2017.

Country	% of population with healthcare coverage (1)	Female life expectancy at birth (2)	Male life expectancy at birth (2)	Age adjusted deaths per 100,000 persons (3)(4)
Canada	99.0%	84.0	79.9	668
United States	91.3%	81.1	76.1	732

Sources:
(1) Canada insured rate from www.health4all.ca/get-the-facts/canadas-uninsured.html and U.S. insured rate from U.S. Census Bureau, 2013, 2016, and 2017 1-Year American Community Surveys.
(2) Canada data from Canadian Vital Statistics, Death Database and Demography Division, Statistics Canada and U.S. data from Centers for Disease Control and Prevention, National Center for Health Statistics, Division of Analysis and Epidemiology.
(3) Canada age adjusted death data from Statistics Canada table 13-10-0800-01 titled "Deaths and mortality rate (age standardization using 2011 population), by selected grouped causes".
(4) U.S. age adjusted death data from National Vital Statistics Reports, Vol. 68, No. 9, June 24, 2019.

IV. A comparison of hospitals and physicians between Canada and the United States

Hospitals

Canadians more often wait for elective medical procedures in Canada (Table 4b, bottom panel), despite the two countries having similar ratios of persons-per-hospital bed, 386 in Canada and 398 in the U.S.

[18] https://www.worldatlas.com/articles/biggest-cities-in-canada.html

This might be the result of a slightly lower inpatient admission per hospital bed in Canada at 36 versus 41 combined with a much longer average length of stay in Canada at 7.4 days versus 4.6 in the U.S. Thus each hospital bed in Canada was used for 266 days while in the U.S. 188 days (Table 4a). Table 4a compares hospitals on bed composition, utilization, and non-financial capex between the two countries. One important contrast is the percentage of total hospital beds that are in teaching hospitals. More than one-half of hospital beds in the U.S. are in teaching hospitals, but less than one-third of hospitals in Canada are teaching hospitals. This is important because as we show on table 5, non-profit and governmental teaching hospitals, the great majority of all teaching hospitals, also have the largest amounts of non-financial capex**.** *A central finding of this research is that payments in North Carolina for common hospital inpatient procedures increase with the amount of non-financial capital investment of hospitals.* (See table 6c, column 3.)

Table 4a. Comparison of persons per bed, number of teaching beds, hospital utilization, and non-financial capex in Canada and the United States, 2017.

Country	Persons Per Bed (1)(2)	Inpatient Admissions Per Hospital Bed (2)(3)	Number of Beds in Teaching Hospitals* (2)(3)	Teaching Beds as a Percent of Total Beds* (2)(3)	Hospital Bed Utilization Rate** (3)	Inpatient Procedure Average Length of Stay (days) (5)	Average Non-financial CapEx Per Hospital (millions of $USD) (2)(3)(6)
Canada	386	36	22,755	31.1%	87.7%	7.4	$73
United States	398	41	447,078	54.7%	58.5%	4.6	$160

* Refers to Staffed Teaching Beds, which can include Acute Care, Long-Term Care, Rehabilitation, Mental Health Care Beds.
**Weighted average across individual hospitals for which utilization rates were available in the Canadian provinces and U.S. states. Only acute care beds were included in DEG calculations of hospital bed utilization in the United States (rehabilitation, psychiatric, and long-term care beds were not) to match Canada's statistical calculations.

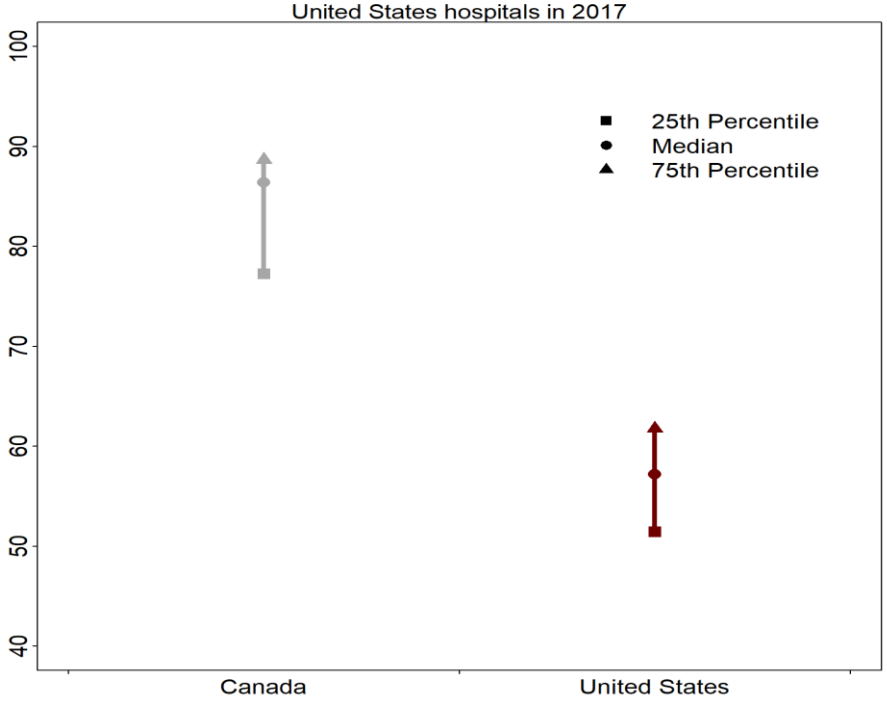
Notes: For Canada, Quebec and Nunavut are only included in the Average Length of Stay estimate. The Average Length of Stay Estimate is for inpatient procedures, calculated as the total number of inpatient days utilized divided by the number of inpatient cases (Canada) or as the average across all inpatient procedures of the number of days a patient stayed in the hospital (discharge date-admission date).

Sources:
(1) Canada Population Statistics from Statistics Canada's Annual Population estimates on July 1st, by age and sex (Table 17-10-0005-01) and U.S. Population estimates from the U.S. Census Bureau, Population Division's Annual Estimate of the Resident Population, April 1, 2010 to July 1, 2018.
(2) Canada Teaching Hospital and Staffed Bed Statistics from Canadian Institute for Health Information's Beds Staffed and In Operation: Breakdown by care setting, 2017-2018. Canadian Inpatient Admissions from Canadian Institute for Health Information's Hospital MIS Statistics, 2017.
(3) U.S. Inpatient Admissions, Teaching Hospital, and Staffed Bed Statistics from the Center for Medicare Statistics (CMS) Medicare Cost Report 2017, downloaded from the NBER.
(4) Canada Bed Utilization Rate from Canadian Institute for Health Information's Your Health System: In Depth, FY2017 data, and U.S. Bed Utilization Rates from Definitive Healthcare's calculations based on 2017 Medicare Cost Reports.
(5) Canada Inpatient Hospitalization Length of Stay data from Canadian Institute for Health Information's Inpatient Hospitalizations: Volumes, Length of Stay and Standardized Rates Report, FY2017-2018 and U.S. Inpatient Hospitalization Length of Stay data from the AHRQ HCUPnet, 2016 national data.
(6) Hospitals with the largest non-financial investment are also teaching hospitals. Canada CapEx Data from Canadian Institute for Health Information's Trends in Hospital Expenditure, 2017-2018 data (Tables A.1.1 - A.12.1) and U.S. Capital Expenditure Data from the Center for Medicare Statistics (CMS) Medicare Cost Report 2017, downloaded from the NBER.

While table 4a shows the weighted average acute care hospital bed utilization rate for Canada and the United States, Chart 1 below depicts a range chart for the same measure, displaying the median as well as the 25th and 75th percentiles. There is no overlap in the ranges for the two countries, with Canada's

provinces having demonstrably higher rates of hospital bed utilization than U.S. states. However, we have not explored this relationship or why Canada's average length of stay for inpatient procedures is almost 3 days longer than that of the U.S. It may be attributable to case-mix, for example, if their older population results in longer hospital stays.

Chart 1. Utilization rate of hospital beds in Canadian and United States hospitals in 2017



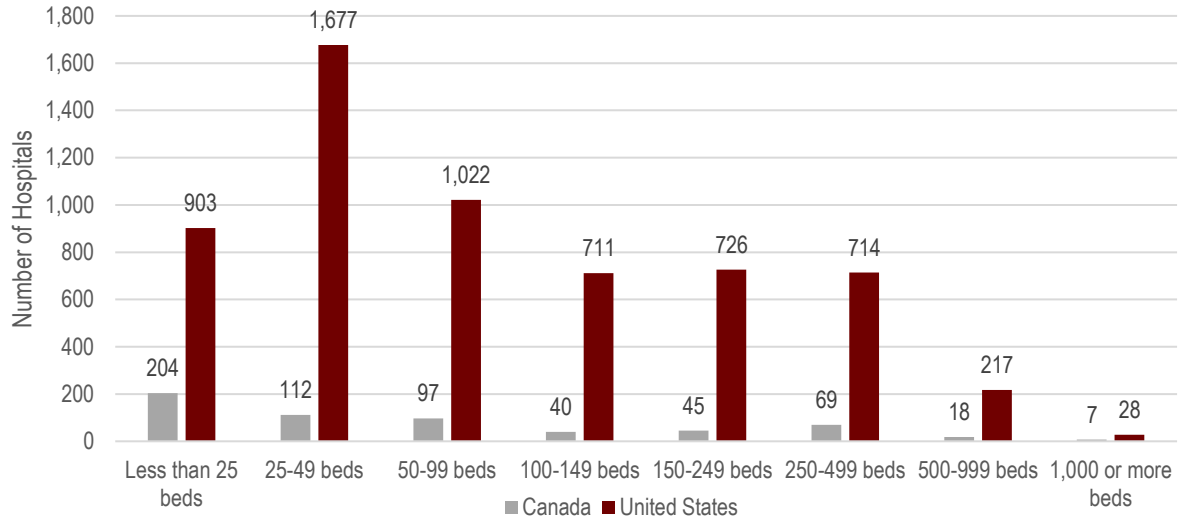
Sources: Canada Bed Utilization Rate from Canadian Institute for Health Information's Your Health System: In Depth, FY2017 data, and U.S. Bed Utilization Rates from Definitive Healthcare's calculations based on 2017 Medicare Cost Reports.

Charts 2a and 2b compare the distribution of hospitals by size and percentage of all hospitals between Canada and the U.S. Because Canada has one-tenth the population of the United States but roughly the same land area, it is not clear that the two countries should have similar distributions of hospital size even though the similar urbanization of the populations, at 80 percent, might suggest that. Given Canada's legal requirement to provide universal health care coverage we ought to expect a greater percentage of small hospitals in Canada to fulfill that law (Chart 2b). However, we do not have an explanation for why Canada has a greater proportion of very large hospitals with over 1,000 beds. It might be due to greater centralized planning of health care facilities as a result of provincial government health care budgets, which provide 70 percent of hospital capital investment funds compared with only 20 percent for the U.S. through federal and state budgets.[19] [20] Further analysis would be needed to explain the differences in size of hospital distribution.

[19] Canadian Institute for Health Information. *National Health Expenditure Trends. 1975 to 2018*. Ottawa, ON: CIHI; 2018

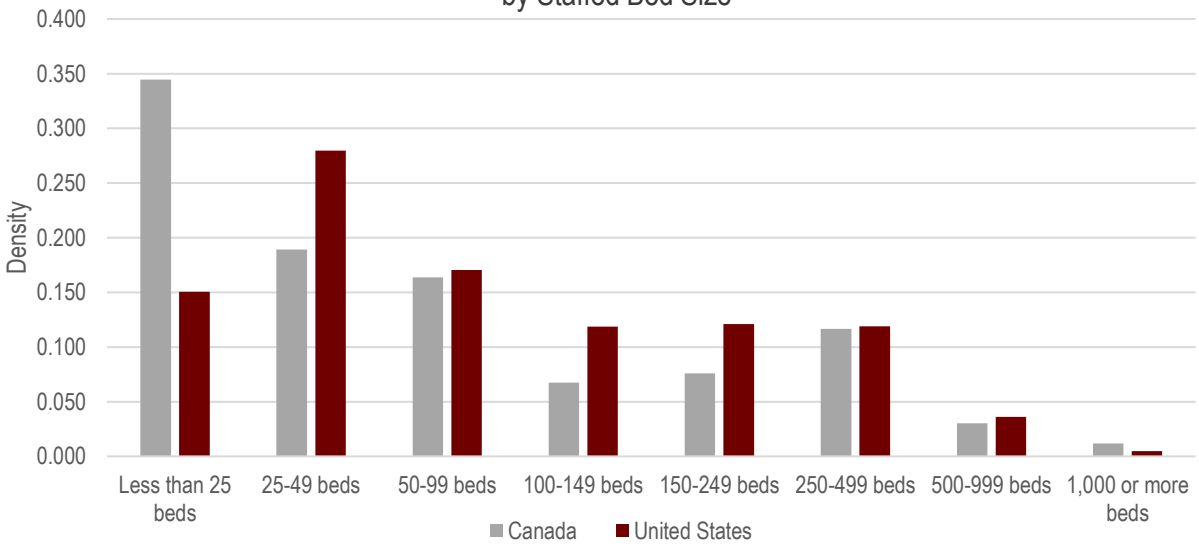
[20] Table 19, National Health Expenditures by Type of Expenditure and Program: Calendar Year 2015.

Chart 2a. Number of Hospitals in Canada (grey) and the United States (maroon) by Staffed Bed Size



Note: United States data is from 2017 and Canada data is from 2018.
Source: Canada Teaching Hospital and Staffed Bed Statistics from Canadian Institute for Health Information's Beds Staffed and In Operation: Breakdown by care setting, 2017-2018 and U.S. Teaching Hospital and Staffed Bed Statistics from the CMS Medicare Cost Report 2017, downloaded from the National Bureau of Economic Research.

Chart 2b. Distribution of Hospitals in Canada (grey) and the United States (maroon) by Staffed Bed Size



Note: United States data is from 2017 and Canada data is from 2018.
Source: Canada Teaching Hospital and Staffed Bed Statistics from Canadian Institute for Health Information's Beds Staffed and In Operation: Breakdown by care setting, 2017-2018 and U.S. Teaching Hospital and Staffed Bed Statistics from the CMS Medicare Cost Report 2017, downloaded from the National Bureau of Economic Research.

