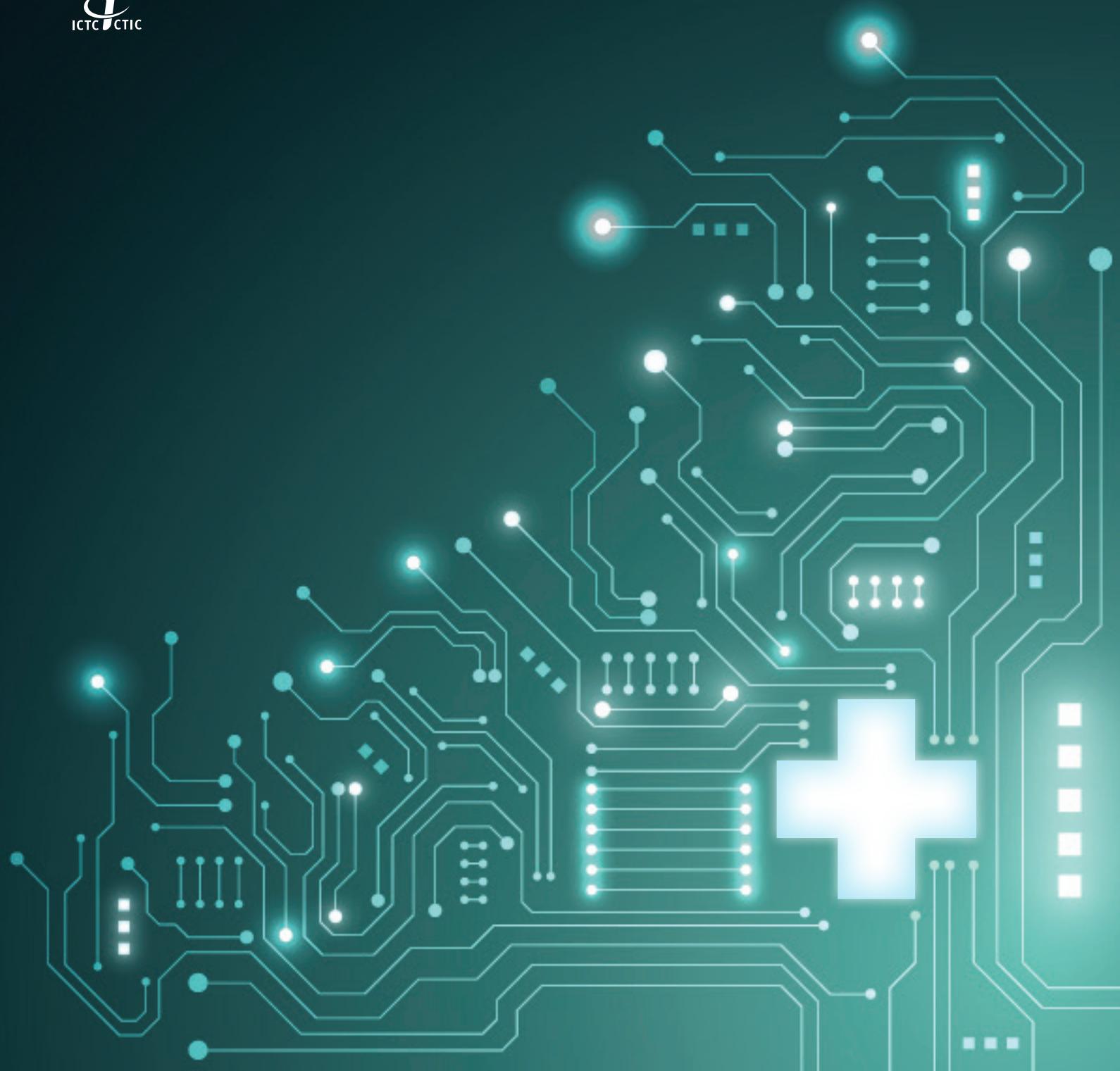


Digital Transformation

The Next Big Leap in Healthcare



Research by



The Information and
Communications Technology Council

Canada 

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Preface

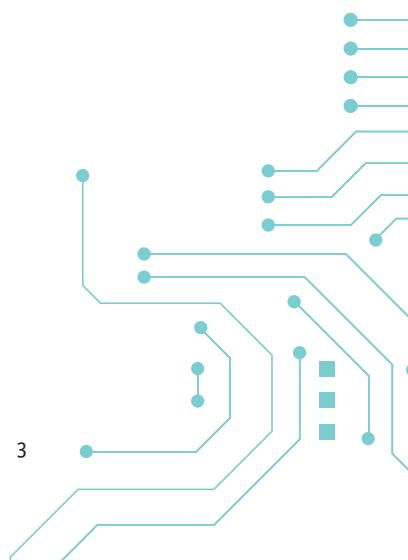
As a not-for-profit, national centre of expertise, ICTC strengthens Canada's digital advantage in the global economy. Through trusted research, practical policy advice, and creative capacity building programs, ICTC fosters globally competitive Canadian industries enabled by innovative and diverse digital talent. In partnership with a vast network of industry leaders, academic partners, and policy makers from across Canada, ICTC has empowered a robust and inclusive digital economy for over 25 years.

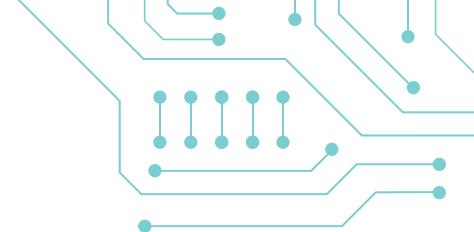
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- Artificial Intelligence (AI)
- Biotechnology
- Canada
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- Digital Economy
- Digital Health
- Healthcare
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Executive Summary

Healthcare is central to the Canadian economy, accounting for 11.5% of Canada's GDP in 2019. In late 2020, COVID-19-related health funding announcements by Canadian governments surpassed \$29 billion, driven by spending on personal protective equipment, screen capacity, labour compensation, and spending for vulnerable populations.¹ Key cost drivers like population growth and age are likely to increase demand for healthcare services and healthcare spending further in the coming years. Technology adoption and the shift to digital could help mitigate these trends while improving access to care and enabling higher-value care models. Telehealth, virtual care, and wearable devices were embraced over the course of the pandemic to meet the demand for distance health, but moving forward, they have the potential to improve access to healthcare and lower costs for patients in rural and remote areas.

At the same time, the health system faces ongoing pressure to adopt new equipment and technology for improving healthcare administration and delivery. For example, while machine learning (ML) and big data applications in healthcare are still only in their infancy, the rapid proliferation of clinical trials and pilot projects—and the increasing sophistication of these applications—point to an exciting future. In this report, ICTC details these and other key trends in health technology. Included is the impact of centralized health records on data management and patient access to data; the growth of telehealth services over the course of the pandemic; the use of wearables, sensors, and cloud technology in-patient monitoring; and the use big data, ML, and AI for drug discovery and clinician support. Further, a dataset of 1202 health technology companies operating in Canada is used to identify key industry groups (e.g., pharmaceuticals and biotechnology, health technology systems, healthcare devices and supplies, healthcare services, and software) and verticals (e.g., health tech, technology, media, and telecommunications (TMT), digital health, life sciences, and AI and ML).

Together, these trends point to increasing demand for digitally skilled labour across the healthcare sector in the coming years. A recent projection by ICTC estimates that demand for digitally skilled labour in the health and biotechnology industry will reach 119,000 by 2022. This report explores the labour market needs resulting from technology trends in the healthcare sector. Of importance are the key roles and skill sets required in different kinds of health technology companies. Various types of health tech companies require medical advisors, software engineers, and full stack developers, as well as data-focused roles like machine learning engineers, data scientists, and data analysts. Meanwhile, product development teams require project managers, designers, and quality assurance professionals, and biotechnology

¹ "National Health Expenditure Trends." Canadian Institute for Health Information, 2020, <https://www.cihi.ca/sites/default/files/document/nhex-trends-2020-narrative-report-en.pdf>

companies require applied scientists and computational scientists. In addition, a key finding in this report is the need for interdisciplinary teams (integrating tech and health backgrounds).

Demand for digitally skilled talent will undoubtedly be moderated by technology adoption trends in healthcare organizations, making adoption an important part of this study. Healthcare organizations are both the clients and customers of health technology companies, and the tech implementation team. The third section of this report situates Canada in the global health tech adoption landscape and identifies domestic regional trends. Canada currently lags its international counterparts in most adoption trends and indicators. Within Canada, geographic differences in health technology adoption are primarily due to urban-rural divides rather than interprovincial and territorial regulatory landscapes. Key barriers to adoption are identified, including complex regulatory environments, cost-based rather than value-based procurement processes, outdated physician compensation models, organizational cultures of resistance, and a lack of capacity compounded by the pandemic. “Calls to Action” to address these and other challenges are discussed throughout the report.

A first-of-its kind study, this report unravels Canada’s evolving healthcare landscape as technology becomes a mainstay of our shared, and largely digital, future. Ensuring health security and delivering higher-value care models for improved patient outcomes requires frameworks that are responsive to current needs, a talent pipeline that is robust, and a focus on technology implementation and equity. Responsive and timely regulation in areas like healthcare data use and privacy is key, as is the development of a skilled and interdisciplinary talent base. Coupled with procurement and funding mechanisms that support innovation, technology adoption, and pan-Canadian access to services, Canada’s digital health future is bright.

Introduction

ICTC's Digital Talent Outlook 2023² report identified health and biotechnology as one of Canada's six key innovation areas: population growth and aging, coupled with high immigration, means certain growth for Canada's healthcare sector in the coming decades. Healthcare is central to the Canadian economy and government spending. The Canadian Institute for Health Information (CIHI) estimates that in 2019, Canada's total health expenditure, which includes public and private health spending, was more than \$265.5 billion.³ This figure is equal to \$7,064 per Canadian and 11.5% of Canada's GDP.⁴ Meanwhile, government spending alone on healthcare reached \$186.5 billion, equal to \$4,910 per Canadian—almost one-quarter of all government spending in Canada (see *Figure 1*).⁵ Health spending as a percentage of GDP has increased in Canada and other OECD countries over the last 30 years,⁶ led by key drivers like population growth, an aging population, the increased prevalence of chronic disease, required improvements to the health system, and the cost of new equipment and technology.⁷

Insights into Canada's Health Spending

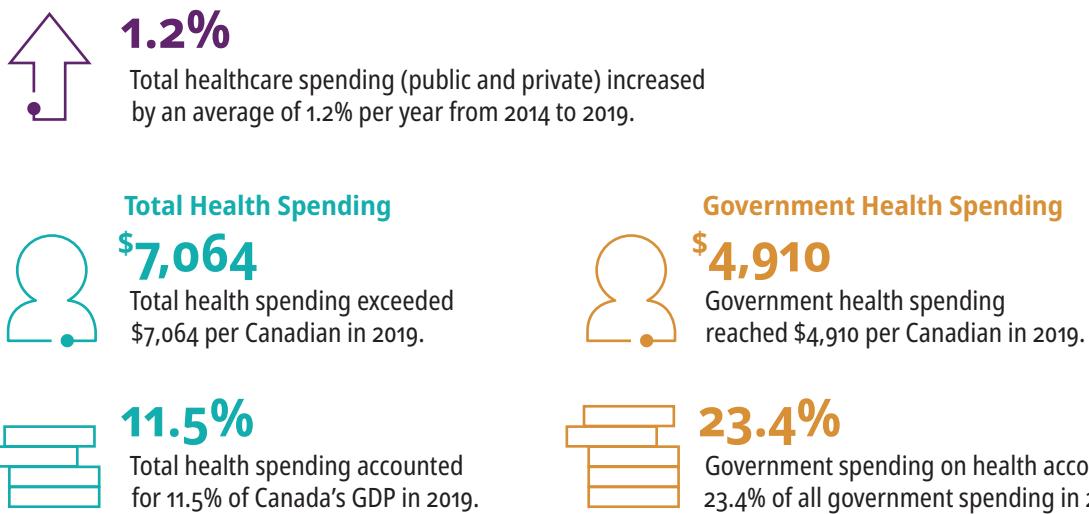


Figure 1. Healthcare spending in Canada. Data source: CIHI. Source: ICTC, 2021

² Alexandra Cutean et al., "Canada's Growth Currency, Digital Talent Outlook 2023," *Information and Communications Technology Council*, October 2019, <https://www.ictc-ctic.ca/wp-content/uploads/2019/11/canada-growth-currency-2019-FINAL-ENG-10.28.19.pdf>

³ "National Health Expenditure Trends," *Canadian Institute for Health Information*, 2020, <https://www.cihi.ca/sites/default/files/document/nhex-trends-2020-narrative-report-en.pdf>

⁴ "National Health Expenditure Trends," *Canadian Institute for Health Information*, 2020, <https://www.cihi.ca/sites/default/files/document/nhex-trends-2020-narrative-report-en.pdf>

⁵ "Three-fifths of total federal, provincial, territorial and local spending went to social protection, healthcare and education in 2019," *Statistics Canada*, November 27, 2020, <https://www150.statcan.gc.ca/n1/daily-quidien/201127/dq201127a-eng.htm>

⁶ "National Health Expenditure Trends: 1975 to 2019," *Canadian Institute for Health Information*, 2019, <https://www.cihi.ca/sites/default/files/document/nhex-trends-narrative-report-2019-en-web.pdf>

⁷ "Healthcare Cost Drivers in Canada: Pre and Post-COVID-19," *Conference Board of Canada*, September 2020, https://www.canadaspremiers.ca/wp-content/uploads/2020/10/CBOC_impact-paper_research-on-healthcare_final.pdf

In 2020 and 2021, the COVID-19 pandemic reinforced the importance of healthcare in Canada. For more than 18 months, healthcare statistics like the number of available beds in intensive care units or the number of new COVID-19 hospitalizations were front and centre in news articles and social media posts. At the same time, COVID-19 has necessitated new spending on healthcare supplies, services, and administration. According to the CIHI, in October 2020, COVID-19-related health funding announcements by federal, provincial, and territorial governments surpassed \$29 billion, driven by spending on personal protective equipment, screen capacity, compensation of health workers, and protecting vulnerable populations.⁸ While the full impact of the COVID-19 pandemic is still uncertain, stakeholders expect healthcare spending to rise more substantially in the short term.⁹ Finally, amid fluctuating lockdowns and stay-at-home orders, COVID-19 also sparked changes in how we deliver healthcare: the pandemic exposed severe challenges with Canada's long-term care system,¹⁰ and for the first time, telehealth services became available to the Canadian public en masse.

Looking forward, healthcare costs are expected to increase further. Pre-COVID-19, the Conference Board of Canada projected that government health spending would increase by an average of 5.4% per year between 2019–20 and 2030–31, and an average of 5.2% per year between 2030–31 to 2040–41.¹¹ By 2040, government health spending per capita would reach a new high of \$7,039 (adjusted for inflation).¹² Similarly, a 2016 report by the Fraser Institute forecasted that healthcare spending would increase by between 4.6% and 6.4% per year from 2015 to 2030.¹³ Meanwhile, Canada's aging population is likely to reduce the available tax base to support new healthcare spending.

While first and foremost a health crisis, the impact of COVID-19 has extended far past the healthcare sector. The pandemic triggered the most significant drop in employment and GDP in Canadian history and necessitated a range of social and economic supports. According to government estimates, in 2021–2022, the federal debt-to-GDP ratio will increase to 52.1%, from approximately 31.2% in 2019–2020.¹⁴ Similarly, the net debt-to-GDP ratio will have increased in most of the provinces.¹⁵ Amid growing costs, Canada's economic position poses an interesting question: how can the healthcare sector continue to serve a growing and aging population, while

⁸ "National Health Expenditure Trends," Canadian Institute for Health Information, 2020, <https://www.cihi.ca/sites/default/files/document/nhex-trends-2020-narrative-report-en.pdf>

⁹ "National Health Expenditure Trends," Canadian Institute for Health Information, 2020, <https://www.cihi.ca/sites/default/files/document/nhex-trends-2020-narrative-report-en.pdf>; "Healthcare Cost Drivers in Canada: Pre and Post-COVID-19," Conference Board of Canada, 2020, https://www.canadaspremiers.ca/wp-content/uploads/2020/10/CBOC_impact-paper_research-on-healthcare_final.pdf

¹⁰ "The Impact of COVID-19 on Long-Term Care in Canada Focus on the First 6 Months," Canadian Institute for Health Information, 2021, <https://www.cihi.ca/sites/default/files/document/impact-covid-19-long-term-care-canada-first-6-months-report-en.pdf>

¹¹ "Healthcare Cost Drivers in Canada: Pre and Post-COVID-19," Conference Board of Canada, September 2020, https://www.canadaspremiers.ca/wp-content/uploads/2020/10/CBOC_impact-paper_research-on-healthcare_final.pdf

¹² "Healthcare Cost Drivers in Canada: Pre and Post-COVID-19," Conference Board of Canada, September 2020, https://www.canadaspremiers.ca/wp-content/uploads/2020/10/CBOC_impact-paper_research-on-healthcare_final.pdf

¹³ Bacchus, B., et al., "The Sustainability of Healthcare Spending in Canada," The Fraser Institute, May 2016, <https://www.fraserinstitute.org/sites/default/files/sustainability-of-health-care-spending-in-canada.pdf>

¹⁴ "Budget 2021: Issues for Parliamentarians," Parliamentary Budget Officer, May 5, 2021, <https://distribution-a617274656661637473.pbo-dpb.ca/9b62e3d2de2a387978d40c6bd7a2beb8386e6d2e7c49d48b55db5a081f862ac6>

¹⁵ "Canadian Federal and Provincial Fiscal Tables," RBC Economics, May 31, 2021, http://www.rbc.com/economics/economic-reports/pdf/canadian-fiscal/prov_fiscal.pdf

also managing costs, modernizing healthcare, and adopting new technologies? Could technology itself play a role in moderating future strain on the healthcare system and lowering costs?

The pandemic has demonstrated that telehealth services can enable greater access to primary care physicians and specialists that are in short supply by removing the location variable from the coordination of care. Where in-person visits are not required and broadband services are available, telehealth and distance-monitoring tools can reduce the need for travel to and from rural and remote areas. Similarly, artificial intelligence (AI) tools can be used to augment and automate certain tasks and help coordinate existing healthcare resources more efficiently. A common example of this is automated radiotherapy treatment planning.¹⁶ Cancer Care Ontario has prioritized the use of AI to conduct radiotherapy treatment planning in its *2019 to 2023 Implementation Plan*,¹⁷ and for some healthcare institutions, automated treatment planning is already the routine standard for certain kinds of cancer.¹⁸

Digital Transformation: The Next Big Leap in Healthcare sets out to assess these and other trends in Canada's health technology industry, including company trends, trends in health technology, technology adoption, and in-demand roles and skill sets. The report uses a mixed-methods research approach, including secondary literature and data, web scraping, 26 key informant interviews (KII), and an industry survey of 306 health technology companies. In addition, over the course of the research project, an advisory committee met twice to validate the research findings. Qualitative material from the interviews is referred to throughout the report. Meanwhile, the survey findings are primarily discussed in **Section III**. Further details about the research methodology can be found in Appendix A.

Section I of the report provides an introduction to the health technology industry, beginning with key definitions and trends. The second part of Section I provides an overview of Canada's health technology industry and delves into a dataset of 1202 health technology companies operating in Canada. It details the prominent industry groups and tech verticals, in addition to trends in company size, location, founding date, ownership status, and financing status. **Section II** presents the in-demand roles and skills in the Canadian health tech ecosystem along with specific examples. Finally, **Section III** provides insight into the health technology adoption landscape in Canada. It reviews technology adoption by region and discusses the key challenges to adoption.

Included throughout the report are Calls to Action to address challenges discussed in the report.