Physicians

Table 4b below shows the concentration of physicians, utilization rates per 100 persons for all physicians and major types of specialties, and survey data on physician access in the U.S. and Canada. Canada's single-payer system is often criticized for restricting access to timely care but, as the survey data in the bottom panel shows, it is mostly caused by limited access to specialist physicians. In fact, under universal coverage*, Canadians visit physicians' 40 percent more frequently than persons in the United States as 390 visits per 1,000 persons versus 278 visits per 1,000 persons in the United States.*

One of the biggest contrasts between Canada and the U.S. health care systems is the mix of general practice physicians to specialist physicians. *Canada has far more general practice physicians for its population than does the U.S., but the U.S. has far more specialist physicians than Canada (see Chart 3).* Access to a physician within one day or a week is similar although persons in the U.S. have slightly greater access. The challenge in Canada is access to specialist physicians, with only 38 percent in Canada being able to see a specialist in less than one month compared with almost 70 percent in the U.S. and similar proportions being able to schedule an elective surgery within one month. Despite faster access to specialists and elective procedures in the U.S., 19 percent of U.S. respondents have difficulties paying for health care versus only 6.6 percent for Canadians.

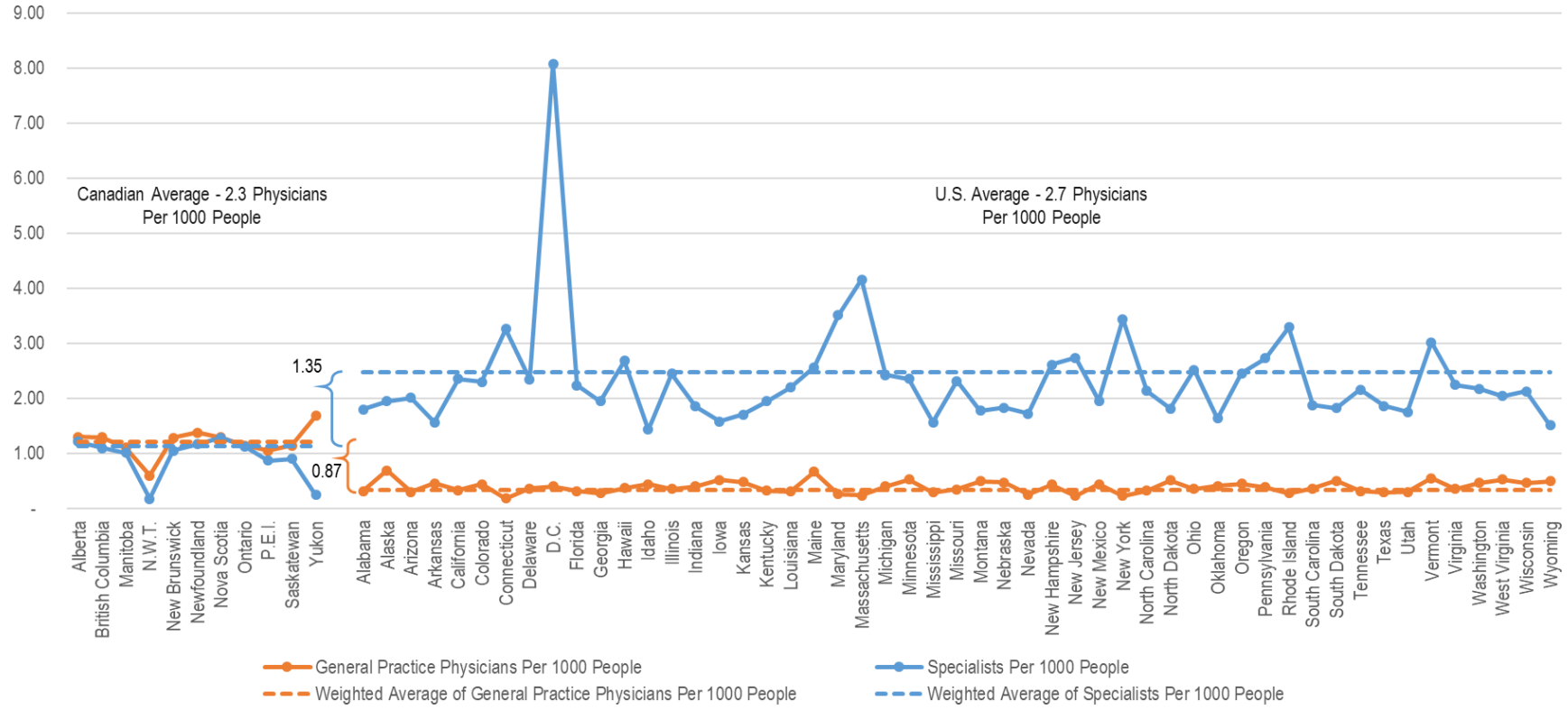
Table 4b. Persons per general practice physician and specialist (Panel 1), physician utilization measured by the number of office visits (U.S.) or consultations and office visits (Canada) per 100 persons (Panel 2), and access statistics (Panel 3), 2017.

Persons per Physician	United States	Canada
Persons Per General Practice Physician (1)(2)	2,892	830
Persons Per Specialist (1)(2)	425	889
Number of Office Visits Type of physician	**United States (3)**	**Canada (4)**
All physicians	278	390
General and family practice	64	336
Pediatrics (per 100 persons under age of 18)	173	83
Obstetrics and gynecology	55	17
Internal medicine	26	62
Dermatology	16	8
Ophthalmology	15	19
Orthopedic surgery	10	10
Psychiatry	9	33
Otolaryngology	9	8
Cardiovascular diseases	9	10
Urology	8	7
General surgery	5	13
Neurology	5	5
Access Statistics	**United States**	**Canada**
% of individuals able to see doctor same or next day (5)	54.7%	45.8%
% of individuals able to see a doctor within a week (5)	72.4%	68.6%
% of individuals able to see a specialist in less than 4 weeks (5)	69.9%	38.0%
% of individuals able to have elective surgery within a month (5)	61.0%	34.8%
% of individuals not seeing doctor because of cost (5)(6)	19.0%	6.6%

Sources:

(1) U.S. Population estimates from the U.S. Census Bureau, Population Division's Annual Estimate of the Resident Population, April 1, 2010 to July 1, 2018: 2017 Population Estimates, and U.S. Physician Statistics from The Association of American Medical Colleges' State Physician Workforce Data Report: 2017 State Profiles.
(2) Canada Population Statistics from Statistics Canada's Annual Population estimates on July 1st, by age and sex (Table 17-10-0005-01) and Canada Physician Statistics from CIHI's Scott's Medical Database, 2017 (Table 1).
(3) National Ambulatory Medical Care Survey: 2016 Summary Tables, Table 1. Physician office visits, by selected characteristics: US, 2016.
(4) National Physician Database Historical Utilization, Canadian CIHI, 2017. Count is of total consultations and visits.
(5) 2016 Common Wealth Fund's International Health Policy Survey of Adults.
(6) DEG tabulations of 2017 Federal Reserve's "Survey of Household Economics and Decisionmaking" data.

Chart 3. General Practice Phyisicans Per 1000 People and Specialists Per 1000 People in Canada in 2017 (left) and the United States at the Beginning of 2017 (right) with Weighted Averages*



Sources: Canada - Supply, Distribution and Migration of Phyisicans in Canada, 2017 data set from the Canadian Institute for Health Information; United States - State Physician Workforce Data Report: 2017 State Profiles from The Association of American Medical Colleges.
* Weighted by the proportion of physicians in each province and state

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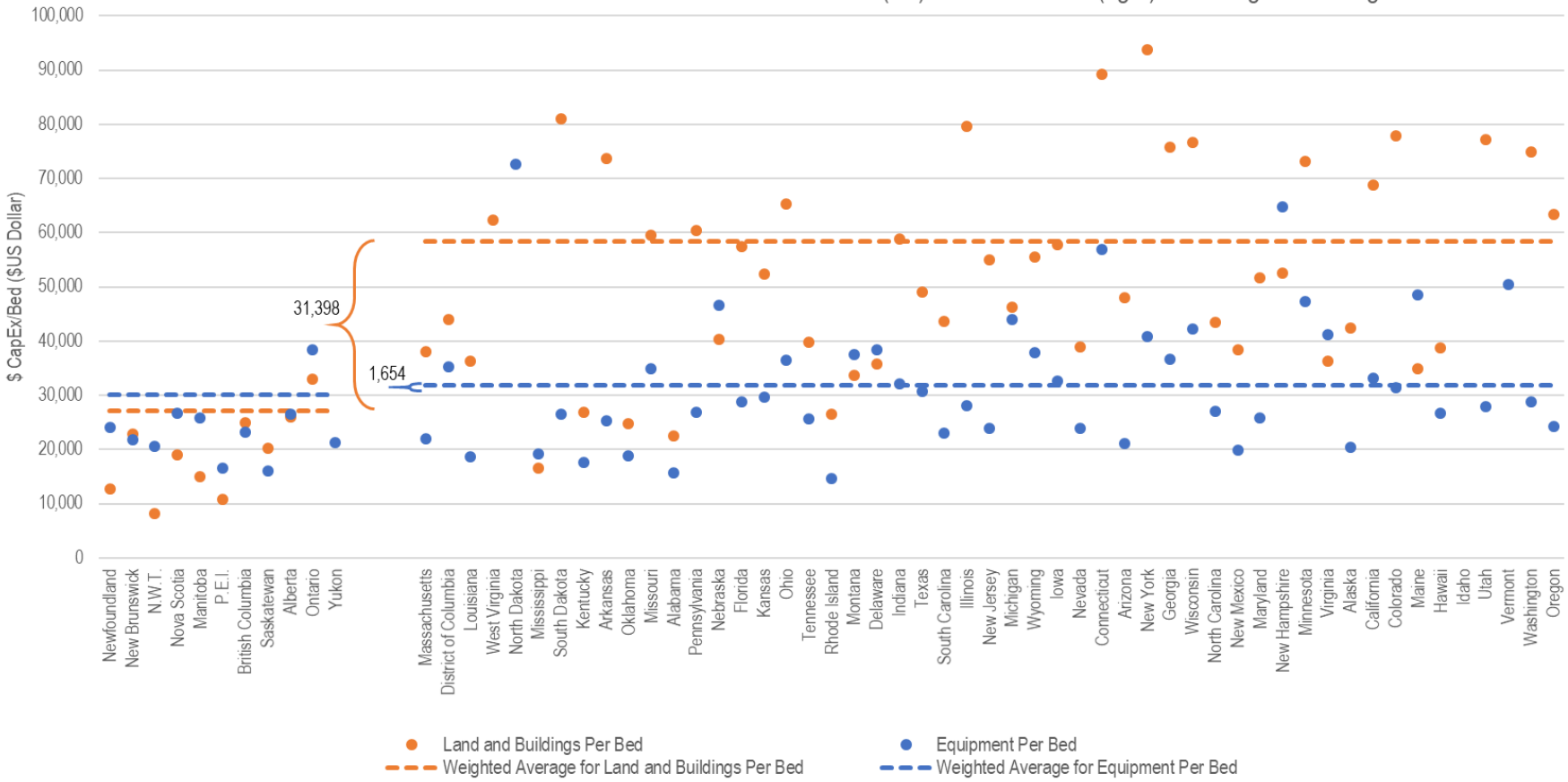
Canada and U.S. hospital non-financial capex

Considering the variation in the distribution of hospital sizes between Canada and the U.S., with Canada having proportionately more very small hospitals with fewer than 25 beds and more very large hospitals with greater than 1,000 beds, and considering the disparity in government funding for hospital capital expenditures – 70 percent in Canada versus 20 percent in the U.S. – it may come as a bit of surprise that during 2017 *capital expenditures on equipment and moveable fixtures within hospitals are nearly the same between the two countries*, as the blue line on chart 4 below shows. When it comes to investing in medical equipment, Canadian hospitals are no different than U.S. hospitals.

However, as the orange line on chart 4 clearly shows, *when it comes to capital investment in land and buildings, Canadian hospitals spent far less in 2017 than U.S. hospitals*. We do not have a good explanation for this. It may be that land and construction costs are much greater in the U.S. It may also be related to the source of funds. As table 4a shows, total investment in land, buildings, and equipment per hospital is, on average, more than twice as large in the U.S. than in Canada. Upwards of 80 percent of capital investment in U.S. hospitals is from private sources whereas for Canada only 30 percent of capital investment is from private sources.[21] It may be that privately sourced funding comes at the price of naming rights whereas funding from public sources would not and that this could drive over investment in buildings in the U.S. Whatever the explanation may be for this disparity between Canadian and U.S. investment in land and buildings, we find that the large size of investment in land and buildings is positively correlated with payments to hospitals for inpatient procedures in the U.S. (table 6c).

[21] Micah Hartman, Anne B. Martin, Joseph Benson, Aaron Catlin and the National Health Expenditure Accounts Team, *National Health Care Spending in 2018: Growth Driven by Acceleration in Medicare and Private Insurance Spending (Exhibit 2),* Health Affairs 39, No. 1 (2020). Canadian Institute for Health Information, *National Health Expenditure Trends, 1975 to 2019*: Data Tables – Series C, Ottawa, ON: CIHI; 2019.

Chart 4. Capital Expenditures in 2017 in U.S. Dollars for Equipment Purchases Per Staffed Bed and Land and Buildings Purchases Per Staffed Bed in Medical Facilities in Canadian Provinces (left) and U.S. States (right) with Weighted Averages*



Sources: Canada - Canadian MIS Database, 2005 to 2017, Canadian Institute for Health Information. Demography Division, Statistics Canada. United States - CMS Medicare Cost Report 2017, downloaded from NBER.

* Weighted by the proportion of capital expenditures in each province and state.