¹⁶ Thomas G Purdie et al., *Automation and intensity modulated radiation therapy for individualized high-quality tangent breast treatment plans*, *Int J Radiat Oncol Biol Phys*, November 2014, <https://pubmed.ncbi.nlm.nih.gov/25160607/>

¹⁷ Ontario Funds New Group of Health Tech Projects, *Canadian Healthcare Technology*, January 2018, <https://www.canhealth.com/2018/01/10/ontario-funds-new-group-of-health-tech-projects/>

¹⁸ "Radiation Treatment Program: Implementation Plan 2019–2023," *Cancer Care Ontario*, 2019, <https://www.cancercareontario.ca/en/cancer-care-ontario/programs/clinical-services/radiation-treatment/implementation-plan>

SECTION I

The Health Technology Industry

Defining Health Technology

As is often the case with emerging industries, there are many of different ways to define Canada's health technology industry. The Canadian Medical Association separates modern developments in health technology into three broad categories: virtual care (to reduce or replace in-person interactions), big health data (to analyze large volumes of health data), and technological developments (including robotics, 3D printing, virtual and augmented reality, nanotechnology, Internet of Things, smartphone apps, and blockchain).¹⁹ Meanwhile, OMERS Ventures, a prominent Canadian investment firm, identifies six "top categories," including care coordination, home care, health data sharing, telemedicine, drug discovery, and wellness.²⁰ For the purposes of this study, the health technology industry includes companies, products, and services that:

- Use information and communication technologies in prevention, diagnosis, treatment and post treatment, and for telemedicine, care coordination, and data sharing
- Use big data to identify correlations between gene sequences and diseases to aid in the design of novel drugs, and tailor treatments to individual patients based on their DNA sequences (bioinformatics)
- Use biotechnology for medical purposes, including the engineering of genetic cures, or designing organisms that create antibiotics (red biotech)²¹

Annual investments in the global digital health industry have grown substantially over the past decade (see *Figure 2*), and with healthcare top of mind for companies, investors, and governments alike, annual investments in digital health set new records in 2020.²² While varied definitions and hard-to-track financial activity make

¹⁹ "The future of technology in health and healthcare: a primer," CMA, <https://www.cma.ca/sites/default/files/pdf/health-advocacy/activity/2018-08-15-future-technology-health-care-e.pdf>

²⁰ Michelle Killoran, HealthTech is Heating Up in Canada, LinkedIn, February 2018, <https://www.linkedin.com/pulse/healthtech-heating-up-canada-michelle-killoran-cpa-ca-cbv/>

²¹ Alexandra Cutan et al., "Canada's Growth Currency, Digital Talent Outlook 2023," Information and Communications Technology Council, October 2019, <https://www.ictc-ctic.ca/wp-content/uploads/2019/11/canada-growth-currency-2019-FINAL-ENG-10.28.19.pdf>

²² "State of Healthcare Q3'20 Report: Investment Trends to Watch," CB Insights, 2020, https://www.cbinsights.com/reports/CB-Insights_Healthcare-Report-Q3-2020.pdf

it difficult to assess the exact size of the global health technology market, most estimates point to an approximate value of USD \$100 billion as of 2019, with a compound annual growth rate of 25% to 29% over the next five to six years.²³ In terms of market distribution, CB Insights reports that the majority of digital health funding comes from North America, Asia, and Europe. Canada ranks fourth in the number of funding deals between Q4 2017 and Q3 2020.²⁴

Investor Funding in the Health Technology Industry 2010–2019

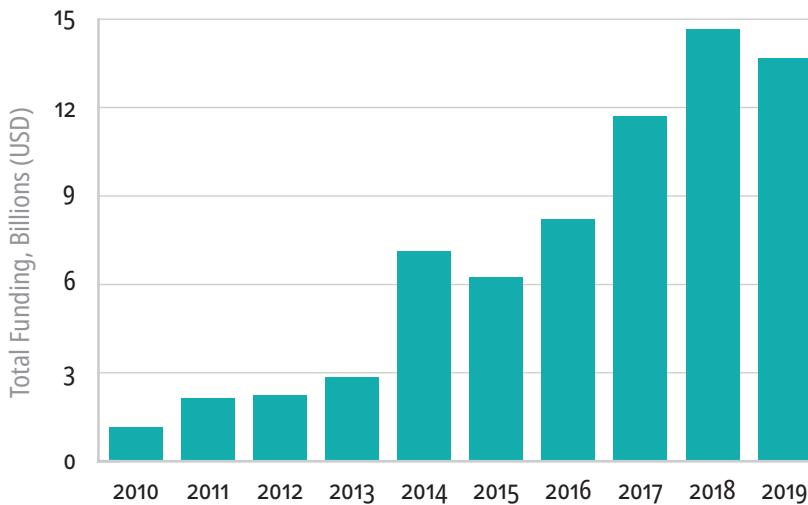


Figure 2. Total digital health industry funding worldwide from 2010 to 2019. Data Source: CB Insights.²⁵

Health Technology Trends

Healthcare technology has changed drastically over time, from the pursuit of electronic health records in the late 1990s and 2000s to the use of sensors and cloud technology for remote monitoring today. Based on interviews with industry stakeholders, this section discusses key trends in health technology.

Centralized Electronic Health Records

An early trend in health technology, beginning in the 1990s, was the transition from paper to electronic documentation (however, there remains today hybrid use of paper and electronic records across Canada's health sector). While an "electronic

²³ "Digital Health Market size was estimated over USD 106 billion in 2019 and the industry will grow at 28.5% CAGR through 2026." See: Sumant Ugamugle and Rupali Swain, Digital Health Market Size By Technology, Global Market Insights, June 2020, <https://www.gminsights.com/industry-analysis/digital-health-market>; "The global digital health market was valued at USD 111.4 billion in 2019 and is expected to reach USD 510.4 billion by 2025." See: Digital Health Market, VynZ Research, April 2020, <https://www.vyzresearch.com/healthcare/digital-health-market>; "The global digital health market is expected to reach USD \$385.8 billion by 2025, from an estimated market size of USD \$103.1 billion in 2019." See: Global Digital Health market Size, Status and Forecast 2025, Valuates Reports, October 2019, <https://reports.valuates.com/market-reports/QYRE-Othe-0A163/digital-health-market>; "The global digital health market size is predicted to grow at a remarkable CAGR of 19.04% from 2020 to 2025. This market is estimated to be worth USD \$312.6 billion by the end of 2025." See: Global Digital Health Market Size, Share, Trends, Growth and COVID-19 Analysis Report – Segmented By Technology, Component and Region – Industry Forecast (2020 to 2025), Market Data Forecast, February 2020, <https://www.marketdataforecast.com/market-reports/digital-healthcare-market>.

²⁴ State of Healthcare Q3'20 Report: Sector And Investment Trends To Watch, CB Insights, https://www.cbinsights.com/reports/CB-Insights_Healthcare-Report-Q3-2020.pdf

²⁵ "Digital health Dossier," Statista, 2020, <https://www.statista.com/study/27232/digital-health-statista-dossier/>

medical record” is a patient’s health record *specific* to a single clinic or practice, an “electronic health record” details a patient’s encounters with the entire health system, including primary care, ambulatory care, in-patient care, and community care interactions, etc.²⁶ Over time, health systems have been moving from the former to the later, with the goal of making patient health records more centralized. However, what this looks like in the different provinces and territories largely depends on the local health system’s organizational structure. For example, while there is a single, centralized health system in Alberta, other provinces like Ontario and British Columbia have multiple health networks.

According to interviewees, electronic health records have provided a wealth of benefits to patients and care providers alike. For healthcare providers, centralized health records have helped reduce the occurrence of medical errors due to lacking or inaccurate health information, prevent redundant diagnostic testing, and improve efficiency.²⁷ From the patient’s perspective, centralized health records have made interactions with the healthcare system less disjointed, allowing for unified, continuous care across health institutions. For example, one interviewee explained that prior to the recent implementation of their centralized information management software, healthcare providers were unable to access patient information from visits to other hospitals or even other departments within the same hospital, including information about their diagnosis, treatment plan, or prescriptions. To get this information, they would have to call or fax the previous healthcare provider or rely on the patient’s recollection of the visit.

Beyond these benefits, centralized health records have enabled greater patient access to health information. Modern healthcare software providers like EPIC²⁸ and Cerner²⁹ have built in-patient portals that provide patients real-time access to health records, test results, and appointment summaries. As one interviewee put it, “One of the bigger opportunities [with patient portals] is patients now being in charge of their care, being a member of the hospital, not a client.” Looking forward, it is likely that centralized health records will continue to improve data access—for things like population health research, big data, and artificial intelligence.³⁰ However, interviewees cautioned that while vast progress has been made in electronic documentation, further work is needed to fully implement the current advances in health information systems, break down regional silos between health information systems, (this is discussed further in the section on industry challenges), and give patients greater control over their data.

²⁶ *Electronic Health Records and Electronic Medical Records*, Canada Health Infoway, 2021, <https://www.infoway-inforoute.ca/en/solutions/digital-health-foundation/electronic-health-records>

²⁷ Boothe, C., et al., “The History of Technology in Nursing: The implementation of electronic health records in Canadian healthcare settings,” *Canadian Journal of Nursing Informatics*, June 20, 2020, <https://cjni.net/journal/?p=7192>

²⁸ “EPIC,” EPIC, June 20 2020, <https://www.epic.com/software>

²⁹ “CERNER,” CERNER, 2021, <https://www.cerner.com/>

³⁰ Boothe, C., et al., “The History of Technology in Nursing: The implementation of electronic health records in Canadian healthcare settings,” *Canadian Journal of Nursing Informatics*, June 20, 2020, <https://cjni.net/journal/?p=7192>

In terms of fully implementing the current advances in health information systems, interviewees noted that many of the existing systems are not being used to their full capacity. Some interviewees clarified that their plan is to roll out the full functionality of their software programs slowly over time (to allow healthcare providers time to adapt), while others highlighted behavioural and organizational challenges to implementing existing rollouts:

"You can get floated to a different floor in the same hospital and find that they're still doing paper charting, but three floors down, everything's online. So that's something that either the hospitals or the health authorities need to enforce better."

— Healthcare Professional

While it was once debated whether health data should be made available to patients, interviewees noted "it is now acknowledged and recognized that citizens should have access to their personal information." Provinces like Ontario have even afforded individuals a legal right to access their personal health information record in an electronic format.³¹ However, while the long-term trend has increased patient access to health data over time, there are still significant barriers to access, and patient control over health data is still limited. For example, one interviewee highlighted that in some provinces, if a patient is moving to a new province or territory and wants to get a copy of their medical record, they would still need to go to each of their medical offices, line up, wait, and pay to have their file photocopied: "To me, that says that we don't actually own our own data," an interviewee said. Several interviewees noted that the next big stride in-patient health information will be ensuring that patients own and have full control of their data. However, the exact technical solution is unclear. One possible approach that was highlighted is self-sovereign identity, a class of identity management where "the user, and only the user, has full control over their data."³² Self-sovereign identity counters provider-centric identity management, which is the existing status quo and has resulted in individuals having many scattered identities with different service providers.

"I would go so far as to say that patients should own and be able to enable access of their personal health information: not just the ability to see your values on a screen, but actually hold your own data, move it around, donate it for research purposes, and be able to see how people are using your personal health information. I think really that's where it's going."

— Professor

³¹ "Recent amendments to the Personal health Information Protection Act," BLG Canada's Law Firm, May 13 2020, <https://www.blg.com/en/insights/2020/05/recent-amendments-to-phipa>

³² Ferdous, S., Chowdhury, F., and A., Madini, "Self-Sovereign Identity Leveraging Blockchain Technology," Institute of Electrical and Electronics Engineers, July 25 2019, <https://ieeexplore.ieee.org/document/8776589>

“What I’d like to see is every Canadian having their own portable electronic health record, so that no matter where they seek healthcare, whether it’s public or privately funded, they can get their information: assessments, tests, diagnostic results would all be in one electronic health record that the patient would not only be able to access but contribute to as well.”

Civil Sector Executive

Telehealth Services

Telehealth services, sometimes referred to as telemedicine, are an alternative to in-person consultations with healthcare professionals. Telehealth services are conducted through electronic communications, whether by telephone, audio or video call, or text, allowing patients to meet with healthcare providers from their own homes and/or enabling them to meet with distant healthcare professionals that would otherwise involve travel.

Interviews were conducted during the COVID-19 pandemic, making telehealth a core topic of discussion. As COVID-19 sparked lockdowns and stay-at-home orders, the interest in and use of telehealth services by Canadians grew. Leveraging telehealth services was one way to help reduce the spread of COVID-19, by ensuring that small waiting room spaces were not congested and helping people maintain social distancing protocols.³³ In terms of impact, interviewees noted that above all, telehealth has “immensely improved access to care” for communities that have insufficient access to primary care physicians or specialists. Prior to telehealth, patients in these communities had to travel to other cities or regions to receive care, increasing the complexity of care delivery and prolonging wait times. These benefits were also realized in prior studies of telehealth pilots.³⁴

Another benefit discussed by interviewees was improved patient discharge (and recovery) from intensive care units (ICU) and long-term wards. Specifically, interviewees cautioned that when patients transition from the ICU or long-term care to their homes, they “do not get better the instant they get home,” and in many cases are “recovering for up to year.” Before telehealth and remote patient monitoring, this transition was much more abrupt: patients would be discharged and have a follow up appointment with their doctor several months later. Telehealth can make this transition smoother by providing doctors a way to monitor their patient’s progress over time without additional in-person checkups. Meanwhile, remote patient monitoring (which is discussed in the following section) can provide doctors with more comprehensive data to inform decision-making or foresee emergencies: one interviewee, whose company focuses on virtual care and remote patient management, reduced the occurrence of readmissions from 26% to 3%.

³³ Elham Monaghesh and Alireza Hajizadeh, “The role of telehealth during COVID-19 outbreak: a systematic review of current evidence,” *BMC Public Health*, August 2020, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7395209/#:~:text=Telehealth%20has%20the%20potential%20to,continuous%20care%20to%20the%20community>

³⁴ “Telehealth Benefits and Adoption: Connecting People and Providers,” *Canada health Infoway*, May 30, 2011, https://www.infoway-inforoute.ca/en/component/edo_cman/resources/reports/333-telehealth-benefits-and-adoption-connecting-people-and-providers-full

Despite the recent surge of interest in telehealth, Canada is still in the early days of its deployment. Many interviewees placed caveats on the long-term impacts of telehealth in terms of its suitability for certain types of healthcare services and patient interest. Interviewees cautioned that while “in some cases, for some people, and some conditions” telehealth services are great, there are a lot of other cases where telehealth does not work well (i.e., instances where broadband infrastructure may be weak or nonexistent). Interviewees hypothesized that when the pandemic is over, the growth of telehealth will reach an equilibrium, giving way to a hybrid model of care where “the use of technologies is no longer dictated by geographic distance or in terms of cost or time savings, but instead by where it makes sense.” In terms of patient interest, interviewees highlighted that not all patients want to engage the in same way, which is reflected in Canada Health Infoway’s “Access to Digital Health Services” survey of Canadians.³⁵ Interviewees also noted that when the novelty of new health technologies wears off, patients can lose interest, posing questions about the long-term sustainability of public sector investments in expensive tech.

Finally, interviewees differed in their perspectives on the role that privatized telehealth services should play in a publicly funded healthcare system. In the past five years, telehealth startups like Maple,³⁶ Babylon,³⁷ and Dialogue³⁸ have begun providing privatized telehealth services in Canada, either via a fee-for-service business model or by integrating with private insurance companies or employer benefits packages. Some interviewees felt that privatized telehealth services are a value-add for Canadian healthcare—enabling greater access to healthcare services, reducing wait times, and “reducing pressure on the public healthcare system at no cost to government.” However, others cautioned that privatized telehealth services actively promote a two-tier system, “exacerbate inequality,” and threaten the universality of Canadian healthcare.

Wearables, Sensors, and Cloud Technology

Wearable technology (“wearables”) are Internet of Things³⁹ devices that can be worn on a user’s body to collect data: this could be biometric data like heart rate, blood-oxygen, or blood-glucose levels; fitness data like calorie use and step count; or other lifestyle data, such as sleep, water intake, or fall detection. Wearable technologies use sensors, microprocessors, network connections, and cloud technologies to collect, process, send and receive, and store data. Over time, wearable devices have become more accessible, smarter, and more capable. As with other sectors, there are a vast number of possible applications for wearables and internet connected

³⁵ “Access to Digital Health Services: 2019 Survey of Canadians Summary Report,” Nielsen Company and Canada Health Infoway, 2019, <https://www.infoway-inforoute.ca/en/component/edocman/3786-access-to-digital-health-services-2019-survey-of-canadians-summary-report/view-document?Itemid=0>

³⁶ “Maple: Online doctors, virtual health, and prescriptions in Canada,” Maple, 2021, www.getmaple.ca

³⁷ “Babylon: Hello. We’re Babylon, a digital health company on a mission,” Babylon, 2020, <https://www.babylonhealth.com/ca/>

³⁸ “Dialogue: One platform. Powerful Health Benefits,” Dialogue, 2021, <https://www.dialogue.co/en/>

³⁹ “The Internet of Things refers to the proliferation of internet-connected objects that are often embedded with sensors and designed to measure a specific outcome.” Cutan, A., McLaughlin, R., “The Rebuild: Going Digital and the Role of Canadian Telecom in a Post-COVID Future,” November 2020, Information and Communications Technology Council, <https://www.ictc-ctic.ca/wp-content/uploads/2020/11/The-Rebuild-ICTC-10.30.20.pdf>

sensors in healthcare. Two of the most prominent applications are **self-monitoring tools** and **remote patient monitoring** (sometimes referred to as **remote patient management**). These devices are empowering patients to become more involved in their healthcare and enabling higher-value care models within the public healthcare system.

Self-Monitoring Tools

It is often said that “patients are the most underused resource in healthcare.” Patients may be disengaged from their health all together or may not properly understand how everyday decisions will impact their long-term health or chronic health conditions. In Canada, there is a high prevalence of avoidable diseases caused by poor health habits, as well as a persistently high prevalence of preventable chronic disease risk factors.⁴⁰ Approximately 80% of Canadians have at least one “modifiable risk factor” for chronic disease, including self-reported tobacco smoking, physical inactivity, unhealthy eating, and harmful use of alcohol.⁴¹ In terms of physical inactivity, Canada has a high prevalence of sedentary behaviour and high rates of obesity, while more than 90% of Canadian children do not meet physical activity guidelines.⁴² Many health tech solutions seek to address these challenges by better engaging patients in their own health outcomes.

“Mobile applications have empowered patients to be more involved in their care, moving from a situation where patients only rely on what their physicians are telling them during their clinic visit to something that’s more involved and enables them to engage their care between clinic visits.”

Professor

“With digital health tools, people can engage with a level of education that just isn’t possible in a 15-minute consult with your doctor. When you get people to engage in that level of education, the results are striking. Caring for yourself is really powerful.”

Health Technology Company Executive

Looking toward the future, interviewees were excited about using self-monitoring tools to transition the health system from low- to high-value care models.

Interviewees used the term “low-value care models” to refer to Canada’s traditional approach to healthcare: a patient schedules an in-person visit with their primary care physician every six months to a year, while their physician uses momentary, scattered data points to inform clinical decision-making. Alternatively, “high-value care models”

⁴⁰ How Healthy Are Canadians? Public Health Agency of Canada, December 2016, <https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/healthy-living/how-healthy-canadians/pub1-eng.pdf>

⁴¹ How Healthy Are Canadians? Public Health Agency of Canada, December 2016, <https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/healthy-living/how-healthy-canadians/pub1-eng.pdf>

⁴² “Canada also ranks amongst the worst of OECD countries for adult obesity rates.” See: How Healthy Are Canadians? Public Health Agency of Canada, December 2016, <https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/healthy-living/how-healthy-canadians/pub1-eng.pdf>

use continuous health monitoring and data collection to augment routine checkups, enable predictive health, and strategically schedule in-person interactions with the healthcare system. They use “individualized, real-time health data” to inform clinical decision-making and treatment options.

Like with virtual care, Canada is still only in the early days of self-monitoring tools: public sector interviewees explained that Canada’s health system is not at the point where personal health information is routinely plugged into the primary care space. They explained that today, data sharing between patients and primary care physicians is the exception, not the norm, and occurs only in exceptional cases—for example, when “a technologically literate physician happens to have a willing patient,” or a patient has a serious condition and therefore “a vested interest in adopting a certain device,” or a remote patient monitoring program is in place (this is discussed further in the following section). Another possible reason provided by interviewees is that many public healthcare organizations are only recently able to integrate with modern information technology infrastructure like web APIs (Application Programming Interface, a software intermediary that allows two applications to talk to each other). Nonetheless, interviewees were optimistic that the health system can get to a point where, given patient permission, data sharing will become more normalized and better integrated into healthcare practices.

Remote Patient Monitoring

Remote patient monitoring is an emerging industry where wearables and sensors are used to gather patient statistics specifically for use by a healthcare professional. More recently, the remote monitoring industry has given way to remote patient management, which extends that focus to include remote patient check-ins and remote provision of healthcare advice. As discussed, remote patient monitoring tools can be used to facilitate smoother and more engaged discharge processes when discharging patients from ICU facilities. They can also be used to alleviate pressure on the healthcare system by preventing hospital readmissions,⁴³ replace expensive services like old age care,⁴⁴ or enable remote clinical research.⁴⁵ Combined with AI and machine learning, remote monitoring tools can be used by clinics to prioritize at risk patients and avoid unnecessary routine checkups:

⁴³ “North York General Hospital has launched a new virtual care program aimed at protecting patients and preventing hospital readmissions through remote monitoring. The [program] utilizes an app called Vivify, which helps monitor two patient populations.” “The purpose of this new virtual care application is to decrease the number of recurring visits to the Emergency Department through enhanced symptom monitoring and rapid care.” See: “Remote Patient Monitoring Virtual Care Program,” NYGH, 2020-2021, [https://www.nygh.on.ca/patients-and-visitors/covid-19-updates/remote-patient-monitoring-virtual-care-program](https://www.nygh.on.ca/patients-and-visitors/covid-19-updates/virtual-care-patients/remote-patient-monitoring-virtual-care-program)

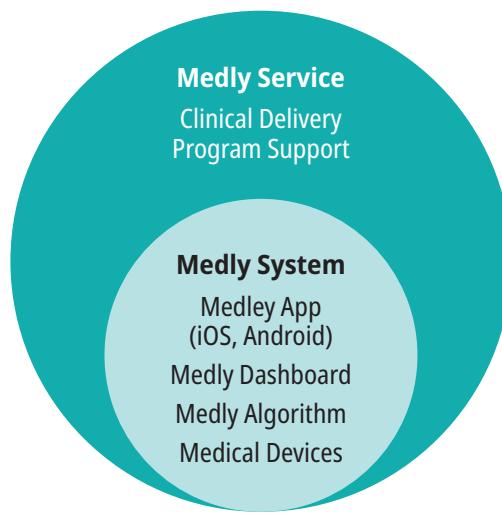
⁴⁴ For instance, Telus Health has been exploring the use of its Home Health Monitoring system with seniors as a cheaper alternative to old age care homes. See: Home Health Monitoring, Telus Health, 2021, <https://www.telus.com/en/health/organizations/health-authorities-and-hospitals/patient-and-consumer-engagement-solutions/home-health-monitoring>

⁴⁵ For example, one interviewee noted that in their field, researchers will “continue to take the technologies that [they] can validate in the lab and bring them into the field: giving wearable sensors, mobile cameras, or apps to clinical partners, so they can collect different types of data, ship them to databases in the cloud, and then analyze them.” Further they noted that, “at least in [their] field, the combination of wearable technology and cloud computing is going to continue to advance a lot.”

"We have these traditional, written-in-stone rules that create supply-side challenges: you have to see a diabetes patient every three months; you have to see a chronic heart patient every three months; or you see your chronic-conditions patients when things get so bad that they end up in emergency. This is where digital health, wearables, and sensors come in. We can find out when patients actually need to see their healthcare professionals, be more predictive, and anticipate. Imagine we continuously or periodically monitor a patient with a wearable device or have a patient self-monitor. That data could be run through a form of intelligence, which would alert the clinic and the patient appropriately if they needed to be seen. We could get to a point where the data collection is almost ambient—where you don't really need to think about it—and we're slowly getting there."

Professor

One example of this type of solution is Medly, a Toronto-based application built by eHealth Innovation at the University Health Network. Medly is "a heart failure self-management program," consisting of a core suite of technology components that support patient monitoring, and the Medly Service, whereby registered nurses, nurse practitioners, and cardiology specialists monitor and respond to incoming alerts (see *Figure 3*).⁴⁶ To date, Medly has been used by eight cardiologists with over 800 patients at the UHN Peter Munk Cardiac Centre, where the app "led to a 50% reduction in the number of heart failure-related hospitalizations and a 24% reduction in the number of hospitalizations for any reason."⁴⁷ According to patients involved in the study, Medly provided increased self-management support, peace of mind, and an improved relationship with their care team.



⁴⁶ "What is Medly," Medly, 2021, <https://medly.ca/about/what-is-medly/>

⁴⁷ Ware, P., et al. "Patient adherence to a Mobile Phone-Based Heart Failure Telemonitoring Program: A Longitudinal Mixed-Methods Study," *Journal of Medical Internet Research*, December 2019, <https://mhealth.jmir.org/2019/2/e13259/>; Seto, E., et al., "Mobile Phone-Based Telemonitoring for Heart Failure Management: A Randomized Controlled Trial," *Journal of Medical Internet Research*, 2020, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3374537/>

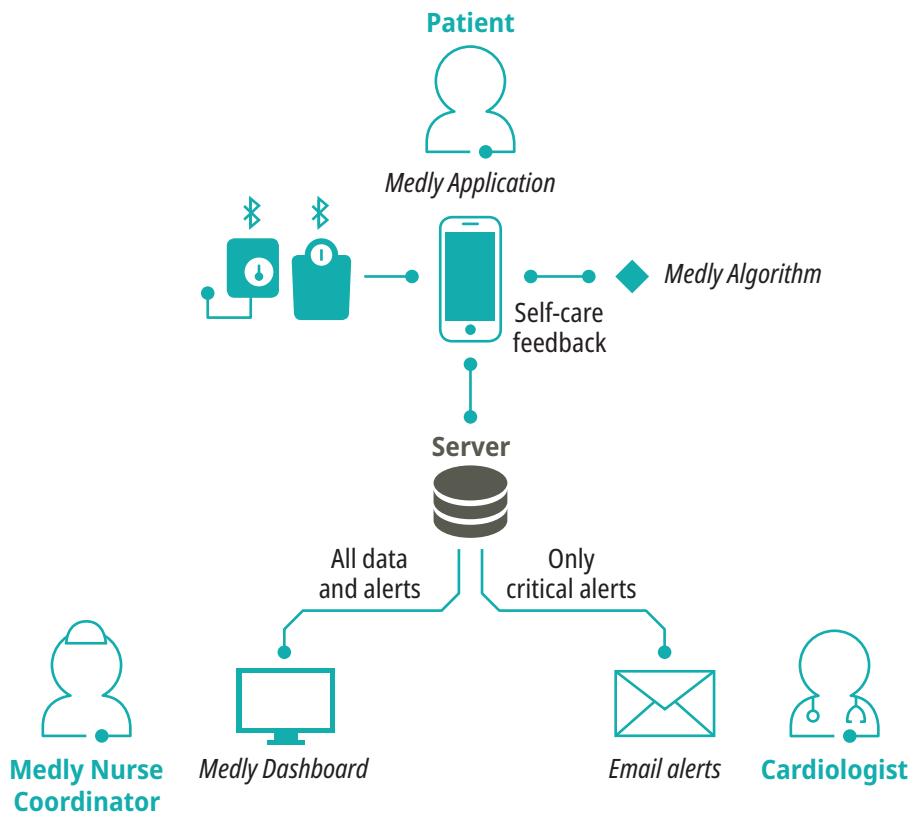


Figure 3. The Medly System and Service. eHealth Innovation @ UHN, 2021.⁴⁸

Big Data, Machine Learning, and Artificial Intelligence

As a greater portion of Canada's health records become digital and centralized, as the health sector's approach to IT matures, and as IoT devices proliferate, so too does the amount of available "big health data." The Canadian Medical Association defines big health data as "the ability to analyze large volumes of different types of data from a variety of sources that are continuously generated." As these trends develop and converge, there is greater opportunity to create and apply AI and ML algorithms within the health sector.

⁴⁸ "What is Medly," eHealth Innovation @ UHN, 2021, <https://medly.ca/about/what-is-medly/>



Figure 4. Health-related big data. Vayena E, Dzenowagis J, Brownstein J, et al. "Policy implications of big data in the health sector," 2018, Bulletin of the World Health Organization

In terms of trajectory, many interviewees highlighted that when it comes to health applications, AI is still "in an embryonic phase." For example, public sector interviewees discussed how AI is mostly being applied in healthcare as pilot programs or clinical trials. That said, interviewees clarified that "there is no doubt that AI is here" and expanding at an "exponential, not linear," pace. Further, pilot projects and clinical trials are beginning to demonstrate clear benefits. While there is a near endless number of possible applications for big data and AI in health, some interesting ones are the following:

Diagnostic and decision support: Clinician decision support systems "are used to augment clinicians in complex decision-making processes."⁴⁹ They analyze electronic health records and other data to assist healthcare providers with diagnosis, decision-making, and "implementing evidence-based clinical guidelines at the point of care."⁵⁰

Chronic disease management: Combined with remote monitoring tools, AI can help healthcare providers deliver ongoing support to chronic disease patients and prioritize those who are most at risk. (Chronic diseases, such as arthritis, diabetes, cancer, and heart disease, are conditions that last more than a year and have a significant impact on daily life.)

Task augmentation or automation: A common example of this is the use of ML to enable automated radiotherapy treatment planning: automated radiotherapy treatment planning is already the standard for certain kinds of cancer. Some industry stakeholders predict that ML will "displace the work of radiologists and anatomical pathologists, who focus on the interpretation of digitized images."⁵¹

Bioinformatics: Bioinformatics uses big data to identify correlations between gene sequences and diseases, aid in the design of novel drugs, and tailor treatments to individual patients based on their DNA sequences. For example, precision medicine is "an innovative approach [to medical treatment] that takes into account individual differences in people's genes, environments, and lifestyles."⁵²

Population health management: This field focuses on the use of aggregate patient data and other big health data to manage population health. In recent years, its focus has expanded to include "the promotion of health lifestyles and the role of non-medical determinants of health."⁵³

Public health emergencies: The use of big data to detect and respond to public health emergencies like disease outbreaks. Canadian start-up BlueDot uses algorithms and big data to track and predict outbreaks in infectious diseases. BlueDot collects data from a variety of sources, including travel information, human, animal, and insect population data, climate data, information from journalists and healthcare workers, and in about 65 languages.⁵⁴

⁴⁹ Sutton, R., et al., "An overview of clinical decision support systems: benefits, risks, and strategies for success," *NPJ Digital Medicine*, February 2020, <https://www.nature.com/articles/s41746-020-0221-y>

⁵⁰ "Clinical Decision Support," US Department of Health and Human Services, June 25, 2020, <https://www.cdc.gov/dhsp/pubs/guides/best-practices/clinical-decision-support.htm>

⁵¹ "The Future of Technology in Health and Healthcare: A Primer," Canadian Medical Association, August 5, 2018, <https://www.cma.ca/sites/default/files/pdf/health-advocacy/activity/2018-08-15-future-technology-health-care-e.pdf>

⁵² "The Future of Technology in Health and Healthcare: A Primer," Canadian Medical Association, August 2018, <https://www.cma.ca/sites/default/files/pdf/health-advocacy/activity/2018-08-15-future-technology-health-care-e.pdf>

⁵³ Ibid.

⁵⁴ Ben Dickson, "How AI Is Helping in the Fight Against COVID-19," *Entrepreneur*, April 2020, <https://www.entrepreneur.com/article/348941>

Despite progress to date, there remains several challenges in applying big data and AI to health research and health system innovation. For one, Canada has yet to establish modern privacy legislation that sufficiently governs the use of personal information in the context of AI.⁵⁵ Secondly, big data and AI require access to large amounts of different types of data, which is hampered by incredibly siloed health system IT infrastructure and health data. For example, interviewees in this study referenced silos between the provincial, territorial, and federal health jurisdictions; local health networks or other local health systems; and public and private sector data sources. These silos have long necessitated the need for more secure data sharing infrastructure, however, past attempts to break them down have faced challenges.⁵⁶ Even within health jurisdictions, individual-level data sharing is challenging. "It is often difficult for researchers to get access to high-quality individual-level data for secondary purposes (e.g., testing new hypotheses and building statistical and machine learning models)."⁵⁷ Personal health information (PHI) is one of the most sensitive types of personal data, and there are strict privacy laws pertaining to health information in almost all the provinces and territories.⁵⁸

One significant challenge with PHI relates to the "reuse" or "secondary use" of PHI—e.g., the use of PHI for reasons other than the original purpose. Privacy legislation generally requires that patients provide prior and informed consent for their data to be used, with consent being limited to specific, clearly defined purposes. Using PHI for secondary purposes therefore requires additional consent. While there are some exceptions to this rule, exceptions vary by jurisdiction and research institution. Broadly speaking, de-identified PHI may be used for secondary purposes without consent if the risk of re-identification is low. PHI may also be used for secondary purposes (without consent) if obtaining consent is impossible or impractical.⁵⁹ In both cases, health researchers and health data custodians may be subject to a high level of risk.

Establishing data mobility provisions within Canadian privacy legislation could help address some of these challenges. Data mobility provisions give individuals the right to direct the transfer of their personal information from one organization to another, which would enable individuals to direct their PHI to research purposes as they see fit. Interviewees in this study highlighted that there is an absence of clear

⁵⁵ "Harnessing the Benefits of AI While Reducing the Harms—ICTC Submission: OPC Consultation on Artificial Intelligence," March 2020, Information and Communications Technology Council, <https://medium.com/digitalthinkankictc/harnessing-the-benefits-of-ai-while-reducing-the-harms-f9175990e5dc>

⁵⁶ Delays, grievous under-budgeting, lack of coordination felled Panorama, the federally funded national information system, created in 2004 to function as an immunization tracking system. As provinces struggled to implement the program, the Public Health Agency of Canada dropped the system, leaving the provinces to their own devices. As Justin Ling put it in his recent Macleans article: "It stopped being a cross-compatible national system, administered provincially, and became a smattering of incompatible systems with no real national buy-in at all"; "Canada's Public Health Data Meltdown - Macleans.Ca," accessed June 22, 2021, <https://www.macleans.ca/news/canada/canadas-public-health-data-meltdown/>.

⁵⁷ Azizi, Z., et al., "Can synthetic data be a proxy for real clinical trial data? A validation study," BMJ Open, March 2021, <https://bmjopen.bmjjournals.org/content/bmjopen/11/4/e043497.full.pdf>

⁵⁸ "Provincial and territorial privacy laws and oversight," Office of the Privacy Commissioner of Canada, June 2020, <https://www.priv.gc.ca/en/about-the-opc/what-we-do/provincial-and-territorial-collaboration/provincial-and-territorial-privacy-laws-and-oversight/>

⁵⁹ Eg., if the patient population is very large or likely to be deceased, geographically dispersed, or difficult to track. This is less common and involves strict qualifiers. See, for example: "Tri-Council Policy Statement Ethical Conduct for Research Involving Humans," 2018, Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council, https://ethics.gc.ca/eng/policy-politique_tcps2-eptc2_2018.html

legislative guardrails and technical standards for health data mobility in Canada. Meanwhile, synthetic data, which generates artificial data from real datasets using ML techniques, can protect individual privacy by removing the need to share real personal data. A recently published Canadian study suggests that synthetic data can be used in place of real clinical trial data in certain kinds of healthcare research.⁶⁰ However, while synthetic data addresses individual privacy concerns, it does not address other ethical considerations such as **group privacy**⁶¹ or **historical bias**.⁶²

Calls To Action: Healthcare Data and Data Privacy

Establishing suitable privacy legislation in Canada is important to effectively govern the use of personal data in artificial intelligence and machine learning applications such as automated decision making. This is particularly important for the healthcare sector, which involves highly sensitive data and is subject to a high degree of risk.

Data mobility provisions that would allow patients to direct the flow of their personal health information from one organization to another and enable secondary use is necessary to give patients control over their data and enable healthcare organizations to benefit from big health data. At the same time, healthcare sector stakeholders should work to establish technical solutions for secure data sharing.

Canada's Health Technology Industry Briefly

Due to differences in definition and data collection methods, estimates of the size of Canada's health technology industry vary. A report by Innovation, Science and Economic Development Canada's economic strategy table indicates that Canada's health and bioscience sector consisted of approximately 900 firms in 2018, which included pharmaceutical and biopharmaceutical companies, generics firms, research and manufacturing organizations, and medical technology manufacturers.⁶³

MedTech Canada, the national association representing Canada's innovative medical technology industry, meanwhile reports that there were 1,500 medtech companies in Canada in 2013.⁶⁴ Finally, Tracxn, which tracks business activity, approximates that there are more than 2,624 health tech startups in Canada.⁶⁵ Considering these varied estimates, it is likely that the industry comprises between 1500 and 2000 companies.

⁶⁰ Azizi, Z., et al., "Can synthetic data be a proxy for real clinical trial data? A validation study," *BMJ Open*, March 2021, <https://bmjopen.bmjjournals.org/content/bmjopen/11/4/e043497.full.pdf>

⁶¹ Group privacy is concerned with inferences that can be made about groups of individuals from de-identified data and is based on the understanding that groups—and not just individuals—can experience harms from the collection, use, or disclosure of information pertaining to their group. For more information, see: Kammoureh, L., et al., "Group Privacy in the Age of Big Data," December 29, 2016, *Philosophical Studies Series* https://link.springer.com/chapter/10.1007/978-3-319-46608-8_3; Christen, M., and Loi M., "Two Concepts of Group Privacy," May 29, 2019, *Philosophy and Technology*, <https://link.springer.com/article/10.1007/s13347-019-00351-0>

⁶² Historical biases in health data can negatively impact groups of individuals that are not sufficiently represented (or are misrepresented) in existing health datasets.

⁶³ "Health and Biosciences: The sector today and opportunities for tomorrow," *Innovation Science and Economy Development Canada*, February 2018, [https://www.ic.gc.ca/eic/site/098.nsf/engaj/ISED_C_Table_HB.pdf](https://www.ic.gc.ca/eic/site/098.nsf/engaj/ISED_C_Table_HB.pdf/$file/ISED_C_Table_HB.pdf)

⁶⁴ "About MEDEC The Voice of Canada's Medical Technology Industry," *Medtec Canada*, 2017, https://cdn.ymaws.com/medtechcanada.org/resource/resmgr/Value_of_Technology/About_MEDEC_2017.pdf

⁶⁵ "HealthTech Startup in Canada," *Tracxn*, September 2019, <https://tracxn.com/explore/HealthTech-Startups-in-Canada>

Using Pitchbook data, ICTC compiled a dataset of 1202 companies that make up Canada's health technology industry. These companies are detailed in the sections below, including information about prominent sub-industries and tech verticals, financing and ownership status, number of employees, founding year, and location.