Finally, we examine whether non-financial capex per bed of a hospital differs among non-profit, governmental, or for-profit hospitals in the United States. In the CMS Medicare data on hospitals, governmental hospitals include the Veterans Administration hospitals and many state university hospitals that are considered part of a state government.[22] We test the hypothesis that non-profit hospitals have the same amount of non-financial capex per bed as governmental hospitals and as for-profit hospitals. This hypothesis is tested separately for whether hospitals are urban, rural, teaching or non-teaching. We then repeat these same tests for governmental hospitals with respect to for-profit hospitals.

For each comparison between the non-financial capex per bed in one type of hospital with another, we use a chi-square test and compute the t-statistic for the hypothesis that the non-financial capex per hospital bed is the same between the two types of hospitals. If the t-statistic is far enough away from 0, then we can reject this hypothesis. We further test whether one type of hospital has a larger non-financial capex per bed than another type using the same chi-square method.

Each cell in table 5 below denotes a chi-square test. For example, the upper left-most cell of the table tests the hypothesis that the non-financial capex per bed in non-profit rural teaching hospitals was the same as in non-profit rural non-teaching hospitals. Because the t-statistic is 2.2, we can reject the hypothesis that they are the same. This test compares the non-financial capex per bed in 138 non-profit rural teaching hospitals with the 1,064 non-profit rural non-teaching hospitals in the CMS data set. This cell is highlighted in red to identify that the group of 138 hospitals in the column (the non-profit rural teaching) had greater non-financial capex per bed than the group of 1,064 hospitals in the row (the non-profit rural non-teaching).

Some intuition about these comparisons might help. We might expect that the non-financial capital investment in urban hospitals would be greater than in rural hospitals because of the greater value of land. However, it might be that newer hospitals are more likely located in rural areas and capex per bed would be greater only as a result of more recent construction. We also expect that teaching hospitals might have greater total capital investment per bed than non-teaching hospitals because of the importance of exposing medical interns to a wider range of medical equipment. However, as far as the practice of medicine is concerned, we expect there to be no difference between non-profit, governmental, or for-profit hospitals when they are of the same type such as urban/rural or teaching/non-teaching. This is because the activity of providing health care should not depend upon whether a hospital is non-profit, governmental, or for-profit. This hypothesis does rely upon the assumption that the case mix of health care activities is similar between these hospital types.[23] As we expected urban hospitals have greater non-financial capex per bed than rural hospitals, and teaching hospitals have greater non-financial capex per bed than non-teaching hospitals. However, we find statistically significant differences in non-financial capex per bed depending upon whether a hospital is a non-profit or governmental compared to a for-profit. For-profit hospitals appear to have lower amounts of non-financial capex per bed consistently across all types.

Our key findings on table 5 are:

[22] CMS Medicare Hospital Cost Report 2017. Downloaded from the National Bureau of Economic Research.
[23] We did not test this case mix hypothesis between the different types of hospitals. This would be a useful topic for further analyses.

- Non-profit teaching hospitals and governmental teaching hospitals have similar amounts of non-financial capex per bed (columns 1 and 2 versus rows 7 and 8)
    - and both have greater amounts of non-financial capex per bed than for-profit teaching hospitals. (columns 1 and 2, and 5 and 6, versus bottom two rows)
- Non-profit teaching hospitals have greater non-financial capex per bed than non-profit non-teaching hospitals regardless of urban or rural setting. (columns 1 and 2 versus rows 1 and 2)
- *Non-profit hospitals, regardless of teaching or non-teaching, have greater non-financial capex per bed than any for-profit hospitals. (columns 1 through 4 versus bottom 4 rows)*
- Governmental hospitals, regardless of teaching or non-teaching, have greater non-financial capex per bed than for-profit hospitals except for the one comparison between governmental non-teaching urban hospitals and for-profit teaching urban hospitals, which have similar capital per bed. (columns 5 through 8 versus bottom 4 rows)
- Urban hospitals *do not always* have greater non-financial capex per bed than rural hospitals because for-profit urban hospitals have lower capital per bed than non-profit rural hospitals or than governmental rural hospitals. (columns 10 and 12 versus rows 1, 3, 5, and 7)

As a first impression it does not make sense to us that for-profit hospitals would be under-capitalized because that would indicate that they are not maximizing profits. If for-profit hospitals have the proper amount of capital stock per bed, then both non-profit and governmental hospitals would appear to be over-capitalized. Alternatively, it could be that non-profit and governmental hospitals are providing different health care services than are for-profit hospitals, and a different health care services mix could explain why the levels of capital are lower in for-profits. We did not examine this issue in greater detail.

However, the non-financial capex of a hospital is related to the amount of payment that a hospital receives for inpatient procedures. We consistently find that payments by Medicare and by commercial insurers for inpatient procedures increase with the size of hospital capital. We consistently find that payments by Medicaid do not (Table 6c).

Table 5. Non-profit hospitals have higher capital expenditures per bed, on average, than governmental and for-profit hospitals in the United States. [based upon 5,807 hospitals*] (Orange denotes column category signifcantly greater than row category and Blue denotes row category significantly greater than column category in average capital expenditure per bed; if cell is not colored, the difference between the categories in the row and column is not significant.)

Average CapEx per bed in non-profit and governmental hospitals is almost always significantly greater than average CapEx per bed in for-profit hospitals.			Non-profit				Governmental				For-profit			
			Teaching (n=926)		Non-teaching (n=1998)		Teaching (n=177)		Non-teaching (n=960)		Teaching (n=216)		Non-teaching (n=1530)	
			Rural (n=138)	Urban (n=788)	Rural (n=1064)	Urban (n=934)	Rural (n=19)	Urban (n=158)	Rural (n=719)	Urban (n=241)	Rural (n=14)	Urban (n=202)	Rural (n=272)	Urban (n=1258)
Non-profit	Non-teaching (n=1998)	Rural (n=1064)	t = 2.20 df = 292	t = 3.69 df = 1263	-	t = 1.65 df = 1800	t = 0.97 df = 19	t = 2.99 df = 211	t = 3.78 df = 1760	t = 0.62 df = 244	t = 4.60 df = 15	t = 9.04 df = 648	t = 16.46 df = 1222	t = 20.63 df = 1385
		Urban (n=934)	t = 3.38 df = 416	t = 4.64 df = 1494	t = 1.65 df = 1800	-	t = 1.49 df = 20	t = 3.82 df = 254	t = 1.51 df = 1577	t = 0.86 df = 246	t = 3.68 df=17.70	t = 6.16 df = 880	t = 11.68 df = 1203	t = 14.21 df = 1099
	Teaching (n=926)	Rural (n=138)	-	t = 1.62 df = 627	t = 2.20 df = 292	t = 3.38 df = 416	t = 0.20 df = 21	t = 1.43 df = 248	t = 5.27 df = 262	t = 0.26 df = 248	t = 5.50 df = 18	t = 9.51 df = 265	t = 14.94 df = 202	t = 17.43 df = 157
		Urban (n=788)	t = 1.62 df = 627	-	t = 3.69 df = 1263	t = 4.64 df = 1494	t = 0.51 df = 23	t = 0.13 df = 346	t = 6.31 df = 1165	t = 0.073 df = 253	t = 6.27 df = 22	t = 9.95 df = 975	t = 14.37 df = 976	t = 16.22 df = 862
Governmental	Non-teaching (n=960)	Rural (n=719)	t = 5.27 df = 262	t = 6.31 df = 1165	t = 3.78 df = 1760	t = 1.51 df = 1577	t = 2.00 df = 19	t = 4.97 df = 202	-	t = 1.09 df = 243	t = 3.10 df = 15	t = 5.70 df = 547	t = 12.97 df = 950	t = 17.08 df = 984
		Urban (n=241)	t = 0.26 df = 248	t = 0.073 df = 253	t = 0.62 df = 244	t = 0.86 df = 246	t = 0.16 df = 224	t = 0.106 df = 264	t = 1.09 df = 243	-	t = 1.95 df = 248	t = 1.80 df = 244	t = 2.45 df = 241	t = 2.65 df = 240
	Teaching (n=177)	Rural (n=19)	t = 0.20 df = 21	t = 0.51 df = 23	t = 0.97 df = 19	t = 1.49 df = 20	-	t = 0.56 df = 28	t = 2.00 df = 19	t = 0.16 df = 224	t = 3.47 df = 29	t = 2.56 df = 19	t = 5.02 df = 18	t = 5.49 df = 18.22
		Urban (n=158)	t = 1.43 df = 248	t = 0.13 df = 346	t = 2.99 df = 211	t = 3.82 df = 254	t = 0.56 df = 28	-	t = 4.97 df = 202	t = 0.106 df = 264	t = 5.79 df = 32	t = 7.82 df = 211	t = 10.91 df = 182	t = 12.04 df = 164
For-profit	Non-teaching (n=1530)	Rural (n=272)	t = 14.94 df = 202	t = 14.37 df = 976	t = 16.46 df = 1222	t = 11.68 df = 1203	t = 5.02 df = 18	t = 10.91 df = 182	t = 12.97 df = 950	t = 2.45 df = 241	t = 1.39 df = 14	t = 5.67 df = 367	-	t = 2.68 df = 460
		Urban (n=1258)	t = 17.43 df = 157	t = 16.22 df = 862	t = 20.63 df = 1385	t = 14.21 df = 1099	t = 5.49 df = 18.22	t = 12.04 df = 164	t = 17.08 df = 984	t = 2.65 df = 240	t = 2.07 df = 13	t = 8.31 df = 262	t = 2.68 df = 460	-
	Teaching (n=216)	Rural (n=14)	t = 5.50 df = 18	t = 6.27 df = 22	t = 4.60 df = 15	t = 3.68 df = 17.70	t = 3.47 df = 29	t = 5.79 df = 32	t = 3.10 df = 15	t = 1.95 df = 248	-	t = 0.74 df = 15	t = 1.39 df = 14	t = 2.07 df = 13
		Urban (n=202)	t = 9.51 df = 265	t = 9.95 df = 975	t = 9.04 df = 648	t = 6.16 df = 880	t = 2.56 df = 19	t = 7.82 df = 211	t = 5.70 df = 547	t = 1.80 df = 244	t = 0.74 df = 15	-	t = 5.67 df = 367	t = 8.31 df = 262

* Certain hospitals from the CMS Medicare Cost Report 2017 data were excluded because they did not provide capital expenditure data.

Note: A t-statistic = 1.95 means that the difference in capital expenditure per bed is significant at the 94.8% level of signficant, and a t-statistic = 2.56 is significant at the 99.8% level, and a t-statistic > 3 is signficant at levels greater than 99.8% .

Source: Center for Medicare Statistics (CMS) Medicare Cost Report 2017, aggregated from individual hospitals up to the ownership levels. Downloaded from the National Bureau of Economic Research.

V. A comparison of average payments for 19 high volume hospital inpatient procedures by type of payer between Canada and the United States.

Table 6a below compares amounts paid to hospitals for 19 hospital inpatient procedures in Canada under the Canada Health Act, in the United States under Medicare, in North Carolina under Medicare and by commercial insurance companies. The 19 procedures had the highest patient volumes for hospital inpatient procedures performed across Canada in 2017. Table 6e lists the 19 procedures, the CMG codes and inpatient volumes which accounted for approximately 27 percent of all hospital inpatient procedures and 22 percent of payments for inpatient procedures in 2017.

Hospital inpatient procedure payments and the units of observation – provinces, states, and hospitals

Hospital inpatient procedure codes are classified under Case Mix Group (CMG) codes created by the Canadian Institute for Health (CIHI) to group patients with similar clinical and resource-utilization characteristics.[24] Diagnosis related group (DRG) codes are used in the U.S. to group hospital patients with similar diagnoses and resources needed for care.[25] Canadian CMG codes are similar to U.S. DRG codes with a key difference that the CMG codes used in this analysis include a wider range of patient complexity and hospital resources used in treatment.[26] The CIHI reports the number of procedures and the average procedure payment for each CMG code in each province and territory while the North Carolina Department of Health and Human Services reports the average procedure payment separately for each of the five highest frequency commercial insurers for each DRG code in each hospital. Most hospitals in North Carolina report between one and three commercial insurer average payments.

Both CMG and DRG codes use resource allocation rules to apportion hospital overhead components such as utilities, maintenance, nursing staff, and administrative staff across hospital procedures whether inpatient or out-patient. We did not compare these allocation rules to determine whether Canadian hospitals allocate more or less of hospital administrative and overhead costs to CMG codes than U.S. hospitals do for DRG codes. We did augment Canada CMG payment amounts for investment in land and buildings, as discussed below.

CMG codes, DRG codes and medical complexity

There are distinct DRG codes for the same procedure because of varying levels of complexity. For example, DRG code 190 is for chronic obstructive pulmonary disease *with complications*, and DRG code 192 is for chronic obstructive pulmonary disease *without complications*. The Canada CMG code 139 for chronic obstructive pulmonary disease includes both procedures with complications and procedures without complications. In this analysis, the DRG code 192 for chronic obstructive pulmonary disease without complications is compared with CMG code 139 that includes procedures with and without complications or co-morbidity.

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[24] https://www.cihi.ca/en/cmg

[25] https://info.ncdhhs.gov/dhsr/ahc/hb834/search.asp . Diagnosis Related Group codes were created by Robert Barclay Fetter and John D. Thompson, at Yale University, in the early 1970's.

[26] Donald A. Redelmeier and Victor R. Fuchs, in "*Hospital Expenditures in the United States and Canada*" The New England Journal of Medicine, March 18, 1993, observed after reviewing physician coding of pairs of CMG and DRG codes in two U.S. and two Canadian hospitals that there was a strong consistency between how physicians in Canada and in the United States coded patient conditions.

Because CMG codes include inpatient cases without complications, with complications, and with co-morbidity while the DRG codes used are only for inpatient cases without complications, *the estimates of average payment by DRG procedure code and type of payer shown in table 6a have a downward bias for Medicare, Medicaid, and commercial insurance payments when compared with Canadian procedure payments. This is deliberate to understate the cost differential between Canada and the U.S. for these procedures.*

In table 6f we explore this issue of downward bias in our estimates of procedure payments that may result from limiting our analysis to DRG codes that do not have complications. We examine the effect of inpatient procedure complexity for two procedures in North Carolina hospitals: chronic obstructive pulmonary disease without complications, DRG 192, versus with complications, DRG 190, and heart failure and shock without complications, DRG 293, versus with complications, DRG 292. For both COPD and heart failure, we find, as expected, that payments increase for all payers – Medicaid, Medicare, and commercial insurers. The bias is significant with Medicare payments increasing by 50 percent and commercial insurer payments increasing by almost 90 percent (Table 6f column "Increase with complications"). However, payments increase the least when Medicaid is paying, next when Medicare is paying, and the most when commercial insurers are paying. While table 6f does not show an exhaustive review of all 19 inpatient procedures and the impact of diagnosis complexity on payments, it lends some support to the view that the difference between payments to Canadian hospitals versus U.S. and North Carolina hospitals for similar procedures shown in table 6a is likely understated.

Cost components in CMG and DRG codes

Canadian CMG code data is publicly available through the CIHI Patient Cost Estimator (PCE) web portal.[27] When providing CMG procedure payment data for each of the provinces and territories, CIHI removes a portion of the payment amounts that would be attributable to capital expenditures associated with land and buildings. This adjustment is made to avoid imparting an upward bias to procedure payments solely because a hospital is newer, and capital expenditures for land and buildings greater.[28] The U.S. data DRG code whether from CMS for Medicare or from the North Carolina Department of Health and Human Services for commercial payments to hospitals does not make an adjustment for the cost component of a procedure that may be attributable to capital expenditures for land and buildings.

We calculated an adjustment to each of the Canadian procedure codes to roughly account for capital expenditures in land and buildings with a top-down approach. First, we allocated provincial investment in land and buildings for hospitals between total inpatient and outpatient revenues. Next, we calculated an annual payment on the amount of the allocated capital for building and land to inpatient procedures by assuming that the investment was *debt financed* over a 25-year period at a rate of 5 percent. This procedure added, on average between 2 and 4 percent to each average procedure payment depending upon the province.

[27] https://info.ncdhhs.gov/dhsr/ahc/hb834/search.asp

[28] This very same issue of cost-push price inflation was identified as contributing to rising hospital payments by payers in an analysis of hospital costs in Colorado. See "Cost Shift Analysis Report", Colorado Healthcare Affordability & Sustainability Enterprise, January 2019.

A caveat

It is likely that the resulting upward adjustment to procedure payments overstates the cost component of capital investment in land and buildings in Canada because *most of this investment would not be financed as it was paid through appropriations in the annual budgets of provincial and federal governments*. For Canadian hospitals the ratio of operating revenue (revenues for patient services mostly) to long-term debt is often greater than 10:1 whereas for U.S. hospitals it is often less than 2:1. Canadian governments had modest fiscal deficits during fiscal year 2017 with the federal government deficit at 0.9 percent of GDP, the largest provincial deficit was for Alberta at 2.4 percent of its GDP and four provinces, Prince Edward, Quebec, British Columbia, and New Brunswick, had fiscal surpluses.[29] However, it is likely that this upward adjustment to Canada inpatient procedure payments does not accurately measure the variation in capital expenditure on land and buildings at the hospital level, and as a result, does not gauge how variation in investment explains payments. It does, however, provide an improved estimate of provincial level procedure payments, which is how the Canada data is used in table 6a.

Payment data aggregation – two different levels of aggregation in data sets

The payment data used in this analysis is not individual case patient payment information. [30] Instead, two sources of data provide inpatient procedures by volume and average payment – Canada for provinces and CMS for states – and one source provides inpatient procedures by average payment for hospitals in North Carolina – the North Carolina Department of Health and Human Services. Canadian data are from the Canadian Institute for Health Information's Patient Cost Estimator tool for procedures by CMG code at the federal, provincial, and territorial level; the Medicare nationwide data are from the CMS annual payment by DRG procedure code data at the state and national level; and the hospital specific North Carolina data are from the Department of North Carolina Health and Human Services annual payment by DRG procedure code at the hospital level.

The Canada procedure data include the actual number of inpatient cases and the average payments to all hospitals in each province and territory and nationwide. We used the Canada nationwide patient case counts to identify the 19 most common procedures and then match the CMG codes up with DRG codes used by Medicare using the rule that only DRG codes without complications would be matched. Table 6a shows this correspondence between CMG and DRG codes used. The data for Canadian provinces and territories and the Medicare procedure data include the actual number of inpatient cases and average payments to all hospitals in a state, and nationwide. These data are shown in the first two vertical panels of table 6a.

Therefore, the variation in average amounts paid for inpatient procedures, whether using Canadian CMG codes or Medicare DRG codes is based upon geography and not the size of the capital stock or the

[29] RBC Economics, Canadian Federal and Provincial Fiscal Tables, November 27, 2019. Canadian provinces and the federal government tend to run modest annual deficits or surpluses. In total, at the end of fiscal year 2017 Canadian federal debt was 31.3 percent of GDP but provincial debt ranged widely from a high of 44.9 percent for Newfoundland and Labrador to a low of 5.8 percent for Alberta.

[30] A recent RAND Research Report by Chapin White and Christopher Whaley, "Prices Paid to Hospitals by Different Health Plans Are High Relative To Medicare and Vary Widely: Findings from an Employer Led Transparency Initiative", RAND Corporation, 2019 used almost four million individual patient records from a consortium of employers to analyze hospital payment rates for commercial insurers.

number of beds for hospitals. For example, for each CMG code, the Canada data show the average payment in British Columbia, Ontario, Prince Edward Island, or any of the other provinces or territories. For each DRG code, the Medicare data show the average payment in Illinois, Rhode Island, Alabama, or any other state. In both instances there is substantial variation across provinces and states for any procedure code. The average payment for procedures in Canada is the average full payment for that procedure because patients have no deductible or copayment. The average payment for Medicare procedures in the United States, however, is also the full payment and includes amounts paid by patients for Medicare part A deductibles of $1316 per episode in 2017. These data provide accurate estimates of the national average amounts paid by provincial governments and by Medicare for procedures and are shown on table 6a in the two leftmost bolded columns.

Table 6a shows the procedure codes (CMG or DRG), the nationwide procedure volumes (Canada or the United States), and the average payment to hospitals that performed the procedure in U.S. dollars.

A closer look at urban/rural payment variation Alberta

Geographic aggregation for both the Canada CMG payments and the Medicare payments prevents analysis of price variation between large and small hospitals within a province, state, or nationwide. This is because the many small hospitals in these provinces and states are summed together with the large hospitals. On average, payment variation for procedure payments in Canada vary between provinces by as much as 40 percent. However, the province of Alberta provides a decomposition of payments by urban and rural hospital zones, and this serves to isolate the two large hospitals that are in urban zones from the many smaller hospitals that are in the rural zone. Table 6d offers a glimpse into price variation in Alberta for 2017 based upon whether hospitals are located in the two urban zones – Calgary with a population of 1.3 million and Edmonton with a population of 1.0 million – or the remaining rural zone of the rest of Alberta. The first three rows show the average payment by procedure in Alberta in these three zones. The yellow highlighted cells identify the high-payment zone. For three of the nine procedures the rural zone had the highest payment.

The bottom two rows of table 6d show the range between the highest and lowest payment for each procedure in Alberta (row 4), and then as a comparator, among each of the 10 provinces and the Yukon territory (row 5). The comparison between the bottom two rows is informative. *First, the payment variation for procedures within Alberta is in all but one case smaller than the variation across provinces and territories*. Alberta, with the fourth largest population in Canada has 2 of the 12 largest hospitals in terms of number of beds in Canada, and these hospitals are located in the urban zones (Foothills Medical Center in Calgary and Royal Alexander Hospital in Edmonton, each with more than 1,000 beds.) If total hospital capital stock is driving procedure payment in Canada, we might expect to see wide variation in payments between Alberta's urban and rural zones, which we do not.[31]

[31] To provide some context, British Columbia, with the third largest population in Canada has only 1 of the 12 largest hospitals in Canada (Vancouver General Hospital in Vancouver), and Quebec, with the second largest population in Canada has 2 of the 12 largest hospitals (McGill University hospital and the hospital of the University of Montreal, both in Montreal).

Because the Canada Health Act prevents private insurance from paying for hospital inpatient procedures, and because provincial health care boards set procedure payments province-wide, we might expect price variation to be restrained within a province. Row 4 of table 6d supports this view. Second, price variation between provinces is also restrained for all procedures (Charts 5, 6, and 7). For most procedures, Alberta is the high-payment province (not shown) but other provinces with the highest average procedure payment include Prince Edward Island and Quebec. The largest province in Canada, Ontario, is neither the highest nor the lowest average payer for any of these procedures despite the fact that Ontario has 6 of the 12 largest hospitals in Canada in terms of number of beds.

Table 6d at least indicates that hospital capital stock may be less important in terms of procedure payments in Canada than in the U.S., but more analysis would be necessary with hospital specific payment information to confirm this view.

North Carolina hospital specific payment data – median values rather than average values

Unlike payment data for Canada and Medicare, the North Carolina Department of Health and Human Services data provides hospital specific average payments to *each* hospital for procedures.[32] For each hospital in North Carolina, the public data set shows the average payment by Medicare, Medicaid, and up to five commercial insurers (not identified by name) for each procedure by DRG code. If too few payments were made by a payer at the hospital level the entry for that payer was left blank. The North Carolina data does not provide procedure patient volumes.

While the Canada average payment data and the Medicare CMS annual data undergo substantial data cleaning and testing resulting in statistically well-behaved data entries, the North Carolina hospital payment data for Medicaid and commercial insurance appears to include a number of questionable average payment amounts – some much too high in the millions of dollars, and some much too low in the single dollars. *These average payment amounts are supplied to the North Carolina Department of Health and Human Services by Medicaid, Medicare, and commercial insurers for each hospital in the state and **are for actual payments made** to hospitals. These amounts are not based upon hospital chargemaster or cost data, which is the key reason that they are used in this analysis.*

We attempted a number of data techniques to resolve these possibly outlier observations such as trimming – or removing from analysis - extreme values, both too high and too low. However, with the large number of inpatient procedures to be examined this technique rapidly demonstrated a randomness that we could not explain. Simply, trimming observations, for example by removing observations greater than 3 times the standard deviation of observations for a procedure became too ad hoc. For example, sometimes a hospital would be included for one DRG procedure but not for another under such a trimming rule. In some cases this rule would remove two observations while for other DRG codes as many as 8 observations would be removed. Sometimes an observation for one type of payer in a hospital would be removed while other payers were not. After several rounds of outlier detection no uniform rule to trim observations across all of the DRG procedure codes presented itself.

Instead, we deployed a statistical strategy often used when a data set is suspected of being "noisy" in the sense that many observations might be incorrectly coded and not representative of the underlying

[32] North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017.

data generating process that an analysis is trying to uncover. We focus on the median values of the data, whether simply by sorting data from largest-smallest, or by applying multivariate techniques that focus on identifying the median influence of a variable such as total hospital non-financial capex. The results in table 6a for North Carolina commercial insurer payments use a least median squares algorithm that identifies the median value of the average payment for a procedure rather than average value of procedure payments. These median payment amounts are shown in the rightmost bolded column.

Analytical methods – Why Least Median Squares estimation?

Least median square (LMS) regression analysis is a useful alternative to ordinary least square (OLS) regression analysis when the quality of a data set is a concern. OLS regression analysis is significantly affected by outlier data points while LMS regression analysis is able to return accurate estimates of the effect of a variable, like hospital non-financial capex, on the key variable of interest, the average payment amount by a payer, even when numerous outliers may be present in the data.[33] LMS regression estimates a variable coefficient that minimizes the median value of the squared residuals instead of an estimate of a variable coefficient that minimizes the mean value of the squared residuals. With OLS estimators, a single "bad" data point, such as a miscoded value of an average payment of $6 million rather than, perhaps the correct value of $60,000, even though a single data point in a set of 100 data points or more, can move the estimate of a variable coefficient a great distance away from the "true" value. With LMS estimators, this single, bad, data point will *have no effect* on the estimated effect of the variable of interest. It can be shown that the LMS estimate of the effect of a variable of interest on the dependent variable will not be swayed, or influenced, even when almost one-half of the data is "bad". Thus, in the presence of concern about the quality of the data collected, LMS will provide a better set of estimates of the model than OLS.

When there are no data quality concerns, OLS and LMS regression analysis should produce very similar estimates of the variables of interest in a model. OLS and LMS estimates may differ because in the absence of bad data, OLS is a more efficient statistical procedure. The superiority of the OLS estimator in the absence of bad data can lead to slightly different values with greater statistical significance (the t-statistic) than LMS, but qualitatively in terms of the sign and magnitude, should be similar to LMS.