Prominent Industries and Tech Verticals

Technology companies transcend traditional sector and industry categories, making it difficult to categorize startups and technology companies. For example, a fintech company providing software tools to banks could be categorized as operating in both the financial services and ICT sectors. This holds true for health technology companies as well, which can be classified as operating in both the healthcare and ICT sectors. Therefore, it is more appropriate to classify Canada's health technology companies by industry and tech vertical. Among companies in the dataset with an identified primary industry group, the most common industry group was pharmaceuticals and biotechnology, followed by health technology systems, healthcare devices and supplies, health services, and software (see *Figure 5*). Additionally, among the list of 1202 health technology companies, the most occupied technology verticals (in order of importance) were the following:

Health Tech: Companies that provide mobility and other information technologies to improve healthcare delivery while decreasing costs.

Health tech entails the use of technology and services (including cloud computing, internet services, and social mobility) to optimize patient-centric care.

TMT (Technology, Media, and Telecommunications): TMT serves as an industry aggregate intended to capture companies that exist in the TMT value chain.

Digital Health: Companies engaged in building hardware and software solutions to empower individuals to keep track of their health and provide healthcare providers with better tools to communicate and treat patients more easily.

Life Sciences: Companies involved in sciences dealing with living organisms and life processes, including biology, pharmaceuticals, biomedical technology, and nutraceuticals.

AI and ML: Companies developing technologies that enable computers to autonomously learn, deduce and act, through utilization of large datasets.

LOHAS (Lifestyles of Health and Sustainability, Wellness):

Companies that provide consumer products or services focused on health, the environment, green technology, social justice, personal development, and sustainable living.

Oncology: Companies involved in the diagnosis or treatment of cancer without regard to whether they do so through the production of pharmaceuticals, devices, or services-based models.

SaaS (Software as a Service): IT companies that provide access to software via an internet login page and who sell that service to customers through an ongoing subscription.

Wearables and Quantified Self: A consumer healthcare sector entailing sensor-based tracking of aspects of a user's life, including moods, nutrition, and activities.

Big Data: Companies providing a product or service where the core technology handles data that is too large for traditional database systems, usually due to data volume, data velocity, or data variety.⁶⁶

⁶⁶ Definitions are taken from the Pitchbook industry verticals glossary. "What are industry verticals?" Pitchbook, 2021, <https://pitchbook.com/what-are-industry-verticals>

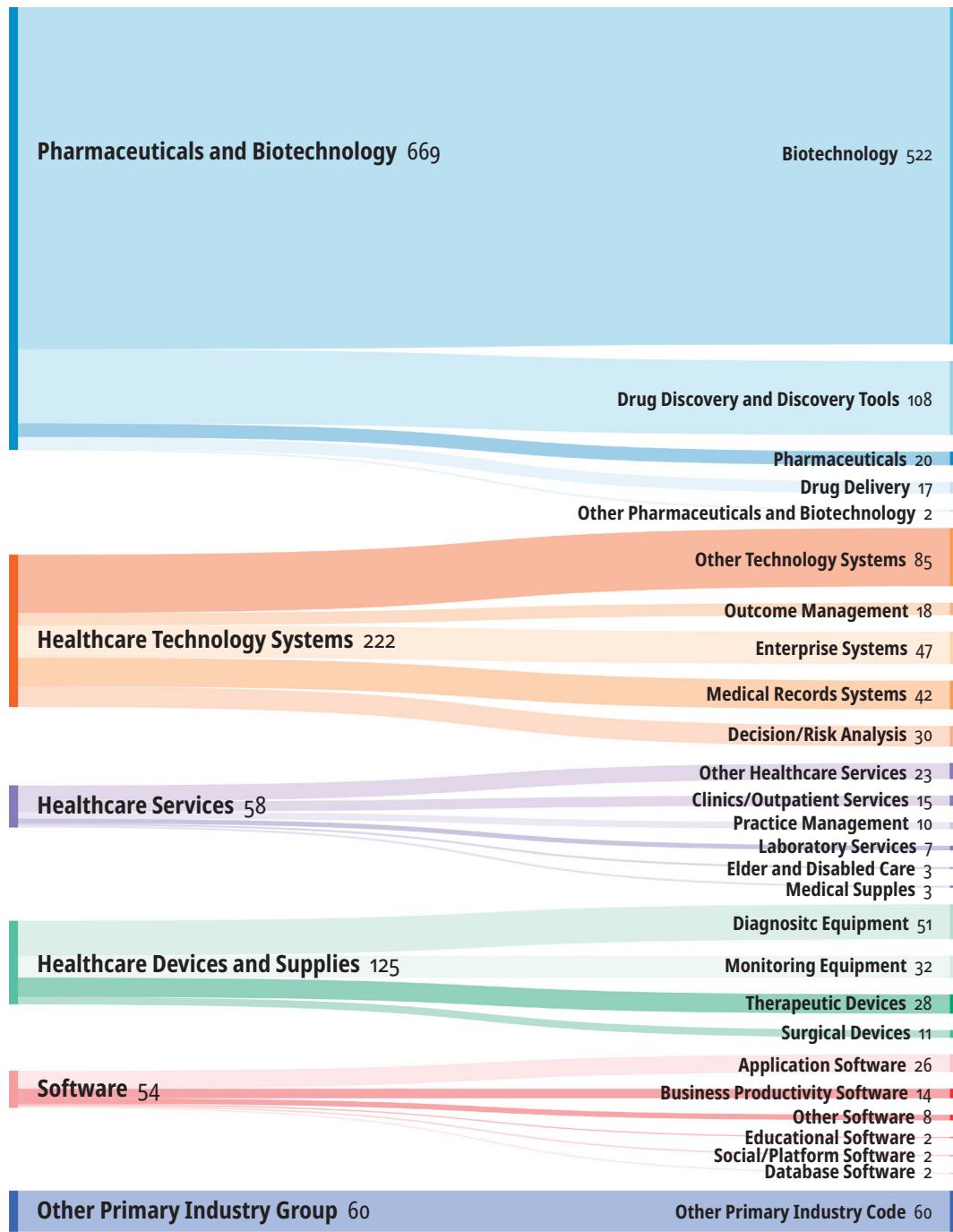


Figure 5. Health technology companies in Canada by primary industry code. Compiled using Pitchbook data.
ICTC, 2021.

Location of Headquarters

In terms of headquarters, the companies in the dataset are primarily located in Canada (94%) and the United States (4%), with a handful of companies headquartered in Europe, the United Kingdom, Middle East, South America, and Asia. Among companies headquartered in Canada, the companies in the dataset are primarily located in Ontario (44%), British Columbia (20%), Quebec (18%), and Alberta (10%). The remaining companies (8%) are headquartered in Nova Scotia, Manitoba, Saskatchewan, New Brunswick, Newfoundland and Labrador, and Prince Edward Island. Figure 6 provides additional detail on the types of companies located in each province, broken down by primary industry group.

Health Technology Companies by Location and Industry

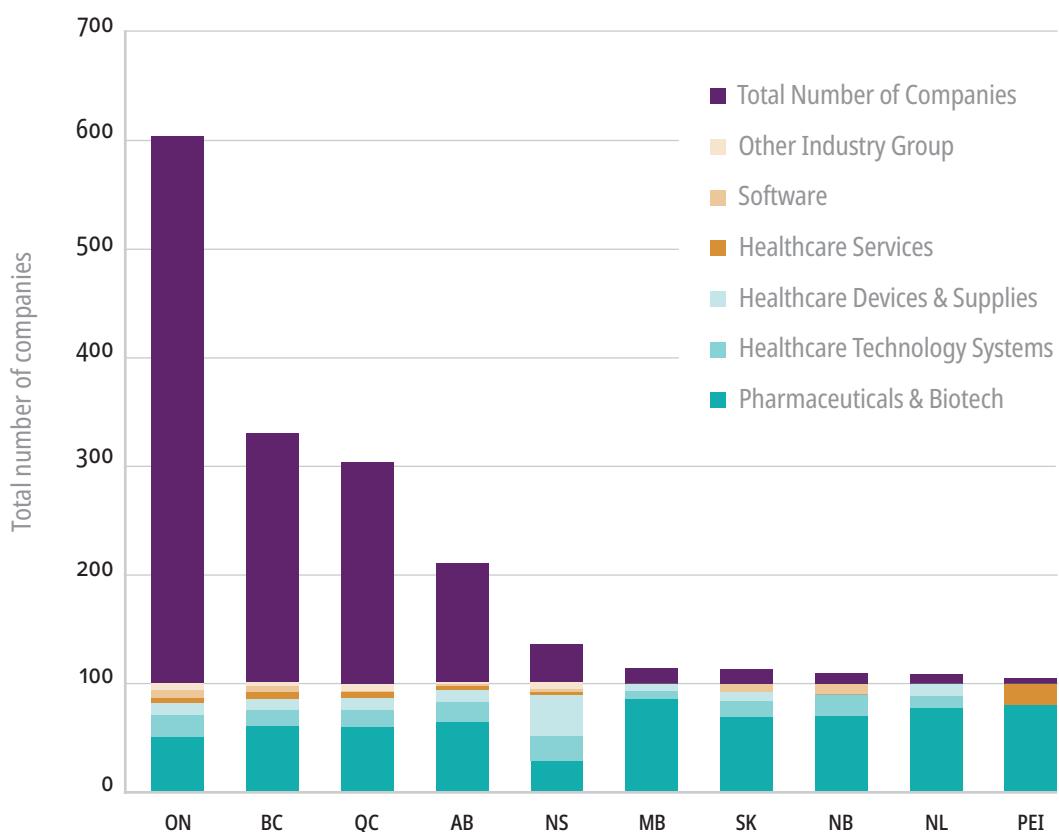


Figure 6. Health technology companies by location of headquarters (province) and industry. Compiled using Pitchbook data. ICTC, 2021.

Company Maturity

Size, founding year, and ownership status are useful indicators for company maturity. While in the larger economy, small to medium sized enterprise (SME)⁶⁷ make up 99.8% of Canadian businesses,⁶⁸ 98% of the companies in the health technology dataset are SMEs (see *Figure 7* for more detail). Interestingly, looking at the companies by industry group, there are clear differences in the average company size. On average, pharmaceutical and biotechnology companies in the dataset have 161 employees, health technology systems companies have 103, healthcare services companies have 71, healthcare devices and supplies companies have 28, and software companies have 17. Almost all of the companies in the dataset that qualify as large enterprises are pharmaceutical and biotechnology firms or ICT firms that provide business-to-business products and services. Similarly, there are differences in the average age of the various industry groups. The average founding date of pharmaceutical and biotechnology companies in the dataset is 2005, followed by healthcare technology systems (2010), healthcare services and healthcare devices and supplies (2011), and software (2012).

Finally, there were also differences in ownership status between industry groups (the ownership status of a company reflects who owns most of the shares in that company). For example, a greater percentage of the pharmaceutical and biotechnology companies were publicly held (10%) as compared with healthcare devices and supplies, healthcare technology systems, and healthcare services companies (5%). No software companies in the dataset were public companies. Meanwhile, a lower percentage of the pharmaceutical and biotechnology companies were privately held with financial backing (27%) as compared with the remaining industry types: 77% of the healthcare devices and supplies companies were privately held companies with financial backing, compared with 63% of the healthcare technology systems, and 60% of the software companies.⁶⁹

Health Technology Companies by Number of Employees



Figure 7. Health technology companies by company size. Of the companies in the dataset, 98% are SMEs with less than 500 employees. Compiled using Pitchbook data. ICTC, 2021.

⁶⁷ According to classification standards developed by Statistics Canada, small to medium sized enterprises are businesses with fewer than 500 employees

⁶⁸ "Key Small Business Statistics – 2020," Industry, Science and Economic Development Canada, 2020, https://www.ic.gc.ca/eic/site/061.nsf/eng/h_03126.html

⁶⁹ According to Pitchbook, a privately held company with financial backing is any company that currently has any level of financial backing, including angel and seed funding.

Funding availability was highlighted by interviewees in this study as crucial to a company's ability to scale. Interviewees explained that the health sector is highly regulated and high risk, and even if clinical trials are not necessary for a given health technology solution, possible clients and customers still need a high degree of assurance that something works before incorporating it into their practice. Health technology companies therefore spend significant time conducting clinical trials or pilot projects to validate their solution and generate evidence that it works in the field before selling to customers. However, many interviewees noted that it is difficult to raise capital successfully in Canada, making access to government funding programs a vital part of company scaling. These comments are reflected in the dataset of 202 health technology companies: 10 of the top 15 investors (for companies in the dataset) are either a university, government, or not-for-profit entity.

"I'd say that even as a digital company, we are more similar to your typical therapeutic company or pharmacological company. When you make a drug, for example, you have to invest heavily in research and clinical trials, all without making any money, and then once proven that it works, that's when you start selling it."

— Health Technology Company Executive

Financing status, sometimes called backing status, is a description of the types of investors that have financed a company. Among Canadian companies in the dataset that have obtained financial backing, more than half—or 56%—have obtained venture capital backing. After venture capital, the second most common type of financing is from an accelerator or incubator, followed by corporate backing, angel investors, and private equity.⁷⁰

In terms of deal count, the top 15 investors in Canada's health technology industry are:

- 1 Ontario Centre of Innovation
- 2 BDC Capital by the Business Development Bank of Canada
- 3 National Research Council of Canada
- 4 Innovacorp
- 5 JLABS by Johnson and Johnson
- 6 Canadian Technology Accelerator
- 7 Fonds de Solidarité FTQ
- 8 MaRS Investment Accelerator Fund by MarS Discovery District
- 9 Anges Quebec
- 10 Creative Destruction Lab
- 11 The UTEST Program by the University of Toronto
- 12 Toronto Innovation Acceleration Partners
- 13 BDC Healthcare Venture Fund by the Business Development Bank of Canada
- 14 Growth Works
- 15 Entrepreneurship@UBC by the University of British Columbia

In terms of deal count, the top six acquirers are:

- 1 WELL Health Technologies (TSE: WELL)
- 2 Vital Hub (TSX: VHI)
- 3 CloudMD Software Services (TSX: DOC)
- 4 Logibec Group Informatique
- 5 QHR Technologies
- 6 Telus / TELUS Health

⁷⁰ For methodology see: *Financing Status (Backing Status) Definitions*, Pitchbook, 2021, <https://help.pitchbook.com/s/article/Financing-Status-Methodology>

SECTION II

Health Tech Labour Needs

ICTC's flagship labour market outlook report, Outlook 2023, identifies health and biotechnology as a key innovation area for the Canadian economy. As discussed, with an increasing and aging population in Canada, new developments in healthcare technology will be necessary to contain healthcare costs. Prior to COVID-19, ICTC reported that "a moderate growth scenario points to a demand for roughly 9,000 workers by 2023," bringing total employment in health and biotechnology to nearly 120,500 in Canada. Following the onset of COVID-19, ICTC released a revised labour market outlook, this time forecasting employment in health and biotechnology to reach approximately 119,000 by 2022. A post-pandemic update to the forecast is tentatively scheduled for August 2021.

Employment in Health and Biotech

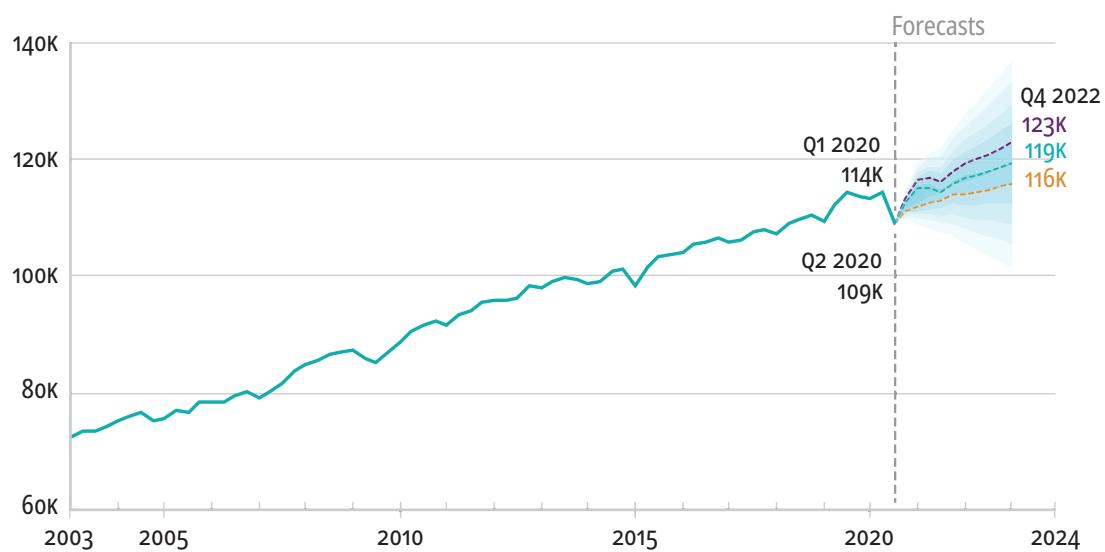


Figure 8: Health and biotech employment in Canada, 2018-2023. Data Source: Ivus, M., Kotak, A., and McLaughlin, "The Digital-Led New Normal: Revised Labour Market Outlook for 2022," ICTC, <https://www.ictc-ctic.ca/wp-content/uploads/2020/08/Outlook-ENG-FINAL-8.24.20.pdf>

Increased demand for healthcare technology talent is coupled with a lack of available talent in Canada. Interviewees in this study (and especially public sector interviewees) explained that they find it difficult to source and retain high-quality talent, which is in turn a barrier to health technology adoption and progress. Public sector interviewees further highlighted that in the public healthcare sector, many professions are unionized, and that professionals who want to experiment with new technical roles and skill sets may be prevented from doing so due to potential loss of seniority,

pension, or other benefits. Public sector interviewees also noted that, even if they are able to find the right candidate for their organization, they are often unable to hire that candidate due to compensation limits. Similarly, candidates they have hired are always at risk of leaving for a more lucrative role:

“I can’t find anybody with any sort of renumeration that I could afford, and I’m also, to a degree, in competition with the private sector when it comes to innovation... We don’t hold on to people for very long—I would prep a [student] candidate for a couple of years and then straight out of university and they would go to a private firm where they can make quite a lot more money doing similar things. So that’s a very real challenge, particularly within the innovation space.”

— Healthcare Sector Executive

ICTC amalgamated ICT and health NOCS⁷¹ to gather job postings data from December 2019 to May 2021 (*Figure 9*). In May 2021, there were over 60,000 job postings related to health tech jobs (the top cities for these jobs include Toronto, Montreal, Vancouver, Ottawa, and Calgary).