High, moderate, and low resource intense procedures

Although the 19 inpatient procedures were selected on the basis of the highest volume inpatient procedures in Canadian hospitals during 2017, as we began to examine the relationships between payments in Canada versus Medicare for the entire United States, Medicare for North Carolina, Medicaid for North Carolina, and commercial insurers for North Carolina, an important pattern began to emerge. The greatest price differentials between payers were for procedures that involved some type of body intervention such as replacing a knee or hip, inserting a pacemaker, inserting a stent, removing a gallbladder, or fixing a broken femur or hip. In addition, some procedures require very expensive and

[33] While we use the term "outliers" to describe an observation that might unduly influence or distort the contribution of a variable on the variable of interest – the average payment for an inpatient procedure – the least median squares algorithm used here will also remove observations that are not extreme in terms of being too small or too large in value if they exert a very large influence on the estimate of the contribution of a variable. See Peter J. Rousseeuw and Annick M. Leroy, "Robust Regression and Outlier Detection", John Wiley and Sons, 1987, for a thorough discussion of outliers, inliers, and detection.

specialized equipment such as dialysis. We categorized these procedures as high resource intense indicating that they might require a high amount of physician and staff time, medical equipment and capital investment, to perform. As tables 6a and 6c show, we found a wide range of payments for the same procedure codes depending upon the payer. Nothing demonstrates this group of procedures more clearly than the prices paid for a knee or hip replacement as shown on the first row of table 6a and the left-most green arrow on Chart 5. The average payment in Canada was $6,071 ($US), for Medicare nationwide $14,752, for Medicare in North Carolina slightly less at $13,848, and for commercial insurers in North Carolina $33,866. *For all high resource intense procedures North Carolina commercial insurers paid more than Medicare or Canada, and often by more than twice as much.*

Another group of procedures does not involve body intervention but does involve significant use of drugs and vigilant monitoring as these diagnoses run a risk of becoming life-threatening. Again, the dimension of significant hospital monitoring would indicate a high amount of medical equipment, although not a surgical suite. These procedures, chronic obstructive pulmonary disease (COPD), heart failure without coronary angiogram, pulmonary embolism, and cellulitis (serious skin infections that if uncontrolled can lead to infection of the lymph system) showed much less payment variation among the average amounts paid by payer types. For two of these procedures, COPD and heart failure without coronary angiogram, Canada paid more per procedure than did Medicare nationwide, and for the other two, pulmonary embolism and cellulitis Medicare nationwide paid more than Canada nationwide. For each procedure North Carolina commercial insurers paid more than either Medicare or Canada but often by a smaller multiple than with the high resource intense procedures.

The last group of procedures typically involves significant use of drugs and monitoring, but with much less risk of a life-threatening outcome. Included in this group of procedures normal birth procedures with and without anesthesia, arrhythmia without coronary angiogram, unspecified sepsis or shock, lower urinary tract infections, treatment for seizures, and two psychiatric inpatient procedures as depressive episodes and schizophrenia. We labeled this group as low resource intense procedures. Of the nine procedures in this group, Canada paid more than Medicare nationwide or in North Carolina for three – unspecified sepsis or shock and the two psychiatric procedures depressive episode and schizophrenia, and more than North Carolina commercial insurers for the two psychiatric procedures as well. Commercial insurers paid more than Medicare in North Carolina for seven of the nine procedures but less than Medicare for the two psychiatric procedures.

A caveat

There are no physicians on the DEG team. We recognize and welcome feedback on the usefulness of this categorization of hospital procedures. For each of the categories, high, moderate, and low resource intensity, we calculated the difference in payments between Medicare and commercial insurance *as if* the total state-wide volume for each procedure was paid for by Medicare or by commercial insurance. *This is a thought exercise* to estimate the ratio of commercial insurer payments to Medicare payments. *For high resource intense procedures commercial insurers in North Carolina would have paid 2.4 times as much as Medicare in North Carolina; 1.6 times as much for moderate resource intense procedures, and 1.4 times as much for low resource intense procedures.*

Table 6a. Comparison of average payments for in patient procedures in Canada with the U.S. and North Carolina, 2017.

Inpatient procedure comparison for 19 high volume procedures in Canada. U.S. procedures are all without complications or co-morbidity while Canada data combines procedures with and without complications. Therefore, the difference in average payments between Canada and the U.S. are understated.

Name of procedure, All amounts in U.S. dollars	Canada (1)			United States (2)			North Carolina (3)		
	CMG code	Number of procedures (2017)	Average procedure cost (U.S. $), no patient copay or deductible	DRG code	Number of Medicare procedures (2016)	Average procedure payment w/patient deductible	Average Medicare procedure payment w/patient deductible (2017) (3)	Number of commercial procedures (2016) (2)	Mid-point of average payment by different commercial insurers w/ patient copay (2017) (3) (6)
High resource intense procedures:									
Unilateral Knee Replacement and Hip Replacement	321 and 320	95,068	**$6,071**	470	679,746	**$14,752**	**$13,848**	18,982	**$33,866**
Fixation/Repair Hip/Femur	727	14,795	**$10,116**	481	109,920	**$14,133**	**$13,294**	1,354	**$26,179**
Renal Failure	477	16,278	**$6,323**	683	205,245	**$6,977**	**$6,571**	3,154	**$11,173**
Laparoscopic Cholecystectomy (removal of gallbladder)	278	21,241	**$3,638**	419	25,395	**$9,397**	**$8,635**	1,311	**$19,792**
Syncope and Collapse (often involves insertion of pacemaker)	205	11,464	**$2,703**	312	112,250	**$6,214**	**$5,709**	935	**$9,853**
Percutaneous Coronary Intervention with MI/Shock/Arrest/Heart Failure (often with insertion of a stent)	175	22,268	**$7,664**	282	36,825	**$5,812**	**$5,496**	856	**$9,257**
Moderate resource intense procedures:									
Chronic Obstructive Pulmonary Disease	139	77,958	**$6,247**	192	73,425	**$5,497**	**$5,104**	766	**$7,648**
Heart Failure without Coronary Angiogram	196	50,827	**$6,190**	293	78,680	**$5,165**	**$4,811**	844	**$6,314**
Pulmonary Embolism	200	9,122	**$4,783**	176	48,750	**$7,022**	**$6,643**	1,553	**$12,384**
Cellulitis (serious skin infections can infect lymph system)	405	18,511	**$5,314**	603	167,510	**$6,517**	**$6,080**	3,256	**$9,515**
Low resource intense procedures:									
Arrhythmia without Coronary Angiogram	202	29,323	**$3,683**	310	105,855	**$4,453**	**$4,249**	2,144	**$7,165**
Unspecified Sepsis/Shock	654	14,813	**$9,721**	872	225,225	**$7,940**	**$7,274**	4,467	**$13,123**
Lower Urinary Tract Infection	487	29,788	**$4,641**	690	214,655	**$5,977**	**$5,621**	2,367	**$8,957**
Normal Newborn, Singleton Vaginal Delivery	576	182,810	**$758**	795	8,885	(5)	**$1,127**	31,563	**$1,652**
Vaginal Birth with Anesthetic and Non-Major Obstetric/Gynecologic Intervention	563	82,001	**$2,132**	775	12,615	**$5,605**	**$4,641**	29,283	**$6,677**
Caesarean Section with uterine scar, no induction	560	42,471	**$2,766**	766	4,795	**$6,927**	**$5,877**	9,965	**$12,001**
Seizure Disorder	40	15,208	**$3,509**	101	60,380	**$6,825**	**$6,197**	1,511	**$11,485**
Depressive Episode	693	16,699	**$6,497**	881	21,680	**$5,691**	**$5,096**	2,420	**$4,764**
Schizophrenia/Schizoaffective Disorder	707	13,448	**$11,080**	885	302,570	**$9,190**	**$7,965**	13,465	**$7,917**

Sources:

(1) Canadian MIS Database, Discharge Abstract Database and Hospital Morbidity Database, Canadian Institute for Health Information, 2013–2014 to 2017–2018.

(2) Medicare data from Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project (HCUPnet), 2016. Volume amounts Medicare nationwide and for commercial North Carolina for 2016. Medicare Payment amounts from 2017 CMS Medicare Provider Analysis and Review (MEDPAR) inpatient data.

(3) Payment amounts from North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017. North Carolina payment amounts for Medicare and commercial insurers for 2017 payments.

(4) Increased the average procedure cost for Canada by 4% to account for Cap Ex for land and buildings that were not included in the PCE data.

(5) CMS did not report an average payment for Medicare for DRG code 795.

(6) A commercially insured patient is typically responsible for 20 percent of the insurer's payment for procedures performed at Duke University Hospital. This percentage is applied to hospital reported commercial insurance payment amounts.

Table 6b. Comparison of payments for 19 highest volume procedures in Canada by Canada, Medicare, and NC commercial payers, 2017.

Amounts in $ U.S.	Canada (1)	Canada at Medicare Rates (2)	Canada at NC Commercial Insurer Rates (3)
Total payments for 19 procedures:	2,918,385,152	4,475,738,190	7,790,509,018
Increase over Canada payments:		53%	167%

Sources:
(1) Canadian payment amounts from the Canadian Institute for Health Information's Patient Cost Estimator, 2013–2014 to 2017–2018.
(2) Medicare payment amounts from 2017 CMS Medicare Provider Analysis and Review (MEDPAR) inpatient data.
(3) North Carolina payment amounts from North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017.

Table 6c. Least Median Squares estimates of payment by type of payer for 19 in patient procedures, 2017.

Inpatient procedure comparison for 19 high volume procedures. U.S. procedures are all without complications or co-morbidity while Canada data combines procedures with and without complications. Therefore, the difference in average payments between Canada and the U.S. are understated.			
Name of procedure, All amounts in U.S. dollars	**Intercept**	**Coefficient per $1 million of non-financial capital investment**	**N**
US hospital capex in $ millions			
Canada hospital capex in $ millions			
High resource intense procedures:			
Unilateral Knee Replacement and Hip Replacement			
North Carolina Medicare	12,265.226 ***	2.6498 ***	73
North Carolina Medicaid	14,507.560 ***	1.1971	66
North Carolina Commercial with Copay	32,987.427 ***	3.0154 *	279
Canada	6,102.488 ***	-0.0367	9
Fixation/Repair Hip/Femur with complication or co-morbidity			
North Carolina Medicare	11,341.637 ***	3.0511 **	65
North Carolina Medicaid	10,044.458 ***	7.5516 *	27
North Carolina Commercial with Copay	17,968.654 ***	8.4142	61
Canada	9,827.697 ***	-0.0555	10
Renal Failure with complication or comorbidity			
North Carolina Medicare	5,596.660 ***	1.7605 ***	73
North Carolina Medicaid	4,676.048 ***	1.0484	61
North Carolina Commercial with Copay	8,734.442 ***	3.6627 ***	151
Canada	5,723.418 ***	-0.0127	10
Laparoscopic Cholecystectomy (removal of gallbladder)			
North Carolina Medicare	7,176.936 ***	1.6176 ***	61
North Carolina Medicaid	8,755.568 ***	1.3128	51
North Carolina Commercial with Copay	19,712.902 ***	0.1028	105
Canada	3,451.145 ***	-0.0183	10
Syncope and Collapse (often involves insertion of pacemaker)			
North Carolina Medicare	4,687.038 ***	1.7397 ***	45
North Carolina Medicaid	4,073.356 ***	1.2493	31
North Carolina Commercial with Copay	6,793.266 ***	3.5331 *	68
Canada	2,693.025 ***	-0.0208	10
Acute Myocardial Infarction (often with insertion of a stent)			
North Carolina Medicare	4,339.635 ***	1.1562 ***	62
North Carolina Medicaid	4,118.780 ***	4.2081 *	23
North Carolina Commercial with Copay	7,485.100 ***	3.3511 **	76
Canada	5,551.942 ***	-0.0070	10

Source: North Carolina Medicare data from 2017 CMS Medicare Provider Analysis and Review (MEDPAR) inpatient data; North Carolina Medicaid and Commercial data from North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017; Canadian data from Canadian MIS Database, Discharge Abstract Database and Hospital Morbidity Database, Canadian Institute for Health Information, 2013–2014 to 2017–2018.
Notes: *** denotes significance at the 0.1% level, ** denotes significance at the 1% level, * denotes significance at the 10% level.

Table 6c. Least Median Squares estimates of payment by type of payer for 19 in patient procedures, 2017.

Name of procedure, All amounts in U.S. dollars	Intercept	Coefficient per $1 million of non-financial capital investment	N
US hospital capex in $ millions			
Canada hospital capex in $ millions			
Moderate resource intense procedures:			
Chronic Obstructive Pulmonary Disease			
North Carolina Medicare	4,508.729 ***	1.1665 *	45
North Carolina Medicaid	3,770.665 ***	0.7144	50
North Carolina Commercial with Copay	5,159.730 ***	5.3374 *	57
Canada	5,115.114 ***	0.0024	10
Heart Failure without Coronary Angiogram			
North Carolina Medicare	4,160.992 ***	1.5027 ***	45
North Carolina Medicaid	3,769.613 ***	0.6328	38
North Carolina Commercial with Copay	5,076.296 ***	3.7156 *	51
Canada	6,824.948 ***	-0.0096	9
Pulmonary Embolism			
North Carolina Medicare	5,505.271 ***	1.8419 **	41
North Carolina Medicaid	5,069.577 ***	0.0904	48
North Carolina Commercial with Copay	10,837.813 ***	2.3115 *	119
Canada	4,256.025 ***	-0.0009	10
Cellulitis (serious skin infections)			
North Carolina Medicare	5,177.752 ***	1.5904 **	71
North Carolina Medicaid	4,009.762 ***	-0.0129	69
North Carolina Commercial with Copay	8,354.382 ***	1.5904 **	193
Canada	4,671.546 ***	-0.0059	10

Source: North Carolina Medicare data from 2017 CMS Medicare Provider Analysis and Review (MEDPAR) inpatient data; North Carolina Medicaid and Commercial data from North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017; Canadian data from Canadian MIS Database, Discharge Abstract Database and Hospital Morbidity Database, Canadian Institute for Health Information, 2013–2014 to 2017–2018.

Notes: *** denotes significance at the 0.1% level, ** denotes significance at the 1% level, * denotes significance at the 10% level.

Table 6c. Least Median Squares estimates of payment by type of payer for 19 in patient procedures, 2017.

Name of procedure, All amounts in U.S. dollars	Intercept	Coefficient per $1 million of non-financial capital investment	N
US hospital capex in $ millions			
Canada hospital capex in $ millions			
Low resource intense procedures:			
Arrhythmia without Coronary Angiogram			
North Carolina Medicare	3,616.422 ***	1.3225 ***	52
North Carolina Medicaid	3,092.740 ***	0.8274	33
North Carolina Commercial with Copay	6,091.586 ***	1.6367 *	132
Canada	3,398.424 ***	-0.0149	10
Unspecified Sepsis/Shock			
North Carolina Medicare	6,287.977 ***	2.0845 ***	72
North Carolina Medicaid	5,773.701 ***	0.5220	70
North Carolina Commercial with Copay	12,167.122 ***	2.0527 *	193
Canada	7,610.521 ***	0.0403	10
Lower Urinary Tract Infection			
North Carolina Medicare	4,803.923 ***	1.6844 ***	70
North Carolina Medicaid	4,079.969 ***	0.0622	67
North Carolina Commercial with Copay	8,170.682 ***	1.7936 **	151
Canada	4,011.951 ***	-0.0021	10
Normal Newborn, Singleton Vaginal Delivery			
North Carolina Medicare	1,270.388 ***	0.8844	15
North Carolina Medicaid	576.905 ***	0.2125 *	66
North Carolina Commercial with Copay	1,507.220 ***	0.3100 **	267
Canada	749.008 ***	-0.0055	10
Vaginal Birth with Anesthetic and Non-Major Obstetric/Gynecologic Intervention			
North Carolina Medicare	3,619.492 ***	1.0031 **	36
North Carolina Medicaid	2,448.681 ***	0.7523 *	70
North Carolina Commercial with Copay	6,496.174 ***	0.8856	295
Canada	2,107.849 ***	-0.0158	10
Caesarean Section with uterine scar, no induction			
North Carolina Medicare	4,780.802 ***	1.0257	22
North Carolina Medicaid	5,272.688 ***	0.5834	67
North Carolina Commercial with Copay	11,911.243 ***	0.3652	239
Canada	2,790.033 ***	-0.0232	10
Seizure Disorder			
North Carolina Medicare	4,695.204 ***	2.0411 ***	33
North Carolina Medicaid	4,054.340 ***	1.1598	49
North Carolina Commercial with Copay	8,636.992 ***	3.1052 *	86
Canada	3,110.342 ***	-0.0022	10
Depressive Episode			
North Carolina Medicare	3,954.170 ***	1.0895 ***	36
North Carolina Medicaid	2,523.025 ***	0.8323	24
North Carolina Commercial with Copay	3,662.680 ***	3.5014 ***	75
Canada	6,405.730 ***	-0.0162	10
Schizophrenia/Schizoaffective Disorder			
North Carolina Medicare	6,301.772 ***	3.2990 *	18
North Carolina Medicaid	3,712.696 ***	1.8134	35
North Carolina Commercial with Copay	6,257.249 ***	3.8710 ***	160
Canada	10,571.738 ***	-0.0233	10

Source: North Carolina Medicare data from 2017 CMS Medicare Provider Analysis and Review (MEDPAR) inpatient data; North Carolina Medicaid and Commercial data from North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017; Canadian data from Canadian MIS Database, Discharge Abstract Database and Hospital Morbidity Database, Canadian Institute for Health Information, 2013–2014 to 2017–2018.

Notes: *** denotes significance at the 0.1% level, ** denotes significance at the 1% level, * denotes significance at the 10% level.

VI. What explains variation in the range of procedure payments?

Canadian provinces and state Medicaid health care systems pay for procedures with a single payer system through provincial or state government payments. State level Medicare systems pay for procedures with a dual payer system through federal government payments plus beneficiary payments as premiums, deductibles, and copayments. Commercial insurance companies pay for procedures with a dual or more often triple payer system in the form of private insurance payments, employer provided insurance premium payments, plus beneficiary payments as premiums, deductibles, and copayments.

From a perspective of market pricing power, we might expect that single payer systems exhibit greater uniformity and therefore less price variation in procedure prices because health care providers – in this case hospitals and the networks they belong to - are price takers. We might expect that dual payer systems could only approach the market power of single payer systems if the two payers are well coordinated. Without a high coordination between the two payers there is an opportunity for hospitals, depending upon the degree of market concentration, to command higher prices. In the case of a triple payer system it would be even more difficult to coordinate the three parties to imitate the pricing power of a single payer. In this case we might anticipate even greater variation in hospital prices commanded.[34]

Charts 5, 6, and 7 below begin to explore this hypothesis. Each chart plots the actual prices paid in North Carolina to hospitals for each procedure by the type of payer. Each payer is represented with a vertical line showing the range of payments for each procedure at the 25th percentile paid by that payer, the 50th percentile (median) paid by the payer, and the 75th percentile paid by the payer. The black line is for the provinces in Canada, the red line is for Medicare in North Carolina, the blue line is for Medicaid in North Carolina, and the green line is for commercial insurers in North Carolina.

In general, the Canadian single payer system pays less than the Medicare dual payer system which pays less than the commercial triple payer system. This can be shown by drawing a line connecting the median points of the Canada, Medicare, and Commercial insurer lines for each procedure. The North Carolina Medicaid single payer system payments are, in general, similar to North Carolina Medicare payments. The Medicare payment amounts in these charts, as with all of the analysis, include patient deductibles.

What is market power for a hospital?

For each of the types of payers, we explored a variety of hospital specific features to determine the extent of market power in commanding payment for each of the 19 procedures. We posited a simple model with the average amount of payment for a procedure by a type of payer (Medicare, Medicaid, commercial insurer 1, commercial insurer 2, …. Commercial insurer 5, ….) in North Carolina for each hospital that received payments for the procedure as the dependent variable. Against this we tested a wide range of independent variables such as whether the hospital was in an urban or rural setting, was a

[34] We do not expand on this hypothesis here because it is sufficient to identify the coordination difficulty among two and three-party payment mechanisms. Further examination of this issue only reinforces the difficulties of coordination because while Medicare, a non-profit entity, may negotiate on behalf of the second-payer, the beneficiaries, for commercial insurers who are for-profit (some are not-for-profit) there is an inherent conflict between their own profit motive and the desire for lower procedure payments by the beneficiaries on whose behalf they negotiate prices for.

teaching hospital, was a for-profit hospital, and the number of beds in the hospital. Each of these variables showed less effect on the price paid than the total non-financial capital stock of the hospital. However, there are other measures of hospital market power, including the strength of the integrated delivery network (IDN) that a hospital may be affiliated with, and geographic measures of market concentration such as a herfindahl index. These, and other metrics could be developed in subsequent analysis.

Table 6c shows the effect of total non-financial capital investment on payments to hospitals in North Carolina using least median squares regression. *In general, hospital total non-financial capital investment has no effect on Medicaid payments, as we might expect with a single payer system*. We also ran this same model for the other single payer system in our data, Canadian provinces, but with only 10 provinces and occasionally the Yukon territory as data, the inefficiency of the least median squares algorithm always fails to show statistical significance of each provinces total capital stock in hospitals. However, both Medicare in North Carolina and commercial insurers are a different story. In many of the least median square estimation models *increases in total non-financial capital investment are associated with increases in the size of payments from Medicare and commercial insurers*. Moreover, in general the effect of the size of a hospital's total non-financial capital investment is greater when the payer is commercial insurance than when it is Medicare. To see this, scan down the column in table 6c titled "Coefficient per $1 million of non-financial capital investment" and compare the value for Medicare and commercial insurance for each procedure. Commercial insurers pay more per dollar of non-financial capex than Medicare for the high resource intense procedures, more, but sometimes the same for moderate resource intense procedures, and often the same and sometimes less for low resource intense procedures.

Chart 5. Range of actual payments to hospitals for high resource intensive inpatient procedures by payer.
(Range shown between 25th and 75th percentile for each procedure.)

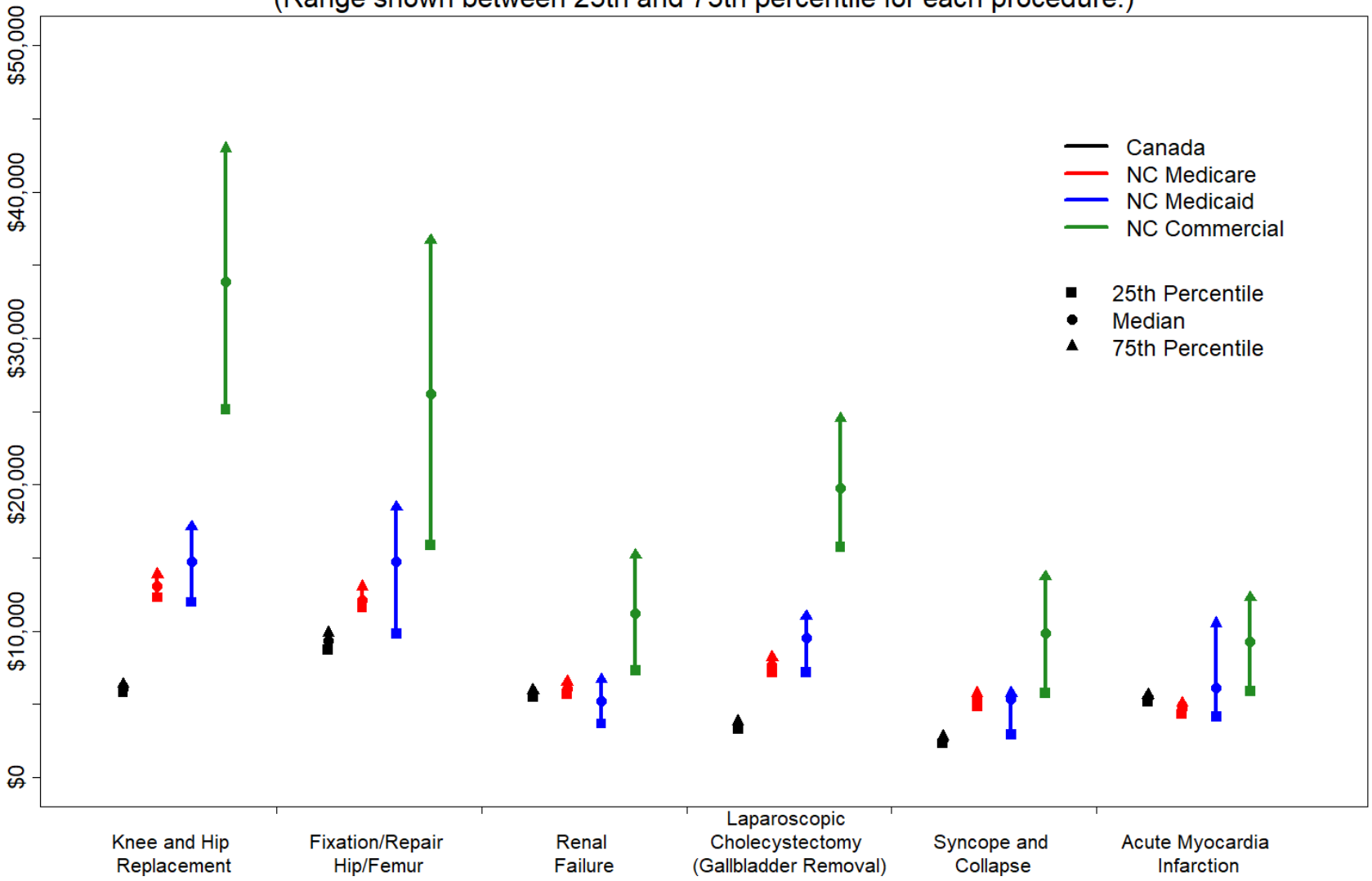

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Chart 6. Range of actual payments to hospitals for moderate resource intensive inpatient procedures by payer.
(Range shown between 25th and 75th percentile for each procedure.)