Number of Healthtech Job Postings

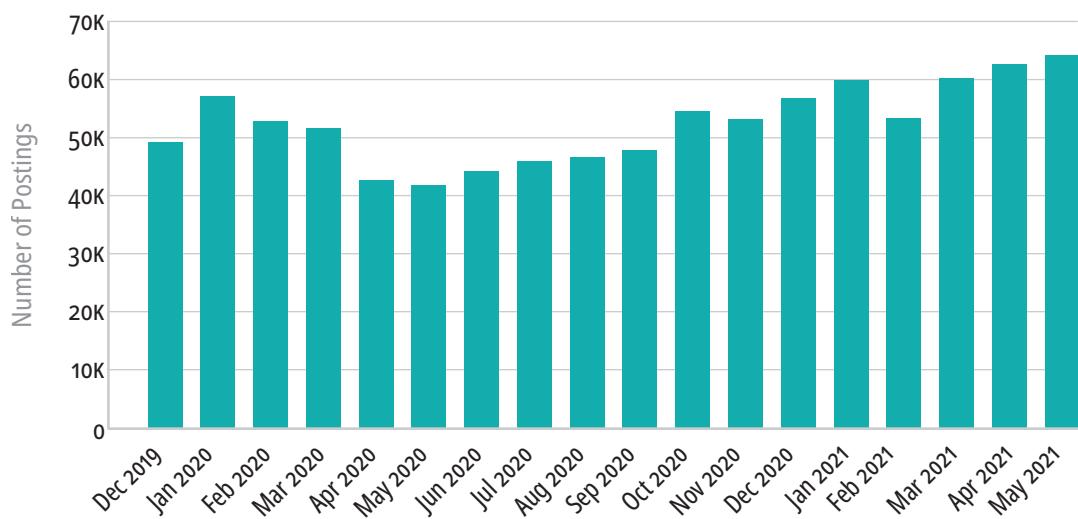


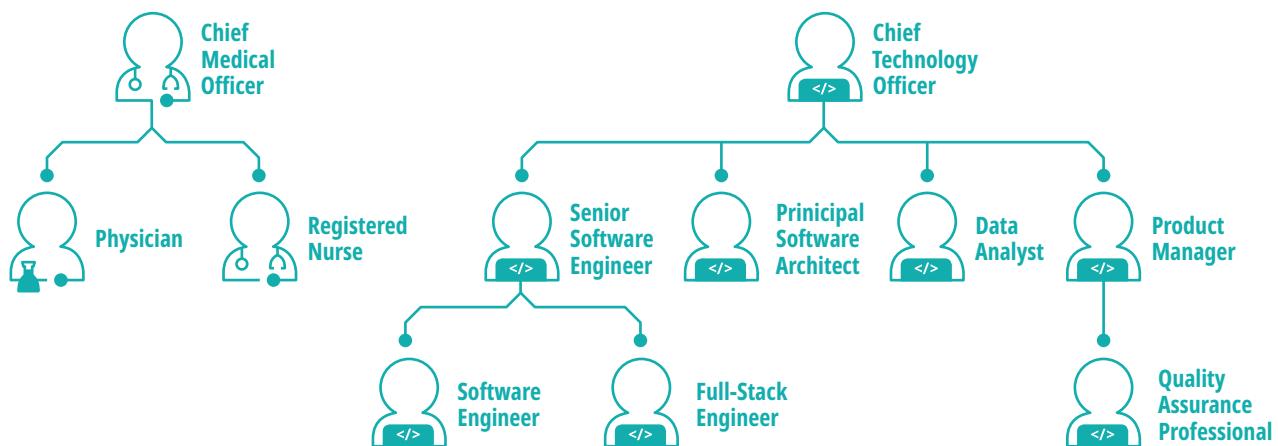
Figure 9. Number of health tech job postings in Canada (December 2019 to May 2021).

⁷¹ The National Occupation Classification Codes (NOCS) are explained further in Appendix C.

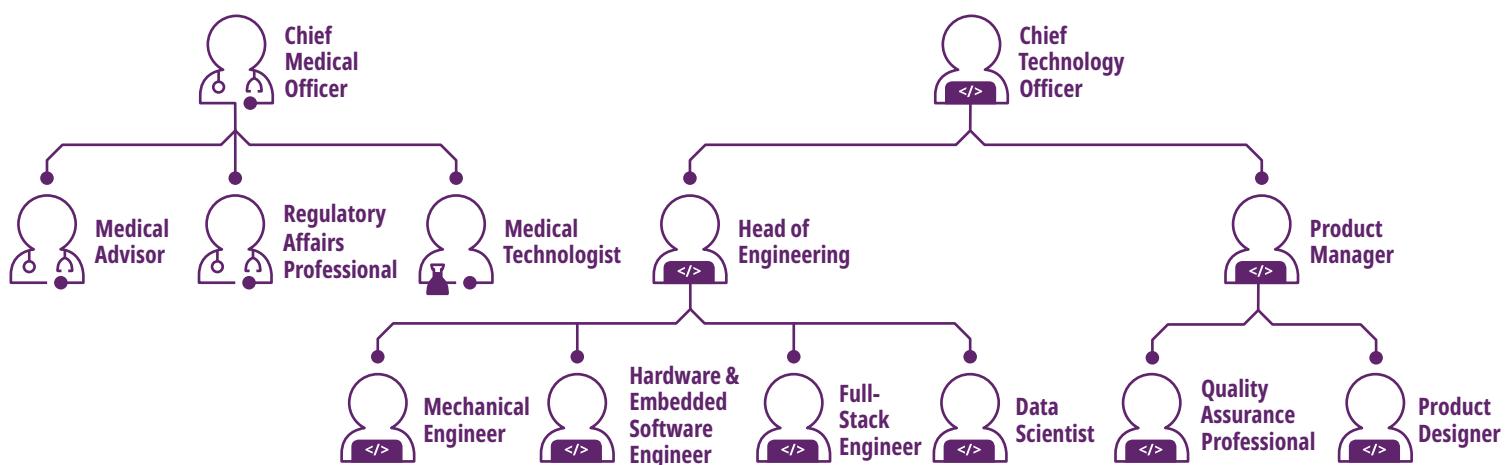
Key Roles and Skill Sets: Health Technology Companies

The exact composition of a health technology company will depend on key characteristics like the company's size, industry, and business model. That said, there are some similarities in the key roles and skill sets needed across different types of health technology companies. This section provides more granular insight about the labour market needs of the health technology industry. It begins with four case studies of archetypal health technology companies: telehealth service providers, biotech companies that use AI for drug discovery; health technology companies that use AI for diagnosis and clinician support; and wearable technology companies. Key technical roles and skill sets were identified through a combination of web scraping (e.g., job postings, company profiles, talent profiles), secondary labour market information, and discussion with industry representatives. While the examples provided are for smaller technical teams, with only 10 to 15 employees each, in a larger organization, each individual employee might represent an entire team or department.

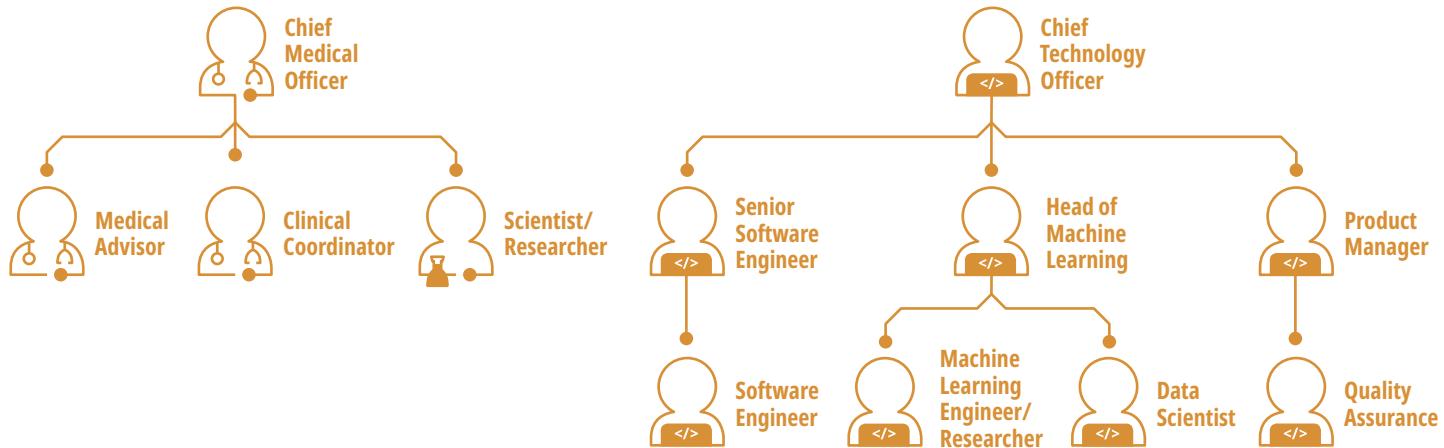
SaaS Company: Telehealth Service Provider



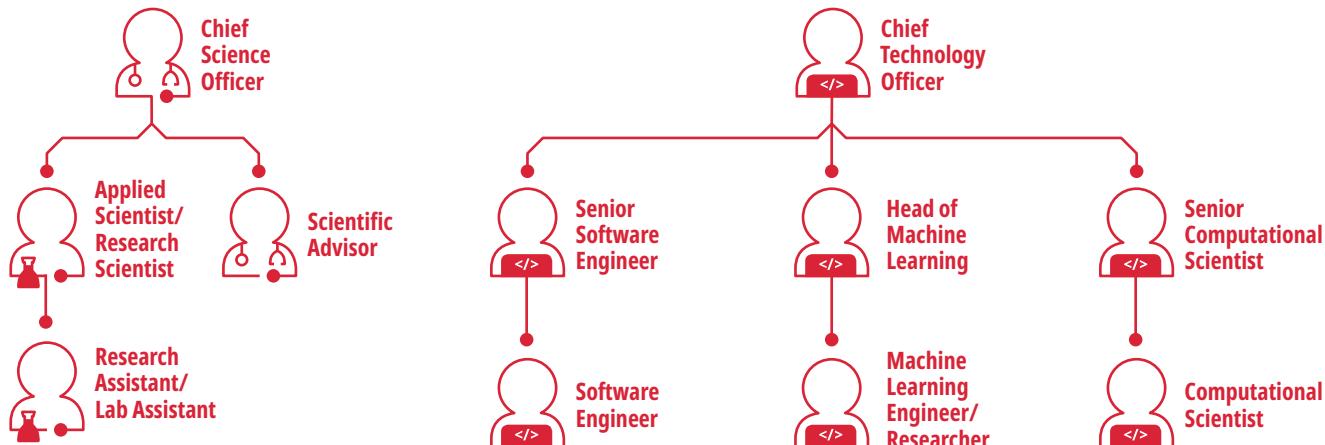
Wearable Device Company



SaaS Company: AI for Diagnosis and Clinician Support



Biotech Company: AI for Drug Discovery



Interdisciplinary Teams

Despite these companies operating in different industry verticals, there are similarities in their respective key roles and skill sets. For example, all of the companies are interdisciplinary, involving a core technical team and either a medical or scientific team. Medical teams consist of medical professionals and/or medical advisors, while scientific teams consist of applied scientists, scientific advisors, and research assistants. The need for interdisciplinary talent is further reflected in ICTC's Building Canada's Future AI Workforce report,⁷² which found that domain knowledge and business knowledge are crucial to the success of an AI product development team. This trend was replicated in key informant interviews as well. Although classic roles such as software engineers are in high demand, an ideal candidate would have a combination of tech skills and clinical skills. Nearly half of interviewees in this study reported difficulty of finding and retaining interdisciplinary workers.

⁷² Dr. Taillon, P.J. et al., "Building Canada's Future AI Workforce: In the Brave New (Post-Pandemic) World," Information and Communications Technology Council, March 2021, https://www.ictc-ctic.ca/wp-content/uploads/2021/03/ICTC_Report_Building_ENG.pdf

"Domain knowledge and technical knowledge...multi-faculty, multidisciplinary, collaborative—it is in the collisions between various disciplines that you find innovation. Somebody going down the track of some specialty science will produce some basic science, and we definitely want to have lots of that, but if what you want is industry applications, it is multidisciplinary work that does that right."

— Health Technology Company Executive

"Our key roles are very much a mix of two different fields and to be successful and work autonomously, you need to understand both. For (some) technical people, it's easy to pick up the clinical side of things, but not everyone does. On my team, I can tell you that all of the analysts understand the technical side of things, but some are not able to meet with a group of physicians, clinicians, or other healthcare providers, listen to what healthcare processes they have or need, and then translate that information into a program or fix bugs. It's a two-part role and if there's challenges on either side, you may have to hire two people together (one with clinician knowledge, one with technical)."

— Healthcare Information Technology Professional

Similarly, advances in diagnosis and treatment in the healthcare sector will result in education and training shifts to focus on an integration of "new genomic paradigms" for clinicians. This means that clinicians will need to work with non-clinicians such as computer scientists, statisticians, and data scientists.⁷³ For example, one interviewee in this study noted that as a researcher, it is important for them to work closely with doctors, clinicians, and other healthcare professionals that will benefit from their work.

Calls To Action: Interdisciplinary Tech Talent

Healthcare organizations must assess and investigate the systemic barriers that may be preventing current and future healthcare professionals from experimenting with or pursuing new career paths in technical roles (e.g., loss of union seniority, benefits, etc.).

Tech companies that develop products and services for use in the healthcare sector must also ensure that their development teams are adequately cross trained, with sufficient technical, healthcare domain, and business know-how.

Canadian academic institutions should assess the availability (and accessibility) of technical training in medical and healthcare programs, and the availability of healthcare domain courses in technical programs like data science or computer engineering. With validation by industry and healthcare providers alike, post-secondary curricula can be updated to reflect current and future skills needs.

⁷³ "The Future of Technology In Health and Healthcare: A Primer," Canadian Medical Association, 2018, <https://www.cma.ca/sites/default/files/pdf/health-advocacy/activity/2018-08-15-future-technology-health-care-e.pdf>

Core Technical Roles

Looking at the four archetypal companies, a series of core technical roles also emerge. Product development teams that are client or patient facing (e.g., the wearable device and SaaS companies) often contain smaller product management teams, consisting of product managers, quality assurance professionals, and designers. While software engineers were common across all product development teams, data-focused roles varied. Companies that are not focused on AI specifically have in-house data analysts and data scientists, while companies focused on AI have machine learning engineers and researchers, data scientists, and computational scientists. Other health data-focused roles that emerged during analysis, but were not necessarily common across many companies, were biomedical data scientists, biostatistics researchers, bioinformatics data analysts, and biocomputational scientists. Below is a list of roles that were common across different types of companies, along with some of their top 10 hard skills.⁷⁴

Software Roles

Director of Software Engineering: The Director of Software Engineering (or Development), sometimes referred to as Head of Software Engineering, leads the software engineering team. They are a senior engineer proficient in project management methodologies, architecture design, and development operations (DevOps).

TOP SKILLS:

Agile Methodology	Scrum (Software Development)	Application Programming
Java	Project Management	Interface (API)
Software Development Life Cycle	Code Review	DevOps
Scalability	Service-Oriented Architecture	

Software Engineer: Software engineers, sometimes referred to as software developers, build applications and programs, then test and maintain those developed products.

TOP SKILLS:

C#	Unit Testing	Research
Agile Methodology	Object-Oriented programming	Java
Test-Driven Development	Python	Automation
Amazon Web Services	Scalability	Object-Oriented Design

⁷⁴ The skills and descriptions for roles Software Engineer, Full Stack Developer, Data Scientist, and Machine Learning Engineer are from the Outlook 2023 Report. See: <https://www.ictc-ctic.ca/wp-content/uploads/2019/11/canada-growth-currency-2019-FINAL-ENG-10.28.19.pdf>
The skills and descriptions for roles Director of Software Engineering, Computational Scientist, Product Manager, and Product Designer were generated using job descriptions available online and labour market data search engine, EMSI.

Full Stack Developer: Full stack developers are proficient with both the back and front end of software development. This means they can manage IT infrastructure like databases or servers and develop and manage APIs along with other elements that focus on the functionality of the product.

TOP SKILLS:

React.js	Web Applications	TypeScript
JavaScript	DevOps	C#
Angular	.Net Framework	Integration
SQL	Agile Methodology	

Machine Learning and Data Roles

Machine Learning Engineer: Machine Learning Engineers create machine learning models and systems, with the ultimate goal of developing and maintaining efficient self-learning applications and products.

TOP SKILLS:

Machine Learning	Deep Learning	Machine Learning
Python	Scalability	Algorithms
Artificial Intelligence	PyTorch	NoSQL
Tensor Flow	Java	

Data Scientist: Data scientists collect, clean, and analyze data from various sources, using it to build algorithms, models, and machine learning tools that automate and optimize processes.

TOP SKILLS:

Python	open-source	SAS
JavaScript	data libraries like TensorFlow	cloud platforms like AWS
SQL		
Excel	data visualization programs like Tableau	AI for data science
Machine Learning		

Computational Scientist: Computational Scientists solve complex scientific problems using computational science techniques, such as high-performance computing, advanced simulation, data analysis, and mathematical models.

TOP SKILLS:

Advanced Mathematics	C++	Machine Learning
Mathematics	Life Sciences	Java
Python	MATLAB	Algorithms

Product Roles

Product Manager: Product managers are needed over the course of a product's lifecycle, from the ideation phase to planning, prototyping, product development, and quality assurance.

TOP SKILLS:

Project Management	New Product Development	Planning	Research
Verbal communication	Cross-department Cooperation		Agile Methodology
Leadership	Sales		Coordination

Product Designer: Product designers, depending on the company and product, are sometimes referred to as UX/UI Designers are a hybrid blend of software development and design. They possess an understanding of usability, ease in navigation, accessibility, and other skills related to creating effective user interfaces and designs for desktop and mobile devices.

TOP SKILLS:

Product Design	Prototyping	Figma (Design Software)	Usability Testing
User Experience	Visual Design	User Interface	Interaction Design

Science Roles

Research Scientists: Research scientists, sometimes referred to as scientists or researchers, exist across a variety of industry verticals, sectors, or types of organizations. In the healthcare and biotech sectors, scientists and researchers are needed to perform research on human genetics, gene expression or disease, chemical structure review, or even pharmaceutical analysis.

TOP SKILLS:

Research	Self-Motivation	Knowledge of immune systems and immunization	Mentorship
Genomics	Teamwork		Critical Thinking
Biotechnology	Knowledge of antibodies	Automation	
Machine Learning			

Lab Technician: Working under a lab manager or principal scientist, lab technicians help perform tests and conduct analysis in a lab setting. The lab technicians' responsibilities will change depending on industry, for example, whether they work in a medical lab or pharmaceutical lab.

TOP SKILLS:

Chemistry	knowledge	Microbiology	Analytical Techniques
Biotechnology	Quality Assurance	Calibration	
Biochemistry	Research	Equipment	
Pharmaceutical	Geology	Maintenance	

SECTION III

Technology Adoption in Canada's Healthcare Sector

Canada's Health Technology Adoption Landscape

Health technology adoption in Canada varies by technology type. For example, some interviewees noted telehealth adoption increased exponentially during the pandemic, while information management software adoption slowed. The following section provides an overview of relevant adoption trends across Canada.

National Adoption

Despite steadily increasing healthcare funding, compared to international counterparts, Canada's pre-pandemic health technology adoption rates are low. Canada's healthcare spending to GDP ratio grew from 7% in 1975 to an estimated 11.6% in 2019.⁷⁵ In 2018, Canada's Health-to-GDP Ratio was 10.7% of GDP, which was higher than the OECD average of 8.8% of GDP.⁷⁶ According to the Canadian Health Policy Institute, however, only 3% of Canadian healthcare spending was directly allocated to health technology, placing Canada 60 out of 72 countries in health tech spending.⁷⁷ Several interviewees link this lack of capital to low health technology adoption rates. Additionally, most interviewees focused their comparisons on the United States, noting that Canada lags in experimentation and implementation. One interviewee noted that "in Canada, the health system does not have enough capital and does not have enough discretionary funds to try out new models."

Interestingly, one respondent framed Canada's slow adoption rates as a positive: Canadians watch experimentation in the United States and avoid the negative consequences of new technology experimentation.

⁷⁵ National Health Expenditure Trends 1975 to 2019, CIHI, <https://www.cihi.ca/sites/default/files/document/nhex-trends-narrative-report-2019-en-web.pdf>
Note: However, the 2018 and 2019 values are provisional estimates

⁷⁶ OECD.Stat, <https://stats.oecd.org/Index.aspx?ThemeTreeId=9#>

⁷⁷ "The Innovation Dilemma: Achieving Value, Health Outcomes and Contributing to the New Economy," MEDEC, January 2017, https://gallery.mailchimp.com/ee57ed699fe269d23646e430e/files/7c63e00e-8602-4d3c-88d5-6734fdf94aa0/MEDEC_Optimus_Research_Paper_Final.pdf

“I think Canada is a laggard, quite frankly. There are exceptions, but there is a lot more experimentation in the US with digital-first models of care.... And we can learn from that because we can pick out what looks like a good idea and what seems to be working. Or we can see what they’re trying there in California is not working and decide we don’t need to adopt it. So, that’s been historically how Canada’s health system has worked. [Watching] the US has been a great way for Canada to avoid bad decisions on technologies. And we’re always a bit late to the game.”

Professor

Results from international surveys such as the 2019 Commonwealth Fund International Health Policy Survey of Primary Care Physicians support the majority of industry opinions, showing Canada falling behind international counterparts in most tech adoption categories. For example, only 31% of Canadian family doctors exchange information with other doctors electronically, compared to the commonwealth country average of 63%.⁷⁸ Patient-facing technology adoption rates are also suboptimal. Despite a doubling in the number of doctors allowing patients to book appointments online from 2015 to 2019 (11% to 22%), Canada’s percentage is still less than half the Commonwealth Fund Average of 56%.⁷⁹ Indeed, in 2019 Canada also fell behind Commonwealth averages on the percentage of family doctors who let patients see summaries or ask for prescription renewals online⁸⁰ and who answer patient questions online⁸¹ (see *Figures 10, and 12* for more detail). Among other causes, low adoption rates are due to varied challenges, including organizational culture, complex payment models, ineffective private-public partnerships, and lack of digital infrastructure (see Barriers to Adoption).

Conversely, Canada is ahead of the curve in a few technology adoption categories. Several interviewees noted that Canada is not “afraid” of a digital transformation, and one noted Canada’s strength in health AI. Moreover, according the same 2019 Commonwealth Fund Survey, Canada pulls ahead of the commonwealth average in remote monitoring and video consultation adoption (see *Figure 11*).⁸²

⁷⁸ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

⁷⁹ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

⁸⁰ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

⁸¹ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

⁸² Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

Health Information Technology That Facilitates Coordinating Care With Clinical Providers

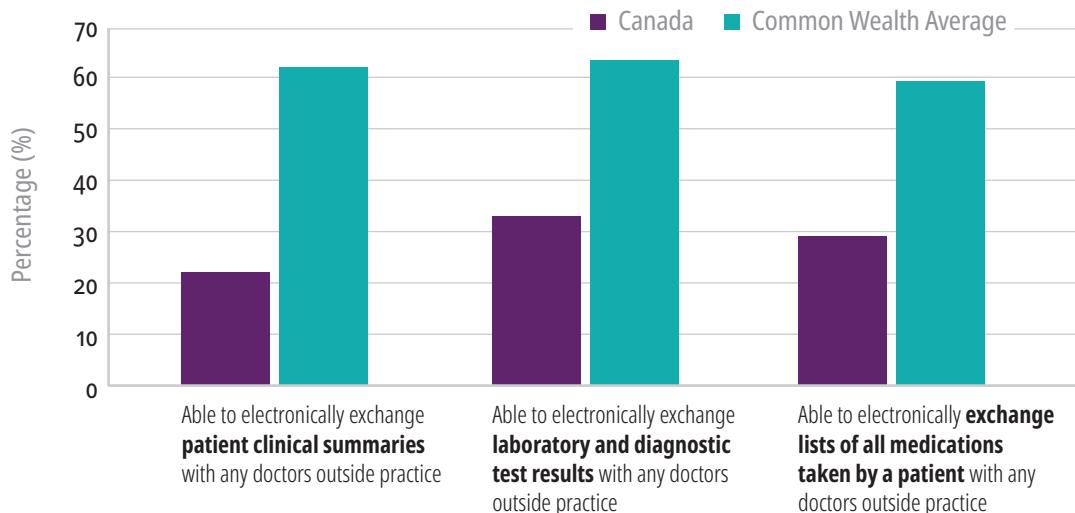


Figure 10. Percentage of family doctors who exchange information electronically. Data Source: CIHI.⁸³

Health Information Technology That Facilitates Coordinating Care with Patients

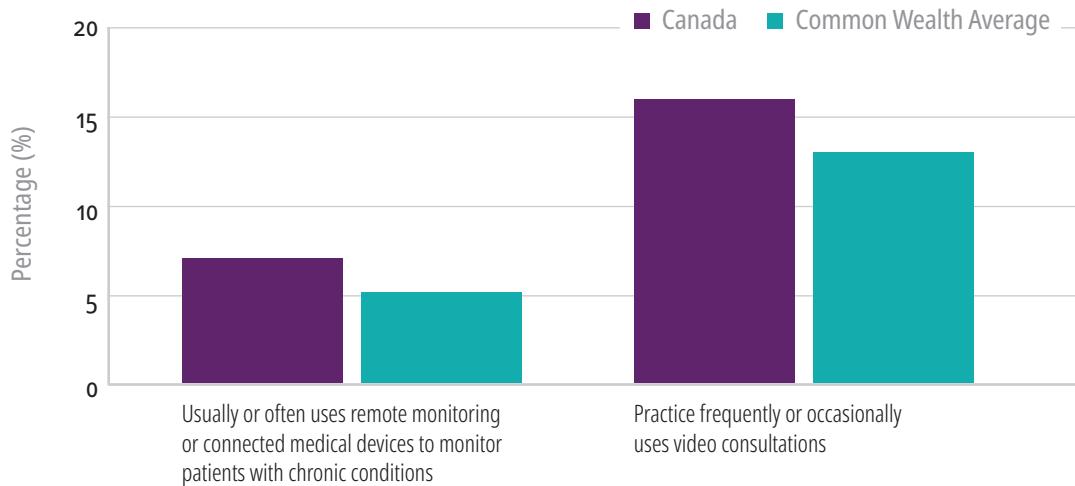


Figure 11. Percentage of doctors who use video, remote monitoring, or medical devices to monitor patients. Data Source: CIHI.⁸⁴

⁸³ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

⁸⁴ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>.

Health Information Technology That Facilitates Coordinating Care with Patients

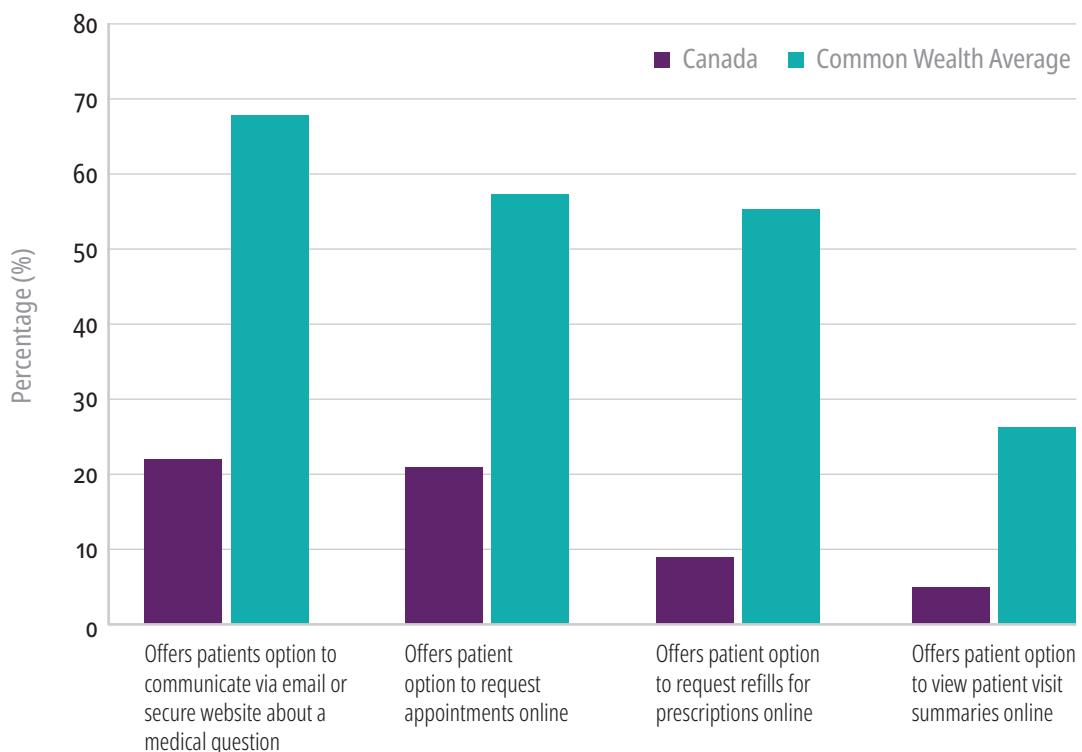


Figure 12. Percentage of doctors who use health tech to coordinate patient care. Data Source: CIHI.⁸⁵

Adoption by Region

Within Canada, health technology adoption rates depend on a variety of factors including age distribution, healthcare expenditure, population density, proximity to urban centers, and population health needs.⁸⁶ When asked about interprovincial and territorial differences in health technology adoption, key informant interviewees emphasize that while provincial and territorial regulatory landscapes have a role to play (see Centralized Electronic Records), geographic differences in adoption are correlated with population density. Interviewees noted high levels of health technology adoption in densely populated urban areas such as Toronto, Ottawa, and Vancouver.

"In my first hospital, there was a wide variety of different electronic charting systems, and sometimes a combination of software and paper charting. Other hospitals might be more behind, but at my first hospital, at least, there was enough exposure for me to be ready to use various charting systems when I got out of school."

— Healthcare Professional

⁸⁵ Use of technology, Commonwealth Fund Survey 2019, CIHI, <https://www.cihi.ca/en/commonwealth-fund-survey-2019/use-of-technology>

⁸⁶ National Health Expenditure Trends 1975 to 2019, CIHI, <https://www.cihi.ca/sites/default/files/document/nhex-trends-narrative-report-2019-en-web.pdf>

In contrast, a Nunavut Tunngavik Inc. report released in October 2020 reveals the challenges rural areas face to adopting health technology. Besides Iqaluit, the 22 other hamlets in Nunavut are only “equipped with basic medical equipment, such as X-ray machines, defibrillators, and tools for conducting blood tests.”⁸⁷ Limited medical technology forces residents of the Kivalliq and Kitikmeot regions to travel outside of the territory for diagnosis that requires more cutting-edge imaging equipment.⁸⁸ Limited health technology adoption could be due to the astronomical cost of healthcare. With significant funds going to out-of-province travel, there is less to spend on new health technologies.⁸⁹

Broadband connectivity is another key barrier. In rural areas, physicians often need to use telehealth to access their patients, but latency, interference, and capacity limits can make diagnosis challenging. Listening to breathing and assessing physical ailments are made more difficult without clear resolution and fast connections. Limited internet infrastructure is more common in rural areas. For example, there are no wireline broadband networks in the entirety of Nunavut. Instead, communities access internet through satellite broadband delivered through mobile and fixed last-mile connections. The speediest of these connections only reaches 15 Mbps, making them 85% slower than the Canadian average of 126 Mbps. Without coverage, speed, and affordable internet, rural and remote areas face challenges with adopting new health technology. Publications analyzing healthcare in rural Alberta report similar technological barriers to a lesser degree.⁹⁰

Interviewees in this study also emphasized that insufficient broadband infrastructure and high internet costs are barriers to health technology adoption in rural and remote communities.

“On paper, in a lot of First Nations communities, it looks like they have good connectivity in the rural and remote areas. For example, let’s say on paper, there’s 200 Mbps coming into a community fibre. But what it doesn’t say is that only 10 of that is getting to the health centre because it’s going to the school, it’s being used for Netflix, like all the normal reasons that people would use internet capacity in a community. So, the health centre at the end of the day really doesn’t have any connectivity. They can’t link up to the lab system or they can’t get access to the diagnostic imaging system. And so that’s been a big barrier in rural and remote more northern communities: the absence of sufficient and dedicated connectivity to the health team.”

— Health Technology Company Executive

⁸⁷ Ry Marcattilio-McCracken, “Nunavut Infrastructure Gap Report highlights Startling Lack of Connectivity Options,” Community Networks, October 2020, <https://muninetworks.org/content/nunavut-infrastructure-gap-report-highlights-startling-lack-connectivity-options>

⁸⁸ Ibid.

⁸⁹ “Rural Health Services Review Final Report,” Government of Alberta, 2015, <https://alberta.cmha.ca/wp-content/uploads/2017/01/Rural-Health-Services-Review-2015.pdf>

⁹⁰ Ibid.

“There are differences in accessibility to the type of technology that you might have access to between somewhere like my city, where there are universities, and what would be available somewhere more rural. That’s also part of the reason why we want to do this type of research and find technology that’s easy to use, that we can put into the field and give to people. And they can process data in the cloud or do different things so that we can get it into more or people’s hands that aren’t necessarily in [major] centres.”

— Healthcare Sector Executive

Improving internet connection in rural and remote areas is a priority for the Government of Canada. In May 2021, the Government of Canada invested \$6.9 million to “improve high-speed internet connectivity and affordability to over 9,800 homes in Nunavut.”⁹¹

Despite the barriers listed earlier, because the need for health technology is higher in these rural and remote communities, their adoption rates for health technologies such as electronic medical records (EMRs) are often higher than in urban areas. According to a 2018 survey on the Use of Electronic Medical Records Among Canadian Physicians by Canada Infoway, there is significant variation between provinces: just 65% of primary care physicians were using electronic medical records in Atlantic Canada in 2018, compared to a high of 95% in Saskatchewan, Manitoba, and the territories.

Calls To Action: Barriers to Adoption

Canada must continue to prioritize the expansion of high-speed broadband services across the country to provide care to all Canadians and support the adoption of health technologies that require network access. For example, the use of telehealth services is currently inhibited by broadband access.

Adoption by Technology

The section below details key adoption trends in health technology over the past five years and the impact of COVID-19. *Figure 13* highlights the specific digital services used by healthcare organizations **before the pandemic**, from 2017 to early 2020. Just under one-third of survey respondents included telehealth as one of their adopted technologies. The next most adopted technology is mobile health, used by over quarter of respondents. The least adopted technologies include AI and automation

⁹¹ “Government of Canada invests \$6.9 million to improve high-speed Internet connectivity and affordability to over 9,800 homes in Nunavut,” Innovation, Science and Economic Development Canada, May 28, 2021, <https://www.canada.ca/en/innovation-science-economic-development/news/2021/05/government-of-canada-invests-69-million-to-improve-high-speed-internet-connectivity-and-affordability-to-over-9800-homes-in-nunavut.html>

for development applications and augmented reality and virtual reality (AR and VR). Although the use AR and VR particularly in medical education and surgery has increased in recent years, these figures point to several current technological limitations with AR/VR for medical purposes, including experience quality, spatial resolution, and volume rendering.⁹² Only 15% of respondents adopted none of the listed technologies.

Digital Services Adopted Pre-Pandemic

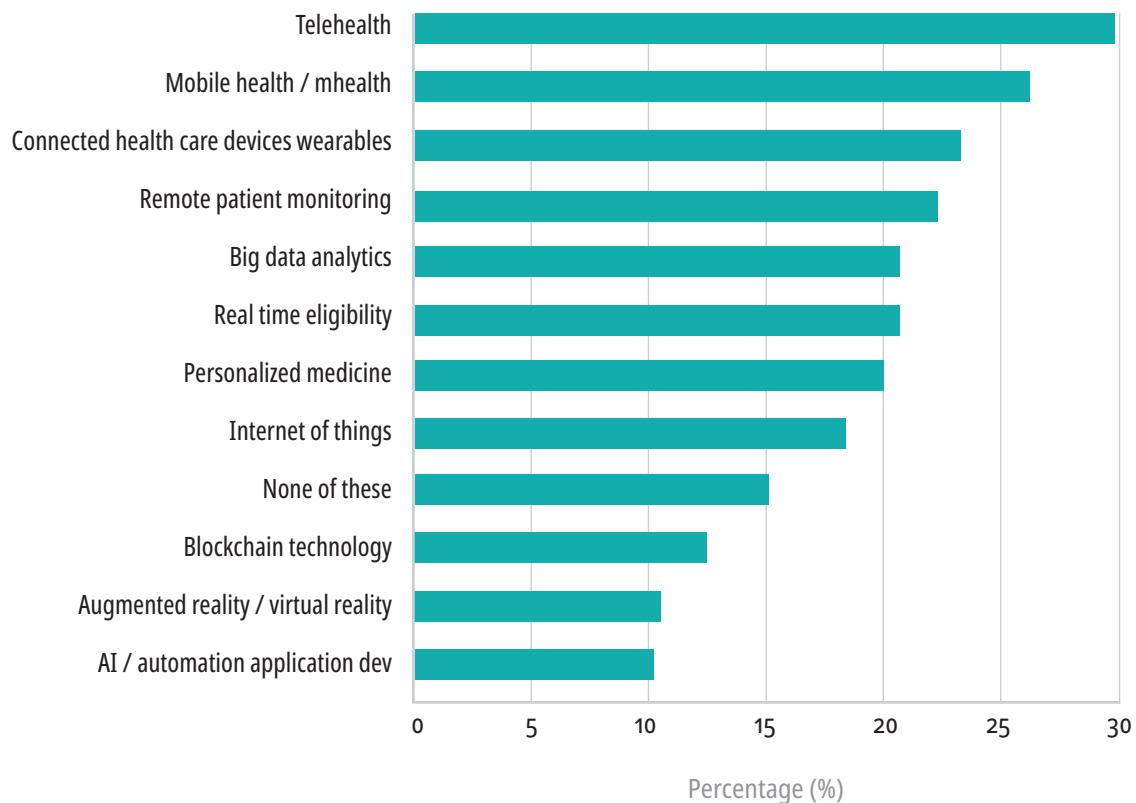


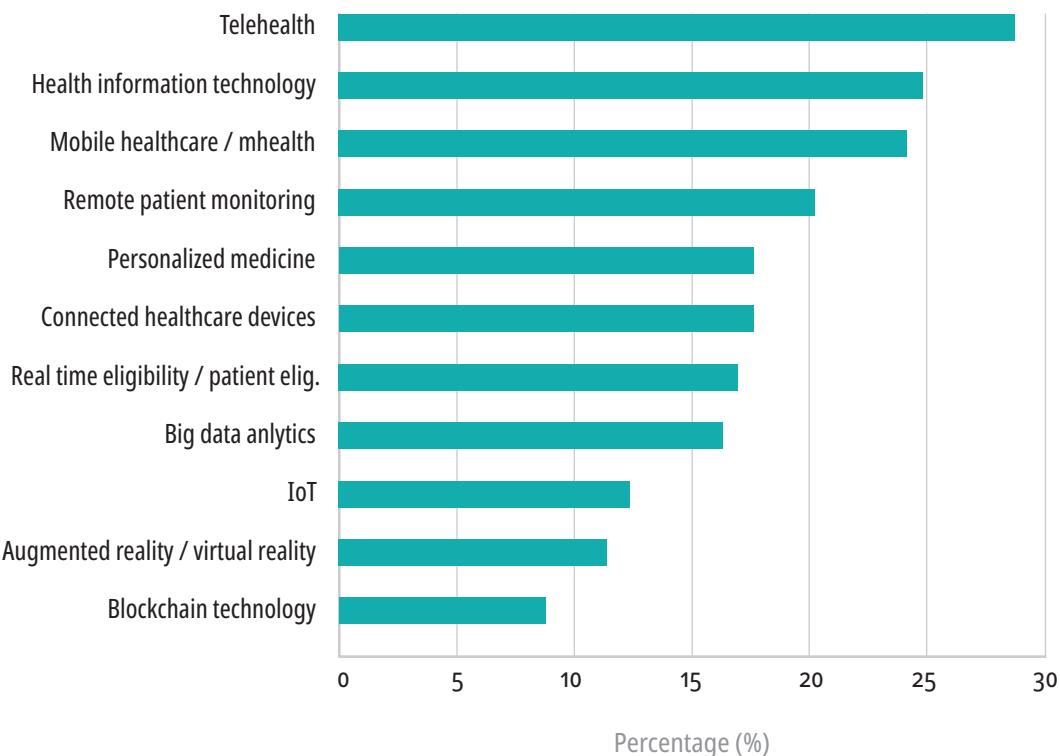
Figure 13. The adoption of digital services before the pandemic. This question had 206 survey respondents. Survey Data, ICTC, 2021.