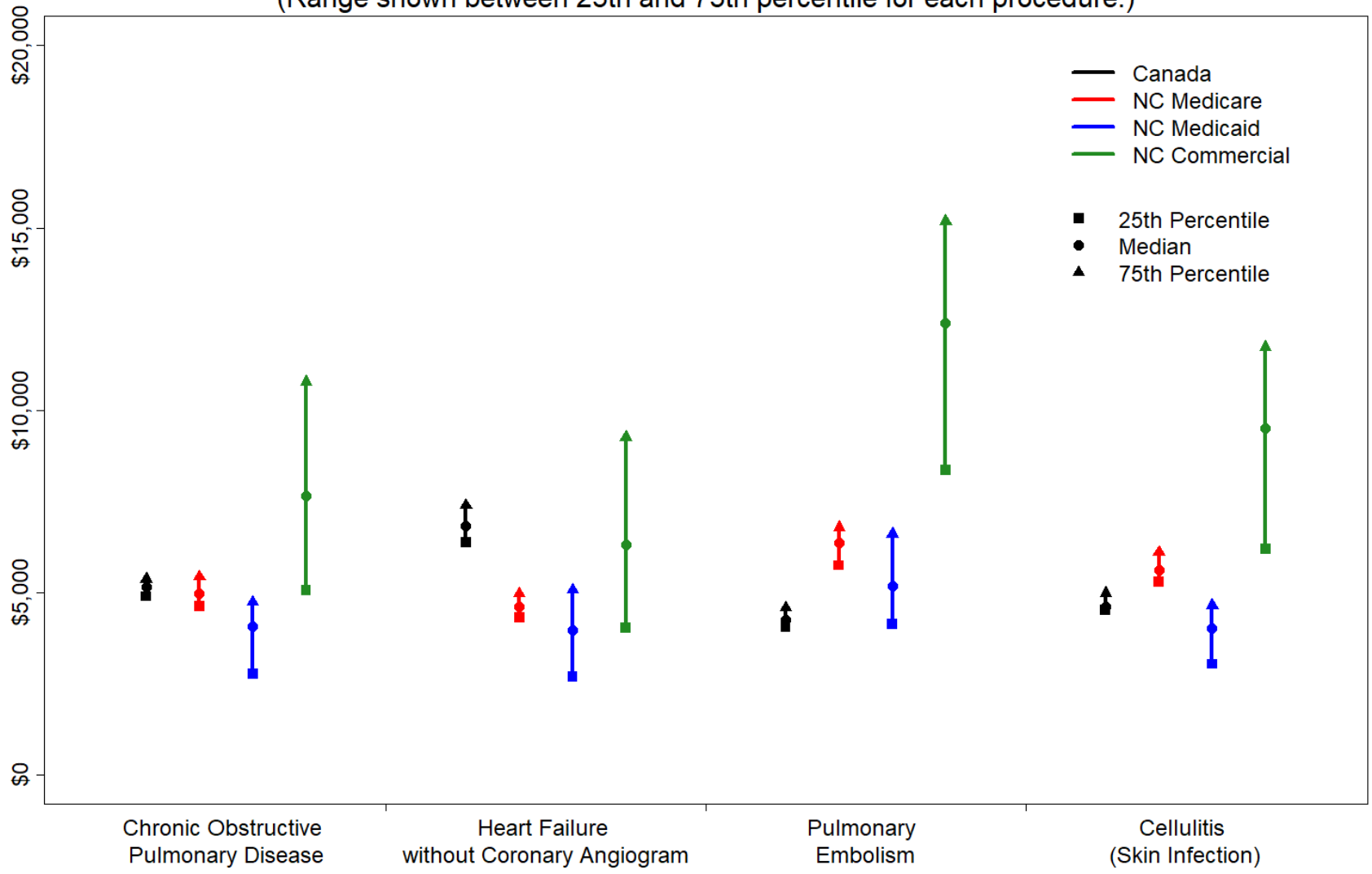

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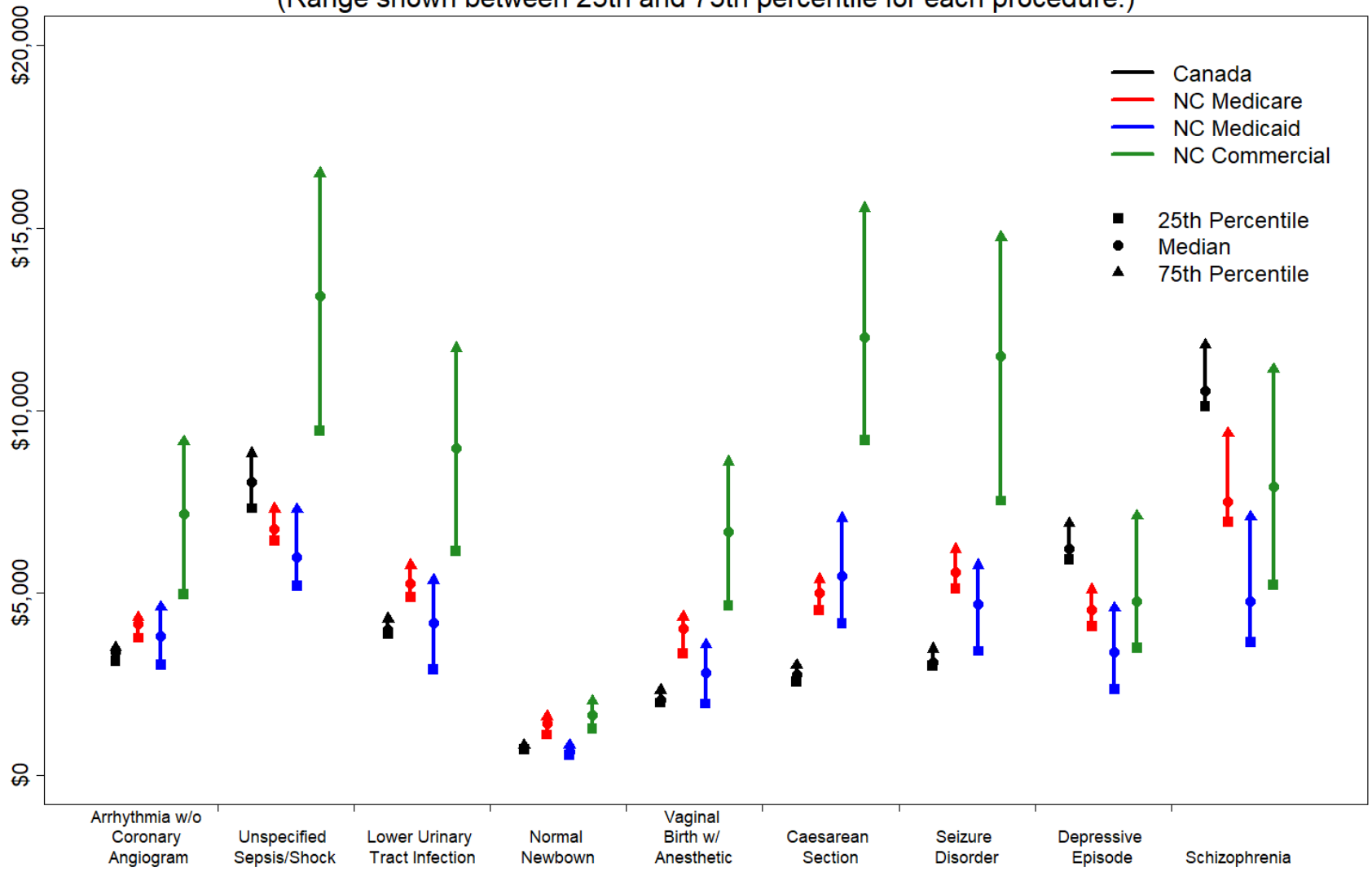
Chart 7. Range of actual payments to hospitals for low resource intensive inpatient procedures by payer.
(Range shown between 25th and 75th percentile for each procedure.)



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VII. Supporting Tables

Table 6d. Intra-Alberta price variation for Alberta fiscal year 2017 (April 1, 2017 to March 31, 2018).

Alberta Zone	Number of Beds	Number of Teaching Beds	COPD	Fixation or Repair of Hip/Femur	Schizophrenia/ Schizoaffective Disorder	Arrhythmia without Coronary Angiogram	Cellulitis	Unilateral Knee Replacement	Unilateral Hip Replacement	Heart Failure without Coronary Angiogram	Vaginal Birth with Non-Major Intervention
Calgary Zone	2,860	2,296	8,188	14,505	24,703	5,278	7,823	9,483	10,126	9,368	4,254
Edmonton Zone	3,366	2,701	7,360	16,767	15,374	5,879	7,916	10,054	10,088	8,203	4,529
Rural Zones	5,044	367	9,339	13,164	12,199	5,007	7,450	8,669	11,374	9,847	4,358
Alberta range as percent of minimum payment			27%	27%	102%	17%	6%	16%	13%	20%	6%
Inter-provincial payment range			46%	37%	37%	34%	46%	45%	46%	49%	49%

Notes: Rural zone payment weighed-averages were estimated using Edmonton, Calgary, and Total Alberta averages. Number of beds and number of teaching beds include Acute Care, Long-Term Care, Rehabilitation, and Mental Health beds, with the former being the total number of beds and the latter referring to only those in teaching hospitals.

Sources:

Calgary and Edmonton Zones: Alberta Health's Interactive Health Data Application on Health Costing with 2018 version of CMG codes, Alberta fiscal year 2017.

Total Alberta: Canadian Institute for Health Information's Patient Cost Estimator, Alberta Fiscal Years 2013-2018.

Inter-provincial payment range from CIHI patient cost estimator.

Table 6e. Canadian procedure (~27%) and payment coverage (~22%)

Name of Procedure	CMG code	Number of Procedures	Percent of Total Procedures in Canada (2017)	Percent of Total Payments in Canada (2017)
Total Percentage			26.8%	21.7%
Seizure Disorder	40	15,208	0.5%	0.4%
Chronic Obstructive Pulmonary Disease	139	77,958	2.7%	3.3%
Percutaneous Coronary Intervention with MI/Shock/Arrest/Heart Failure	175	22,268	0.8%	1.2%
Heart Failure without Coronary Angiogram	196	50,827	1.8%	2.1%
Pulmonary Embolism	200	9,122	0.3%	0.3%
Arrhythmia without Coronary Angiogram	202	29,323	1.0%	0.7%
Syncope	205	11,464	0.4%	0.2%
Laparoscopic Cholecystectomy	278	21,241	0.7%	0.5%
Unilateral Knee Replacement and Hip Replacement	321 and 320	95,068	3.4%	4.1%
Cellulitis	405	18,511	0.7%	0.7%
Renal Failure	477	16,278	0.6%	0.7%
Lower Urinary Tract Infection	487	29,788	1.1%	0.9%
Caesarean Section with uterine scar, no induction	560	42,471	1.5%	0.8%
Vaginal Birth with Anesthetic and Non-Major Obstetric/Gynecologic Intervention	563	77,030	2.7%	1.1%
Normal Newborn, Singleton Vaginal Delivery	576	182,810	6.4%	0.9%
Unspecified Sepsis/Shock	654	14,813	0.5%	1.0%
Depressive Episode	693	16,699	0.6%	0.7%
Schizophrenia/Schizoaffective Disorder	707	13,448	0.5%	1.0%
Fixation/Repair Hip/Femur	727	14,795	0.5%	1.0%
Total of Top 19 Procedures		759,122		3,860,285,193
Total of All Canadian Procedures (Payments in C$)		**2,828,495**		**17,758,312,136**

Note: The Canadian Institute for Health Information suppresses volumes of patients less than 5 in the Patient Cost Estimator (PCE) so the totals for procedure counts and payments calculated using the PCE are slightly lower than actual totals.

Source: Canadian Institute for Health Information's Patient Cost Estimator, Calendar Years 2013-2018.

Table 6f. Least Median Squares estimates of effect of procedure complications and presence of co-morbidity on payments for Chronic Obstructive Pulmonary Disease and Heart Failure and Shock paid by Medicaid, Medicare, and Commercial insurance in North Carolina during 2017.

DRG Procedure Code	Procedure name	Intercept in $ dollars per procedure (all significant at the 0.1% level)			Additional amount for each $1 million of non-financial capex per hospital		
w/o, and with complications		without complications	with complications	Increase with complications	without complications	with complications	Increase with complications
192, 190	**Chronic Obstructive Pulmonary Disease**						
	Medicaid	3,770	5,330	41%	0.7144	1.2435	-
	Medicare	4,508	7,019	56%	1.1665 *	2.2164 ***	90%
	Commercial	5,159	9,774	89%	5.3374 *	5.0581 ***	-5%
293, 292	**Heart Failure and Shock**						
	Medicaid	3,769	4,198	11%	0.6328	1.5521*	145%
	Medicare	4,160	5,683	37%	1.5027 ***	2.1462 ***	43%
	Commercial	5,076	8,822	74%	3.7156 *	3.8735 **	4%

Notes: *** denotes significant at the 0.1% level, ** denotes significant at the 1% level, and * denotes significant at the 10% level
Source: North Carolina Medicare data from 2017 CMS Medicare Provider Analysis and Review (MEDPAR) inpatient data; North Carolina Medicaid and Commercial data from North Carolina Department of Health and Human Services Transparency in Healthcare Costs Dataset, 10/1/2016-9/30/2017.

Table 7. Price Comparison between Medicare Part D and Canada for 20 brand name drugs with largest Medicare Part D sales. Comparison applies Medicare Part D volumes to Medicare Part D, Veterans Administration, and Canadian Drug Prices in 2017. These 20 drugs accounted for 22% of total Medicare Part D spending in 2017.

Drug	Dosage Unit	Medicare Average Spending per Dosage Unit	Highest Price per Dosage Unit Negotiated by the VA	Highest Price per Dosage Unit by Canadian Province			Aggregate drug spending using Medicare Part D volumes during 2017 (Millions)		
				Alberta	Ontario	Saskatchewan	Medicare Part D	Veterans Administration	Canada
Eliquis	One tablet	$6.42	$1.51	$1.23	$1.23	$1.23	$3,076	$723	$588
Januvia	One tablet	$12.87	$9.74	$2.31	$2.33	$2.33	$2,786	$2,109	$504
Lantus Solostar	One 3ML syringe	$24.82	$22.75	-	$13.93	$13.93	$2,632	$2,413	$1,477
Xarelto	One tablet	$12.77	$11.01	$2.15	$2.15	$2.15	$2,612	$2,252	$440
Lyrica	One capsule	$6.67	$5.68	-	$1.80	$1.80	$2,517	$2,142	$678
Advair Diskus	One powder in inhaler	$6.22	$6.60	$1.80	$1.80	$1.80	$2,375	$2,519	$688
Humira Pen	One pen	$2,235.96	$1,796.18	$571.93	$577.48	$571.93	$2,016	$1,619	$521
Spiriva	One capsule	$12.15	$9.03	$1.35	$1.36	$1.35	$1,662	$1,235	$186
Lantus	3ML	$24.95	$22.76	$13.93	$13.93	$13.93	$1,554	$1,417	$867
Copaxone	One 1ML syringe	$444.24	$350.69	$36.04	-	$36.04	$1,499	$1,184	$122
Sensipar	One tablet	$40.88	$55.94	-	$23.87	-	$1,437	$1,966	$839
Levemir Flextouch	One 3ML syringe	$26.85	$18.96	$16.72	$16.73	-	$1,404	$991	$875
Enbrel Sureclick	One 1ML syringe	$1,139.13	$769.77	$301.16	$304.49	$304.49	$1,158	$782	$309
Humalog Kwikpen U-100	One 3ML syringe	$33.54	$21.21	$8.64	$8.94	$8.94	$1,090	$689	$291
Tecfidera	One capsule	$116.81	$82.01	$12.91	-	$24.80	$1,024	$719	$217
Latuda	One tablet	$39.69	$39.27	$3.19	$3.29	$3.19	$992	$981	$82
Epclusa	One tablet	$897.35	$288.91	$535.71	$535.71	$535.71	$941	$303	$562
Invega Sustenna	One 1ML syringe	$1,603.62	$1,770.87	$467.17	$476.87	$474.06	$904	$998	$269
Breo Ellipta	One powder in inhaler	$5.39	$7.86	$3.32	$3.32	$3.32	$813	$1,185	$500
Myrbetriq	One tablet	$10.79	$7.78	$1.10	$1.10	$1.10	$787	$567	$80
						Totals	**$33,278**	**$26,796**	**$10,094**

Note: There are various levels of strength for each drug listed in the table. The prices of the drugs vary as the strength of the drug does. For each drug, the highest listed price was recorded in the table above for the VA and the Canadian provinces. Medicare creates a weighted average spending figure which weights the different prices by the proportion of claims.

There are several dashes listed as prices for Alberta, Ontario and Saskatchewan. These dashes indicate that there was no price listed for the drug in the province's drug formulary.