Figure 14 shows health tech adoption **since the start of the pandemic**.

Unsurprisingly, telehealth remains the most adopted digital service since the pandemic. Health information technology is the second most adopted technology, with just under a quarter of respondents selecting it, followed closely by mobile healthcare. The significant number of organizations who adopted information technology (IT) systems during the pandemic points to the necessity of IT in day-to-day work (mass notifications, client information, and service interoperability), IT to support virtual care, as well as IT for COVID-19 tracking and forecasting.

⁹² Justin Sutherland et al., "Applying Modern Virtual and Augmented Reality Technologies to Medical Images and Models," *Journal of Digital Imaging* 32, no. 1, February 2019, <https://doi.org/10.1007/s10278-018-0122-7>.

Digital Services Adopted Since COVID-19



*Figure 14. The adoption of digital services following the onset of the COVID-19 pandemic.
This question had 306 survey respondents. Survey Data. ICTC, 2021.*

A Closer Look: Telehealth and Covid-19

Interviewees note that prior to the pandemic, telehealth services were used in the public healthcare system primarily in exceptional cases or for pilot projects. Previously, the lack of physician billing codes for telehealth services was a major barrier to widespread telehealth adoption, but at the onset of the pandemic, provinces like Ontario, Alberta, and Newfoundland and Labrador were forced to establish new billing codes to continue providing care (see Compensation for more information). Meanwhile, the Royal College of Physicians and Surgeons of Canada, advised physicians to provide telehealth services in place of in-person visits when possible.

Increased adoption of telehealth is evidenced by the experience of Canadian telehealth provider Maple, which saw significant growth in telehealth visits during the pandemic. Pre-COVID, Maple saw about 1,000 patients per day on a busy day. During the pandemic, that number jumped to more than 4,000 visits per day.⁹³ Dialogue, another Canadian

⁹³ "How COVID-19 set the stage for a Canadian healthtech boom," BetaKit, June 2020, <https://betakit.com/how-covid-19-set-the-stage-for-a-canadian-healthtech-boom/>

telemedicine and virtual health provider, saw a similarly dramatic increase in-patient volume: the number of patients that now frequent the platform is 10 times higher than pre-pandemic times.⁹⁴ Key informants from both industry and clinical settings confirm these increased rates of telehealth adoption.

“As a patient myself, I can tell you that telehealth was used a lot more in the past year. There are so many more programs across the country for Zoom calls with doctors, similar to walk-in clinics. I’ve only seen a dermatologist online for the last year, and she’s now my go-to dermatologist.”

— Healthcare Professional

“Virtual health was a multimillion-dollar infrastructure investment that we happily made with the onset of COVID-19 to ensure that we could continue to deliver healthcare services.”

— Healthcare Sector Executive

When asked which telehealth services they adopted, two-thirds of survey respondents used web-based communications like Zoom, closely followed by telemedicine, and video conferencing. Image storage and streaming media were the least adopted telemedicine options. Interviewees similarly noted the increase in web-based communications, telemedicine, and video conferencing.

“Over the course of just a few weeks we had to move thousands and thousands of in-patient visits to a virtual care model—some of that was Zoom, Teams, or other solutions, and quite frankly, most of that was just phone calls.”

— Healthcare Professional

Telehealth Service Adopted 2017–2021

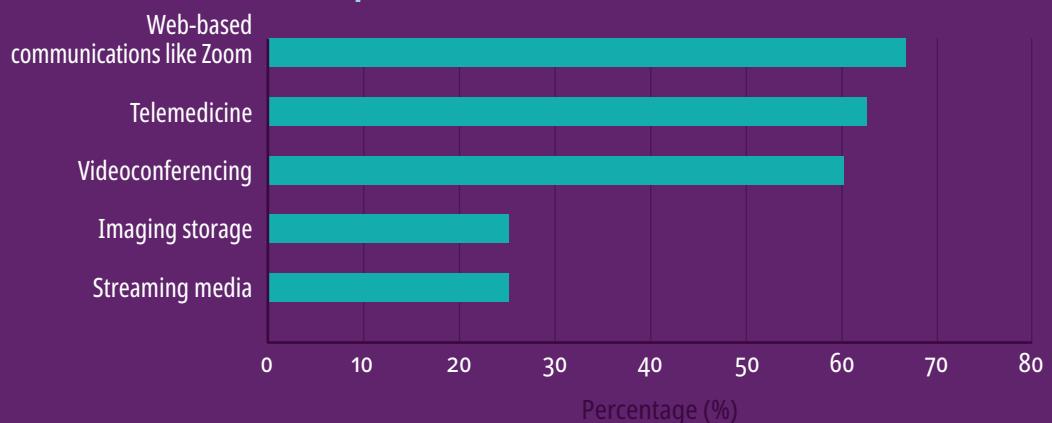


Figure 15. The adoption of telehealth services from 2017 to 2021. This question had 123 survey respondents. Survey Data. ICTC 2021.

⁹⁴ “How COVID-19 set the stage for a Canadian healthtech boom,” BetaKit, June 2020, <https://betakit.com/how-covid-19-set-the-stage-for-a-canadian-healthtech-boom/>

Barriers to Adoption

Thousands of new technologies attempt to enter the Canadian market each year. Throughout the healthcare system, there is pressure to adopt these tools to expand healthcare access and improve the quality of patient care. This section explores barriers to health technology adoption in Canada.

Regulations

Health Canada oversees the licencing process necessary for firms that want to enter the Canadian market. To help make evidence-based decisions, Health Canada funds non-profit organizations like the Canadian Agency for Drugs and Technologies in Health to research and create non-binding standards.⁹⁵ The resulting regulations aim to protect Canadians by establishing high-quality standards. Moreover, as a recent publication from Healthcare Policy states, these regulations "also establish credibility for tools among patients and providers and can be structured to align to other international standards; together, these facilitate market access."⁹⁶

Market access and adoption are hampered, however, by Canada's approval process.⁹⁷ Existing research focuses on variety of factors that make the process complex in the following ways:

Lack of guidance: Existing research on industry feedback notes that a lack of help for navigating Canada's regulatory approval process is a major barrier to market entry.⁹⁸ Moreover, app manufacturers, not distributors or vendors, are in charge of manoeuvring through this system.⁹⁹ This lack of guidance particularly impacts small businesses that often do not have the capacity to work through the complex system.¹⁰⁰

Time-consuming approval process: Health Technology Assessments typically take at least one year, by which time the technology may no longer be in-demand.¹⁰¹ This timeline assumes the approved technology is unchanged.¹⁰² While medical equipment may not require constant updating, this timeline hinders, for instance, mobile apps that may need biweekly updating.¹⁰³ Even if the technology is classified as "low risk," processing cycles take an average of 120 days.¹⁰⁴

⁹⁵ Jogova, M., Shaw, J., and Jamieson, T. "The Regulatory Challenge of Mobile Health: Lessons for Canada," *Healthcare Policy*, Volume 14, Issue 3, February 2019, <https://www.longwoods.com/content/25795/healthcare-policy/the-regulatory-challenge-of-mobile-health-lessons-for-canada>

⁹⁶ Ibid.

⁹⁷ "Unleashing Innovation: Excellent Healthcare for Canada," July 2015, <https://www.deslibris.ca/ID/247266>

⁹⁸ Jogova, M., Shaw, J., and Jamieson, T. "The Regulatory Challenge of Mobile Health: Lessons for Canada," *Healthcare Policy*, Volume 14, Issue 3, February 2019, <https://www.longwoods.com/content/25795/healthcare-policy/the-regulatory-challenge-of-mobile-health-lessons-for-canada>; Maggie MacNeil et al., "Enabling Health Technology Innovation in Canada: Barriers and Facilitators in Policy and Regulatory Processes," *Health Policy* Volume 123, Issue 2, February 2019, <https://www.sciencedirect.com/science/article/pii/S0168851018305396?via%3Dihub>

⁹⁹ Ibid.

¹⁰⁰ Innovation Government of Canada, "Report from Canada's Economic Strategy Tables: Health and Biosciences," 2018, <https://www.ic.gc.ca/eic/site/098.nsf/eng/00025.html>

¹⁰¹ MacNeil et al., "Enabling Health Technology Innovation in Canada." *Health Policy*, Volume 123, Issue 2, February 2019, <https://www.sciencedirect.com/science/article/pii/S0168851018305396>

¹⁰² Steven R. Chan and Satish Misra, "Certification of Mobile Apps for Healthcare." *JAMA*, Volume 312, Issue 11, doi:10.1001/jama.2014.9002

¹⁰³ Jogova, M., Shaw, J., and Jamieson, T. "The Regulatory Challenge of Mobile Health: Lessons for Canada," *Healthcare Policy*, Volume 14, Issue 3, February 2019, <https://www.longwoods.com/content/25795/healthcare-policy/the-regulatory-challenge-of-mobile-health-lessons-for-canada>

¹⁰⁴ Ibid.

Outdated frameworks: Regulatory frameworks for new technologies often fall behind the rapid pace of health technology innovation.¹⁰⁵ For instance, one study on mHealth notes that mHealth is approved as a medical device, however, current regulations are still linked to hardware functionality, failing to account for software performance developments (e.g., Dialogue will perform differently on an iPhone vs. Android).¹⁰⁶ A recent Report from Canada's Economic Strategy Tables: Health and Biosciences, similarly noted that duplications in processes and fragmented purchasing and approvals make it difficult for innovators to scale in Canada.¹⁰⁷

Key informant interviewees for this study also noted that procurement processes hamper their business expansion:

"I've spoken to people and companies working in this space who said, 'We've given up on Canada because it is difficult to do business here.' They look south of the border as their main market because, in some ways, it is easier to penetrate that market. Unclear procurement policies for technology and reimbursement—again, not well done."

Professor

Complicated regulatory approval mechanisms deter global and Canadian companies from breaking into the Canadian market. If fewer companies venture through Canadian procurement processes, fewer hospitals will have the option to adopt cutting-edge technologies.¹⁰⁸

Procurement

Canada's healthcare is a publicly funded system designed to provide patients with affordable, high-quality care.¹⁰⁹ Hospitals are funded through fixed-term global budgets that are determined in conjunction with provincial health authorities.¹¹⁰ Once benchmarks are reached, these budgets have hard caps to help regulate continually rising healthcare expenditure.¹¹¹ Paradoxically, this focus on affordability has resulted in complex procurement, regulatory, and funding mechanisms that support bulk-purchasing based on price rather than patient outcomes.¹¹²

¹⁰⁵ Jorgova, M., Shaw, J., and Jamieson, T. "The Regulatory Challenge of Mobile Health: Lessons for Canada," *Healthcare Policy*, Volume 14, Issue 3, February 2019, <https://www.longwoods.com/content/25795/healthcare-policy/the-regulatory-challenge-of-mobile-health-lessons-for-canada>; MacNeil et al., "Enabling Health Technology Innovation in Canada." *Health Policy*, Volume 123, Issue 2, February 2019, <https://www.sciencedirect.com/science/article/pii/S0168851018305396>

¹⁰⁶ Jorgova, M., Shaw, J., and Jamieson, T. "The Regulatory Challenge of Mobile Health: Lessons for Canada," *Healthcare Policy*, Volume 14, Issue 3, February 2019, <https://www.longwoods.com/content/25795/healthcare-policy/the-regulatory-challenge-of-mobile-health-lessons-for-canada>

¹⁰⁷ Government of Canada, "Report from Canada's Economic Strategy Tables."

¹⁰⁸ Ibid.

¹⁰⁹ "Current Funding | Healthcare Funding," accessed June 21, 2021, <https://healthcarefunding.ca/key-issues/current-funding>; According to a 2016 report by the Canadian Institute for Health Research 70% of health system funding is public and the remaining 30% is private. <https://healthcarefunding.ca/key-issues/current-funding/>

¹¹⁰ Ibid.

¹¹¹ Bradley Chen and Victoria Y. Fan, "Global Budget Payment: Proposing the CAP Framework," *The Journal of Healthcare Organization, Provision, and Financing*, Volume 53, <https://journals.sagepub.com/doi/pdf/10.1177/0046958016669016>

¹¹² "Report from Canada's Economic Strategy Tables: The Innovation and Competitiveness Imperative," Government of Canada, https://www.ic.gc.ca/eic/site/098.nsf/eng/h_00020.html

Indeed, healthcare organizations are not incentivized to spend on new technologies.¹¹³ For example, government funding structures often restrict carrying over funds from one fiscal year to the next and moving funds between departments. These funding restrictions push purchasers to focus on the immediate technology costs rather than potential long-term benefits to patients.¹¹⁴

Siloed provincial regulatory environments further hamper new technology adoption for hospitals. In a 2016 survey from the Council of Academic Hospitals of Ontario, over three-quarters of respondents reported that procurement regulations, policies, and directives limit innovation adoption.¹¹⁵ “Strict” and complex procurement requirements that vary from province to province make hospitals less likely to purchase new health technologies.¹¹⁶ Too often, hospitals departments are siloed with no links to procurement structures.¹¹⁷ Without simple, user-friendly platforms to help hospitals try out new technologies and streamline purchasing, Canadian health technology adoption rates will continue to lag.

While Canada currently lags in procurement agility compared to its international counterparts,¹¹⁸ the Canadian health system can leverage its size to foster innovation and shift to value-based procurement. A 2018 University of Toronto Impact Brief, *The Land of Stranded Pilots*, details how Canada can turn things around: “Given its heft, [Canada’s health system] could drive the adoption through demand-pull by acting as a powerful platform for innovation and reversing the direction and the fragmentation we see to date.”¹¹⁹ Additionally, switching to value-based procurement models that emphasize long-term patient outcomes along with price would help Canadian health organizations purchase the best technology to suit their needs.¹²⁰ For instance, the European Union has already seen early success with their value-based Most Economically Advantageous Tender (MEAT) model.¹²¹ Indeed, Quebec, Ontario, and Alberta have already started adopting value-based procurement models that could improve patient outcomes and drive economic growth.¹²² In short, Canada is well positioned to make the transition to value-based procurement, which would both encourage industry market entry and health technology adoption.

¹¹³ *The Land of Stranded Pilots*, University of Toronto, <https://narwhalproject.org/wp-content/uploads/2019/04/Health-Tech.pdf>

¹¹⁴ MacNeil et al., “Enabling Health Technology Innovation in Canada,” *Health Policy*, Volume 123, Issue 2, February 2019, <https://www.sciencedirect.com/science/article/pii/S0168851018305396>

¹¹⁵ “Guide Helps Entrepreneurs with Hospital Procurement,” *Canadian Healthcare Technology*, July 2018, <https://www.canhealth.com/2018/07/04/guide-helps-entrepreneurs-with-hospital-procurement/>.

¹¹⁶ *The Land of Stranded Pilots*, University of Toronto, <https://narwhalproject.org/wp-content/uploads/2019/04/Health-Tech.pdf>

¹¹⁷ Ibid.

¹¹⁸ MacNeil et al., “Enabling Health Technology Innovation in Canada,” *Health Policy*, Volume 123, Issue 2, February 2019, <https://www.sciencedirect.com/science/article/pii/S0168851018305396>

¹¹⁹ *The Land of Stranded Pilots*, University of Toronto, <https://narwhalproject.org/wp-content/uploads/2019/04/Health-Tech.pdf>

¹²⁰ “Report from Canada’s Economic Strategy Tables: The Innovation and Competitiveness Imperative,” Government of Canada, https://www.ic.gc.ca/eic/site/098.nsf/eng/h_00020.html

¹²¹ Ibid.

¹²² Ibid

A Closer Look: Capital Funding

As discussed earlier, Canada's spending on health has grown over the past 20 years in all areas except capital investment. Indeed, capital investment has declined in Canada since 2013.¹²³ For healthcare, capital spending refers to spending on facilities, care operations, and new technologies.¹²⁴ Although most of the capital funding in Canada comes from charitable donations and taxation, other sources can include other government funds; debt; and social impact grants or bonds.¹²⁵ Available capital, then, varies based on uneven charitable giving, credit and interest rates, politics, and economic cycles. If healthcare organizations lack adequate funding, they cannot spend on new technologies or equipment, and patient outcomes may suffer.¹²⁶ Key informant interviewees support several recent publications¹²⁷ that list lack of capital funding as a key barrier to health technology adoption in Canada.

"Well, it's not just that the US is a bigger market. They have more money, and they spend it."

— Health Technology Company Executive

Figure 16 shows that survey results further validate key informant insights: the most selected answer for reasons new technology was not adopted is insufficient capital to cover equipment and maintenance.

Adoption Barriers Among Surveyed Organizations

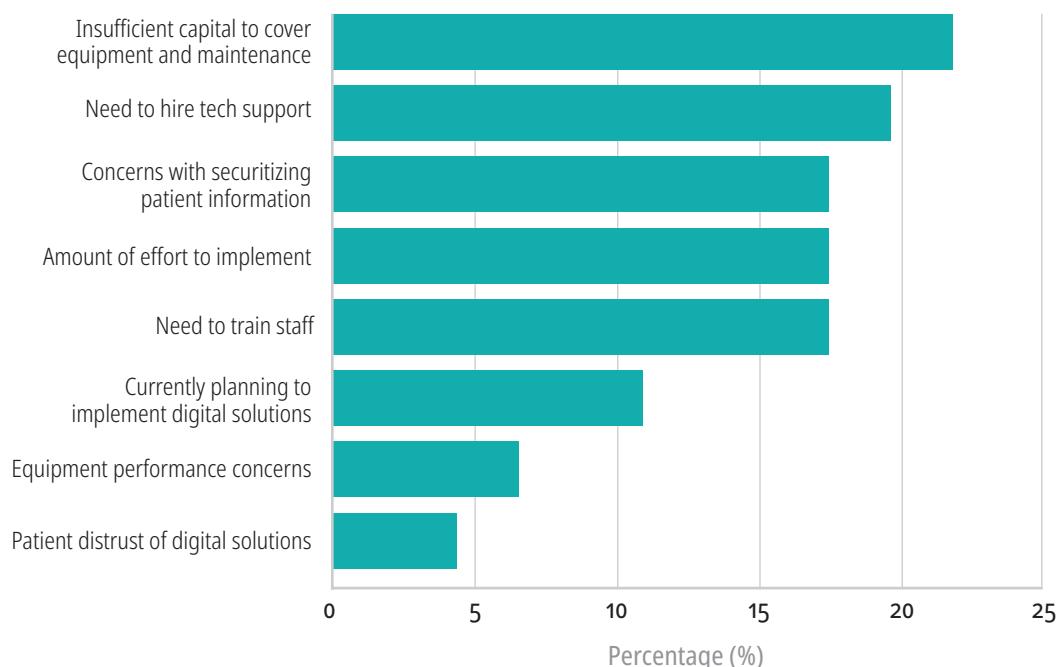


Figure 16. Barriers to adoption among surveyed healthcare organizations. This question had 46 survey respondents. Survey Data. ICTC, 2021.