Sources:

Medicare spending data: Centers for Medicare & Medicaid Services' Medicare Part D Drug Spending and Utilization Table, Calendar Years 2013 - 2017

Veterans Affairs price data: U.S. Department of Veterans Affairs, Office of Procurement, Acquisition and Logistics, Pharmaceutical Pricing Data Excel Sheet found here - https://www.va.gov/opal/nac/fss/pharmPrices.asp

Alberta price data: Alberta Interactive Drug Benefit List created by Alberta Blue Cross on behalf of the Alberta Health and Human Services - https://idbl.ab.bluecross.ca/idbl/load.do?reset=true&_cid=0ba382ca-dde9-4e92-ae0e-2b7ae0e9cb9a

Ontario price data: Ontario Drug Benefit Formulary/Comparative Drug Index created by the Ontario Ministry of Health -https://www.formulary.health.gov.on.ca/formulary/

Saskatchewan price data: Saskatchewan Online Formulary Database created by the Saskatchewan Ministry of Health- http://formulary.drugplan.ehealthsask.ca/SearchFormulary/

Table 8. Comparison of Medicare payments and Canadian Single-Payer System payments for common laboratory procedures in Canada and the U.S. (U.S. Dollars)

Laboratory Procedure	Number of Tests Covered by Medicare Part B in 2017 (Millions) (1)	Medicare Part B Price of Procedure in 2019 (2)	Ontario Price of Procedure in 2019 (3)	British Columbia Price of Procedure in 2019 (4)	2017 Aggregate Laboratory Procedure Spending for Medicare Part B assuming Medicare Part B 2019 Prices (Millions)	2017 Aggregate Laboratory Procedure Spending for Medicare Part B assuming Ontario 2019 Prices (Millions)	2017 Aggregate Laboratory Procedure Spending for Medicare Part B assuming British Columbia 2019 Prices (Millions)
Complete Blood Count - CBC and automated differential WBC	41.5	$8.63	$3.16	$8.71	$358.15	$131.21	$361.32
Clotting Time (Prothrombin PT Time)	17	$4.37	$2.11	$9.59	$74.29	$35.92	$163.00
Thyroid Stimulating Hormone	21.5	$18.67	$2.84	$7.86	$401.41	$61.14	$169.09
Hemoglobin A1C	19.7	$10.79	$5.76	$4.21	$212.56	$113.46	$82.94
Vitamin D3 Level	8.9	$32.89	$9.26	$48.71	$292.72	$82.44	$433.54
Parathormone level	2.3	$45.86	$7.46	$13.92	$105.48	$17.16	$32.01
Cyanocobalamin (B12) level	5.6	$16.75	$2.84	$11.42	$93.80	$15.93	$63.97
Ferritin level	3.8	$15.15	$2.36	$8.04	$57.57	$8.97	$30.55
				Totals	**$1,595.97**	**$466.23**	**$1,336.43**

Sources:

(1) Exhibit 3 from the Office of Inspector General's Data Brief "Medicare Payments for Clinical Diagnostic Laboratory Tests in 2017: Year 4 of Baseline Data", September 2018.

(2) Centers for Medicare & Medicaid Services' 2019 Clinical Diagnostic Laboratory Fee Schedule .

(3) Ontario Ministry of Health's Schedule of Benefits for Laboratory Services, July 1, 2019.

(4) British Columbia Ministry of Health's Schedule of Fees for the Laboratory Services Outpatient Payment Schedule, July 31, 2017.

Table 9. Physician average gross clinical payment for physicians in the United States (in $USD) and in Canada (in C$).

	Physician Specialty						
	Family Medicine	Pediatrics	Obstetrics & Gynecology	Cardiology	General Surgery	Ophthalmology	Anesthesia
U.S. average 2018 (in dollars)	242	223	335	454	403	371	405
Canada average 2017 (in C$)	304	322	421	610	481	788	451
Province: (in C$)							
Newfoundland and Labrador	250	291	386	589	415	787	445
Prince Edward Island	291	376	456		446	632	331
New Brunswick	282	332	393	556	417	819	333
Quebec	279	356	400	535	488	660	463
Ontario	341	305	444	625	480	779	467
Manitoba	337	335	469	681	543	977	439
British Columbia	252	312	367	732	464	976	404

Note: For Canada, the average payments are for physicians with payments of greater than $60,000, 2016-2017. End of 2017 Canadian to U.S. dollar exchange rate was 0.79.
Sources: Canada - CIHI National Physician Database - Payments Data 2016 - 2017. U.S. - Doximity 2019 Physician Compensation Report: Third Annual Study, Published March 2019, found at https://s3.amazonaws.com/s3.doximity.com/press/doximity_third_annual_physician_compensation_report_round4.pdf and based on a study and analysis of self-reported compensation surveys of approximately 90,000 full-time licensed U.S. Physicians who practice at least 40 hours per week.

Table 10. Regulated Nurse Counts with a breakout for Registered Nurses (RN), and current starting RN salaries for Canadian Provinces (in $CAD) and for the United States (in $USD) [Excludes Quebec]

	Regulated Nurses*	Regulated Nurses Per 100,000 People	Regulated Nurses Per Staffed Bed **	Registered Nurses (RNs) (Not Including Nurse Practitioners)	RN Current Starting Hourly Rate ***	RN Current Starting Annual Compensation, Full-Time ****
United States (2018)	**3,833,300**	**1,172**	**4.7**	**2,951,960**	**$24.42**	**$50,794**
Canada (2017)	**327,650**	**1,162**	**4.5**	**231,044**	**C$ 34.34**	**C$ 67,101**
Canadian Details:						
Newfoundland and Labrador	8,537	1,616	3.6	5,969	C$ 32.33	C$ 63,044
Prince Edward Island	2,322	1,543	4.7	1,628	$33.55	$65,423
Nova Scotia	13,803	1,452	4.4	9,498	$34.86	$67,981
New Brunswick	11,422	1,490	4.1	8,045	$31.23	$60,899
Ontario	152,968	1,087	4.9	101,912	$33.23	$64,799
Manitoba	17,671	1,324	4.0	14,180	$36.52	$73,585
Saskatchewan	15,370	1,335	5.0	11,524	$35.99	$70,181
Alberta	51,204	1,207	4.5	36,765	$36.86	$71,877
British Columbia	52,475	1,066	3.8	40,075	$34.83	$67,919
Yukon, NWT, and Nunavut	1,878	1,537	-	1,448	-	-
U.S. Details:						
NY-Newark-Jersey City, NY-NJ-PA Metro Area	227,320	1,138	4.2	176,780	$30.14	$62,691
Portland, ME Metro Area	5,400	1,009	3.8	4,630	$25.39	$52,811
Bismarck, ND Metro Area*****	2,440	1,839	4.8	1,910	$22.95	$47,736

* Includes Licensed Practical Nurses, Registered Nurses (including Nurse Practitioners), and Registered Psychiatric Nurses.
** Includes Acute Care, Mental Health, Rehabilitation, and Long-Term Care beds.
*** To estimate U.S. RN starting salary rates, the 10th percentile wage estimate from BLS was utilized at the respective national/area level. Canadian national average is the weighted average of the provincial rates, weighted by the provinces' share of regulated nurses.
**** While 2080 hours is considered "year-round, full-time" in the U.S. according to the BLS, most provinces require 1950 hours of work annually to be considered full-time. Manitoba sets its pay schedules based on 2015 or 1885 annual hours, and the annual pay in Manitoba can vary from region to region: the 2015 annual hour count and the midpoint of the regional hourly wages was utilized.
***** The most recent BLS estimate available for the number of Nurse Practitioners in Bismarck, ND is from 2016. The 2016 estimate is included in the calculations to best represent the number of Regulated Nurses in the metro area.

Sources:
(1) Canadian nurse count data from the Canadian Institute for Health Information's Canada's Health Care Providers: Provincial Profiles, 2008 to 2017 - Data Tables, Table 1 and U.S. nurse count data from BLS May 2018 Occupational Employment Statistics for Nurse Practitioners (29-1171), Registered Nurses (29-1141), and Licensed Practical and Licensed Vocational Nurses (29-2061), https://www.bls.gov/oes/current/oes291141.htm.
(2) Canada Population Statistics from Statistics Canada's Annual Population estimates on July 1st, by age and sex (Table 17-10-0005-01) and U.S. Population estimates from the U.S. Census Bureau, Population Division's Annual Estimates of the Resident Population, April 1, 2010 to July 1, 2018: 2018 Estimates.

(3) Canada Teaching Hospital and Staffed Bed Statistics from Canadian Institute for Health Information's Beds Staffed and In Operation: Breakdown by care setting, 2017-2018. U.S. Teaching Hospital and Bed Statistics from Definitive Healthcare county-level hospital data and the Center for Medicare Statistics (CMS) Medicare Cost Report 2017.
(4) Estimates for starting RN salaries for U.S. from BLS May 2018 Metropolitan Area Occupational Employment and Wage Estimates (29-1141), found at https://www.bls.gov/oes/current/oessrcma.htm with filters for the different metropolitan statistical areas
(5) Canadian provinces' most recent starting RN hourly rates and full-time hour counts taken from provincial bargaining agreements and wage grids:

(a) Newfoundland and Labrador: https://www.exec.gov.nl.ca/exec/hrs/working_with_us/collective_agreements/RNUNL.pdf
(b) PEI: https://peinu.com/wp-content/uploads/2019/06/PEIC-646842-v1-PEINU_-_Collective_Agreement_-_2019_-_Final.pdf
(c) Nova Scotia: http://www.nshealth.ca/sites/nshealth.ca/files/nova_scotia_council_of_nursing_unions.pdf
(d) New Brunswick: https://nbnu.ca/wp-content/uploads/2019/10/NURSES-PART-III-1.pdf
(e) Ontario: https://www.ona.org/wp-content/uploads/ona_hospitalcahighlightdoc_20180731f.pdf
(e) Manitoba: https://manitobanurses.ca/collective-agreements
(f) Saskatchewan: https://www.saskatoonhealthregion.ca/joinourteam/Documents/Common/SUN%20Collective%20Agreement.pdf
(g) Alberta: https://www.una.ab.ca/files/uploads/2018/11/Provincial_AHS_UNA_CA_2017-2020.pdf
(h) British Columbia: https://www.bcnu.org/Contracts-Bargaining/Documents/NBA_Wage_Grid.pdf

VIII. Conclusions

The central focus of this analysis is the comparison of payments to hospital in Canada, the U.S., and North Carolina for the 19 most frequently performed inpatient procedures in Canada. The comparison is designed to bias downward the payment differentials between Canadian and U.S. hospitals by selecting DRG codes that exclude complications for the U.S. hospitals. Despite this, payments to Canadian hospitals are much less than Medicare to U.S. hospitals, which are much less than commercial insurers pay to hospitals in North Carolina.

We explored a number of components of Canadian hospital cost, and at least two, nursing costs and equipment investment costs, are on par with U.S. hospitals. On the other hand, costs for drugs, laboratory tests, land and building investment, and administration are lower.

We also explored a very strong positive correlation between the total amount of non-financial capital investment in hospitals in North Carolina and the amounts paid by Medicare and commercial insurers for the same procedures. There can be many reasons for this. For example, if greater non-financial capex results in lower costs per procedure – that is increasing returns to scale to providing hospital inpatient procedures - then these hospitals are making larger profits than lower capex hospitals even if they collected the same payment for each procedure. So why do we find larger payments for each procedure from Medicare and commercial insurers? For this hypothesis it is more than mere coincidence that the larger procedure payments are from commercial insurance payers where generally three parties are paying – employers, employees, and insurers – and the smaller payments are from the single-payer Medicaid system. On the other hand, if greater non-financial capex does not result in an improvement in the efficiency of providing hospital inpatient procedures, then these hospitals may be generating a lower profit on each inpatient procedure indicating that there are decreasing returns to scale for these procedures. If these hospitals are making lower profits than the smaller, lower capex hospitals, then they might need larger payments to maintain the same level of profit as the smaller hospitals. However, we cannot find a single source that identifies hospitals as having decreasing returns to scale from capital investment. Why hospitals with more non-financial capital investment require larger payments per inpatient procedure remains to be explained.

IX. Least Median Squares estimation in R

For analysis of the North Carolina hospital level Medicaid, Medicare, and commercial insurance payment data we used the 'quantreg' package in the R programming language. Within this package is function 'rq' that runs quantile regressions which is used. To perform a least median square regression with the 'rq' function an additional parameter identifying the size of the subsets of data points to analyze, 'tau', must be set to 0.5. We use the default method parameter 'br' which uses the Barrodale and Roberts algorithm to calculate the fit of the model and is efficient for data sets which contain less than one thousand observations. As the data sets in the analysis contain at most 295 observations, the Barrodale and Roberts algorithm is used. The 'quantreg' package also contains a function to calculate the standard errors for all the estimators. This is useful as the standard errors are needed to calculate the significance of each estimator. The 'summary.rq' function within the 'quantreg' package returns the standard error, t-value, and p-value associated with each estimator. The parameter 'se' must be specified when using this function. The 'se' parameter specifies the method used to compute the standard errors. In the analysis, the 'se' parameter is set to 'boot'. This tells R to use bootstrapping techniques to estimate the standard errors. LMS estimates of the effect of hospital capital stock on the average payment price for a procedure by Medicare, Medicaid, commercial insurers, and in Canada are shown on table 6b.

The 'quantreg' package in R does not include a goodness of fit statistic for least median squares estimation. That is, there is no 'R-square' statistic that we are all familiar with for ordinary least squares estimation. Goodness of fit is a difficult concept when outliers are present within a dataset. The goodness of fit of a model is assessed by examining the difference between the predicted values and the actual values. Models that have a good fit will have smaller differences between the predicted values and the actual values. However, when outliers are present in a data set the difference between the predicted value and the outliers will be quite large even especially when the LMS algorithm excludes subsets of data from estimation of the effect of the variable(s) of interest. As a result, none of the LMS model estimates on table 6b show a goodness fit of measure, such as an "R-square" that OLS models typically would.

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