¹²³ Teja, B. et al., "Ensuring Adequate Capital Investment in Canadian Healthcare," *CMAJ*, Volume 192, Issue 25, June 2020, <https://www.cmaj.ca/content/192/25/E677>

¹²⁴ *Ibid.*

¹²⁵ *Ibid.*

¹²⁶ "Capital Funding of Healthcare in Canada Is Critical, yet Declined in Last 20 Years," *Braceworks*, <https://braceworks.ca/2021/01/15/health-tech/capital-funding-of-health-care-in-canada-is-critical-yet-declined-in-last-20-years/>

¹²⁷ Teja, B. et al., "Ensuring Adequate Capital Investment in Canadian Healthcare," *CMAJ*, Volume 192, Issue 25, June 2020, <https://www.cmaj.ca/content/192/25/E677>

Simply increasing available capital, however, will not solve adoption issues. Canada's health system capital funding structure has remained almost unchanged for the past century.¹²⁸ Without more research, innovative private-public partnerships, expert leadership, tax reforms that favour charitable giving, and community engagement, increased capital spending will remain vulnerable.¹²⁹ A 2020 paper published in the Canadian Medical Association Journal advises that "in the years ahead, Canada should invest in improving Canadian healthcare capital funding, engaging new sets of investors and increasing our sophistication in capital planning and allocation."¹³⁰

Compensation

Most physicians in Canada are compensated through a fee-for-service (FFS) model.¹³¹ FFS models compensate physicians based on the procedure they deliver. To receive payment, physicians invoice their province's ministry of health with patient and service details. The provincial ministry of health then reimburses physicians based on a list of fees and services, known as a schedule of benefits. For example, in Alberta patients pay a base rate of 122\$ for intravascular ultrasounds.¹³² Less common forms of payment include capitation (number of patients), salaried compensation, First Nations and Rural Northern Physician Group agreements, as well as bonuses for "after hours" care and for meeting cumulative preventive care targets (e.g., childhood immunizations and colorectal cancer screening).¹³³ The use of these and other alternate payment models grew quickly from 1999–2008 (10.6% to 27%), but since 2008 FFS payments stabilized: accounting for 71% – 73% of total clinical payments.¹³⁴ As one key informant put it: "There's different alternate payment models, but most physicians are still incented on a fee for service basis with occasionally some additional more extensive fee codes, such as the once-a-year health check."

While FFS can be effective in clinical settings, recent critiques argue that FFS encourages low-value care.¹³⁵ A C.D. HOWE Institute brief asserts FFS "creates a pervasive culture that rewards providers for delivering more care, not necessarily the right care."¹³⁶ This critique is particularly evident in Canada's low levels of health technology adoption. FFS models have historically limited virtual health technology adoption because prior to the pandemic most FFS codes in Canada required an in-person component.

¹²⁸ Teja, B. et al, "Ensuring Adequate Capital Investment in Canadian Healthcare," *CMAJ*, Volume 192, Issue 25, June 2020, <https://www.cmaj.ca/content/192/25/E677>

¹²⁹ "Capital Funding of Healthcare in Canada Is Critical, yet Declined in Last 20 Years," Braceworks, <https://braceworks.ca/2021/01/15/health-tech-capital-funding-of-health-care-in-canada-is-critical-yet-declined-in-last-20-years/> "Capital Funding of Healthcare in Canada Is Critical, yet Declined in Last 20 Years | Braceworks Custom Orthotics."

¹³⁰ Teja, B. et al, "Ensuring Adequate Capital Investment in Canadian Healthcare," *CMAJ*, Volume 192, Issue 25, June 2020, <https://www.cmaj.ca/content/192/25/E677>

¹³¹ Kristie Jones, "Scaling up Virtual Care in Canada: Addressing the Barriers to Capitalize on the Opportunities," Hospital News (blog), April 9, 2019, <https://hospitalnews.com/scaling-up-virtual-care-in-canada-addressing-the-barriers-to-capitalize-on-the-opportunities/>; "Physicians in Canada, 2019," Canadian Institute for Health Information, 2019, https://secure.cihi.ca/free_products/physicians-in-Canada-report-en.pdf

¹³² "I - Certain Diagnostic And Therapeutic Procedures," Dr. Bill, <https://www.dr-bill.ca/i-certain-diagnostic-and-therapeutic-procedures>

¹³³ Ricardo de Mello Brandão, "Primary healthcare in Canada: current reality and challenges," *Saúde Pública*, Volume 35, Issue 1, 2019, <https://www.scielo.br/j/csp/a/sFKhjCMFVqHsdqdLr9mNjC/?lang=pt>; "Information and Procedures for Claiming the Cumulative Preventive Care Bonus, Ministry of Health and Long-Term Care Ontario Health, March 2018, https://www.health.gov.on.ca/en/pro/programs/ohip/bulletins/11000/bul11190_cpcb.pdf

¹³⁴ "Physicians in Canada, 2019," Canadian Institute for Health Information, 2019, https://secure.cihi.ca/free_products/physicians-in-Canada-report-en.pdf

¹³⁵ Mafi, J.N., and Parchman, M. "Low-value care: an intractable global problem with no quick fix," *BMJ Quality & Safety*, Volume 27 Issue 5, May 2018, <https://qualitysafety.bmjjournals.com/content/27/5/333>; Dr. Bhaitia, R.S., and Falk, W., "Modernizing Canada's Healthcare System through the Virtualization of Services," Howe Institute, <https://www.cdhowe.org/public-policy-research/modernizing-canada%20%99s-healthcare-system-through-virtualization-services>

¹³⁶ Mafi, J.N., and Parchman, M. "Low-value care: an intractable global problem with no quick fix," *BMJ Quality & Safety*, Volume 27 Issue 5, May 2018, <https://qualitysafety.bmjjournals.com/content/27/5/333>

Key informant interviewees cited a lack of financial incentive as a primary barrier to health technology adoption. Because in a fee-for-service-model physicians are not compensated for services without billing codes, there is no incentive for them to adopt new technologies. Moreover, new technologies could reduce the number of services physicians need to provide their patients. For instance, a wearable device could reduce the number of scheduled check-ins required, replacing pre-scheduled visits with strategic check-ins based on data (see Wearables, Sensors, and Cloud Technology for more information). In fact, one Professor (JC) went so far as to claim that the primary barrier to health technology adoption is physicians' unwillingness to relinquish revenue from their potentially reduced patient load. In other words, physicians want to maintain their heavy patient load to make more money—even if it means providing lower-value care. Most interviewees, however, commented that once billing codes change, physician adoption will follow.

“A lot of medical doctors just said, ‘Our ability to get patients is going away: people aren’t visiting anymore, so we can’t charge, and our revenue stream is going down. How do we maintain our revenue stream through our clinic while doing this virtually?’ And so, there are specific billing codes in the US for things like remote patient monitoring. And the U.K is kind of a split between the two: there are funded models for certain diseases whereby, if you fit a certain criterion, you can get funding through the NHS.”

— Health Technology Company Executive

An alternative to traditional fee-for-service care models is value-based healthcare. The New England Journal of Medicine defines value-based care as a “delivery model in which providers, including hospitals and physicians, are paid based on patient health outcomes.”¹³⁷ While end-product models for value-based care differ, there is general agreement that compensation is based on health outcomes measured against service costs rather than the volume of services physicians deliver.¹³⁸ Value-based compensation models are also more amenable to technology adoption. One key informant confirmed that value-based care encourages health technology innovation.

“There have been a lot of regulatory changes recently where they’ve tried to shift payment models or reimbursement models toward a value-based and outcome-based approach. This includes things like using technology for new models such as hospital-at-home models, virtual care models, or remote patient monitoring models. And this, of course, encourages companies like ours that work with technology to innovate within those new models in Canada and specifically in Ontario.”

— Health Technology Company Executive

¹³⁷ NEJM Catalyst, “What Is Value-Based Healthcare?” NEJM Catalyst, January 2017, <https://catalyst.nejm.org/doi/full/10.1056/CAT.17.0558>.

¹³⁸ Ibid.

Calls To Action: Barriers to Adoption

Exploring new approaches to health tech procurement in the public sector that help address absent or misaligned incentives for health technology adoption is essential. For example, value-based procurement focuses on improving patient outcomes and lowering the total cost of care versus cost-based procurement, which seeks to find the lowest cost version of a specific product or service.

Healthcare stakeholders should explore how to encourage the use of technology to achieve higher value care models. For example, self-monitoring tools, wearables, and telehealth services can be used by patients and healthcare providers in between appointments to augment routine check-ups.

Culture

Organizational culture can determine the success of health technology adoption. Existing research reveals that lack of support and stakeholder engagement as well as cultural resistance to change can be detrimental to adoption rates.¹³⁹ For instance, a Canadian case study, “Barriers to Organizational Adoption of EMR Systems in Family Physician Practices,” notes that physician resistance to using digital information systems can prevent successful EMR adoption.¹⁴⁰ While this resistance is also based on other factors including integration, usability, and patient outcomes, it nonetheless shows the impact of health provider culture on new technology adoption.¹⁴¹ Numerous key informant interviewees also noted the impact of culture on health technology adoption.

“Social acceptance by the patients, by the doctors, by the community will be one of the biggest challenges for any innovation in digital healthcare.”

— Health Technology Company Executive

“Some [hospital] unit cultures are more hesitant to jump into using the software program: like perhaps a nurse who has been working there for 10 years and has been doing the same assessments on paper for 10 years, over and over again: for them to start doing something new, that would put a dent in their day.”

— Healthcare Professional

“The truth of the matter is that physicians don’t want to be replaced, and they don’t really want to change their practices.”

— Professor

¹³⁹ “Accelerating the Adoption of Digital Health Technologies in Canada,”

<https://technnationcanada.ca/wp-content/uploads/2020/10/Accelerating-Adoption-Health-Whitepaper-2018.pdf>

¹⁴⁰ Guy Paré et al., “Barriers to Organizational Adoption of EMR Systems in Family Physician Practices: A Mixed-Methods Study in Canada,” *International Journal of Medical Informatics*, Volume 83 Issue 8, August 2014, <https://www.sciencedirect.com/science/article/abs/pii/S138650561400104X?via%3Dihub>

¹⁴¹ Palacholla R.S., “Provider- and Patient-Related Barriers to and Facilitators of Digital Health Technology Adoption for Hypertension Management: Scoping Review,” *JMIR*, Volume 3 Issue 1, 2019, <https://cardio.jmir.org/2019/1/e11951/>

There are many strategies that help create an organizational culture that accepts newly adopted technologies. An example that interviewees and studies¹⁴² suggest is adopting “physician champions” or “super users”:

“In one of the hospitals that I worked in, they were bringing in a brand-new software. They were rolling it out and all the senior nurses were irritated about it. They would say, ‘I don’t want to do this. I don’t know-how to do that.’ They were nervous, but it seemed organized. They had a bunch of super users and communicated to everyone that there was a set date they’d be rolling it out by, whether or not the nurses liked it. So, everyone just had to get used to it and adapt to the changes and the innovation.”

— Healthcare Professional

Physician champions or super users can function as tech support and provide needed leadership that can positively influence organization culture. Other strategies mentioned include mandatory adoption and training tools. The 2020 iteration of Deloitte’s Global Health Sector Outlook even suggests using virtual reality to train physicians, encouraging them to feel confident about the new technology in question.¹⁴³

Talent and Skill Capacity

Canadian healthcare organizations that want to adopt health technologies face capacity and skill challenges. Almost 20% of survey respondents noted lack of capacity as a factor preventing them from adopting health technologies, specifically the need to hire tech support, the amount of effort to implement this technology, and the need to train staff. Moreover, healthcare organizations that adopt health technologies may risk employee burnout and uneven adoption without proper implementation measures. Indeed, the Canadian Medical Association’s guide for recognizing burnout lists “changes to work context and care delivery models due to new technology” as one of eight causes of burnout. For example, in a recent survey examining the impact of electronic health records (EHR) on physician burnout in Canada, 74.5% of respondents reported EHR as partly responsible for their burnout.¹⁴⁴ These high levels of physician burnout point to a Canada-wide lack of technology implementation capacity. Key informant interviewees report that pandemic-induced staff shortages¹⁴⁵ reduce the already limited time physicians have to learn new tools and implement new solutions. Interdepartmental miscommunications further hamper adoption efforts.

“The floor nurses, the management, everyone’s always saying, “I’m so busy. I’m so busy.” The pandemic also causes a lot of people to feel overwhelmed because there are new courses and new things we have to learn, and we don’t have time. It’s upsetting to me, because if we had 100% of the [software’s] capabilities, it would be so useful.”

— Healthcare Professional

¹⁴² Palacholla R.S., “Provider- and Patient-Related Barriers to and Facilitators of Digital Health Technology Adoption for Hypertension Management: Scoping Review,” *JMIR*, Volume 3 Issue 1, 2019, <https://cardio.jmir.org/2019/1/e11951/>

¹⁴³ Dr. Stephanie Allen, 2020 global healthcare outlook, Deloitte, <https://www2.deloitte.com/content/dam/Deloitte/cz/Documents/life-sciences-health-care/2020-global-health-care-outlook.pdf>

¹⁴⁴ Tajirian, T. et al., “The Influence of Electronic Health Record Use on Physician Burnout: Cross-Sectional Survey,” *Journal of Medical Internet Research* 22, Volume 22 No 7, 2020, <https://www.jmir.org/2020/7/e19274>

¹⁴⁵ “Healthcare Job Vacancies in Canada Are Soaring despite COVID-19 Demand. Here’s Why - National | Globalnews.ca,” accessed June 22, 2021, <https://globalnews.ca/news/7713735/job-vacancies-canada-coronavirus/>.

“It’s not fair because you don’t get a pay raise to obtain that extra skill. You’re constantly being told that you need to do this certificate, you need to do this course, etc., and it’s like, ‘Okay, but how many new things am I doing now that I’m not getting paid for?’”

— Healthcare Professional

These challenges are amplified in rural areas. In addition to the adoption barriers mentioned above (see Adoption by Region), rural communities face recruitment and retention challenges as well as higher turnover rates. Indeed, the 18% of Canadians that reside in rural areas are served by only 8% of Canadian physicians.¹⁴⁶ This service shortage makes it difficult to adopt new technologies.¹⁴⁷ When technologies are adopted, lack of support compounds pre-existing labour shortages.¹⁴⁸ ICTC key informant interviews confirm difficulties finding and retaining talent in rural areas with the right technical skills, which makes it harder to adopt health technologies.

“In an urban environment, there’s more capacity because it’s easier to hire people. There is a bigger pool of people to hire from, and there’s usually more IT support agencies or even just informal peer networks where providers can reach out to other provider groups for help and assistance. Whereas in the rural and remote communities, that tends to be more of a challenge.”

— Health Technology Company Executive

“There tends to be, from my experience, sometimes more turnover in the smaller, more rural and remote locations, which makes it hard to advance initiatives that might span a significant period of time.”

— Health Technology Company Executive

To help mitigate burnout and capacity challenges, respondents suggested a variety of solutions, including consulting with experienced healthcare providers when designing a roll out, increasing upskilling support in the form of super users and dedicated support staff, increasing incentives, and clarifying connections between users and IT staff to facilitate required changes.

Calls To Action: Interdisciplinary Tech Talent

In light of the additional healthcare stresses and time constraints imposed by COVID-19, it is critical to prioritize and support upskilling programs to address broad ICT skill needs among healthcare professionals.

¹⁴⁶ Charbonneau, G. “Recruiting physicians to practice in rural communities,” *Canadian Family Physician*, Volume 64 Issue 8, August 2018, <https://www.cfp.ca/content/64/8/621>

¹⁴⁷ Baylak A. et al., “Telehealth in Rural Canada: Emergent Technologies to Address Historical Issues,” *Canadian journal of Nursing Infographics*, Volume 15 Issue 2, June 2020, <https://cjni.net/journal/?p=7188>

¹⁴⁸ “2021 Global Healthcare Sector Outlook,” Deloitte, accessed June 22, 2021, <https://www2.deloitte.com/global/en/pages/life-sciences-and-healthcare/articles/global-health-care-sector-outlook.html>.

Conclusion

The healthcare sector is a core pillar of the Canadian economy: healthcare spending accounted for 11.5% of Canada's GDP in 2019. With population growth, aging, high immigration targets, and the increased prevalence of chronic disease, the importance of healthcare to the Canadian economy is likely to grow. Meanwhile, the health system faces ongoing pressure to adopt new equipment and technology, and improve healthcare administration and delivery. In this context, health technology is both a solution to increasing costs (e.g., AI-powered augmentation and automation, telehealth) and a driver of new economic activity (e.g., new healthcare technology products and services like AI-driven drug discovery and wearable technologies), including job growth.

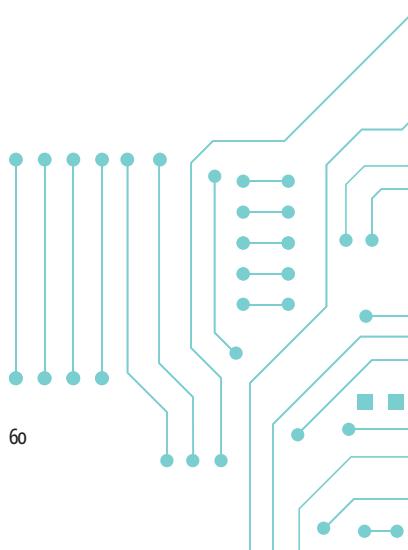
To accelerate health technology adoption and innovation in Canada, it is vital to establish comprehensive privacy legislation with agile data mobility provisions and prioritize the development of interdisciplinary tech talent. Mitigating barriers to health technology adoption by re-evaluating cost-based procurement mechanisms, improving implementation support, and ensuring equitable access to new technologies will allow more Canadians to access high-quality healthcare. These interventions will help Canada increase care value and improve patient outcomes while supporting Canada's health technology industry.

Section I of the report discussed specific technology trends that are driving this growth, including electronic health records becoming more centralized and accessible; the proliferation of telehealth services due to COVID-19; growth in the use of wearables, sensors, and cloud technology; and the onset of big data and machine learning applications in health.

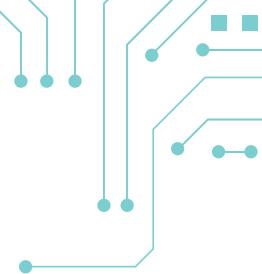
Delving into a dataset of 1202 health technology companies operating in Canada, the second part of **Section I** identified the top industry groups and verticals in Canada's health technology industry. Among the companies in the dataset, the most common industry groups were pharmaceuticals and biotechnology, health technology systems, healthcare devices and supplies, health services, and software. Meanwhile, the most common tech verticals were health tech, TMT, digital health, life sciences, and AI and ML. Finally, **Section I** discussed trends in company size, founding year, and ownership status, which are useful indicators of company maturity. While approximately 98% of companies in the dataset are SMEs, almost all of the large enterprises were pharmaceutical and biotechnology firms or ICT firms that provide business-to-business products and services. On average, companies that qualify as part of the pharmaceutical and biotechnology industry group are larger, older, and more likely to be a public company. Meanwhile, companies that offer healthcare devices and supplies, healthcare services, and software are smaller, younger, and more likely to be privately held.

Section II highlighted that prior to the onset of COVID-19, ICTC projected demand for digitally skilled talent in Canada's health and biotechnology industry to be nearly 119,000 by 2022. Further, Section II presented some of the key roles and skill sets that will be needed in Canada's health tech ecosystem, including software roles like software engineers and full stack developers, data-focused roles like machine learning engineers, data scientists, and computational scientists, and product focused roles, such as project managers and designers.

Finally, **Section III** situated Canada in the global health technology adoption landscape and identified relevant adoption trends by region and technology. While Canada falls behind international counterparts in most adoption rates, one KII noted that cautious adoption can reduce weak returns on investment. Adoption by region varies based on a variety of factors, however, geographic differences in health technology adoption are primarily due urban-rural divides rather than interprovincial and territorial regulatory landscapes. Finally, and unsurprisingly, survey results reveal that telehealth and, in particular, web-based communications such as Zoom were the most adopted technologies before and during the pandemic. Additionally, Section III listed key barriers to adoption, including complex regulatory environment, cost-based rather than value-based procurement processes, outdated physician compensation models, organizational cultures of resistance, and lack of capacity compounded by the pandemic.



Appendix A



Research Methodology

This study uses both primary and secondary research methods which are described below.

Primary Research

The primary research of this study was comprised of three components: a survey, key informant interviews, and an advisory committee.

Survey. The employer survey was targeted to health tech organizations across Canada, and responses included those from individual with higher-level decision-making within their organizations, such as owners/founders, CEOs, executives, and managing directors. All provinces are represented in the 306 responses that ICTC received. Questions ranged from organization activities before and during COVID (i.e., number of employees, crucial roles and talent questions, digital solutions, technology adoption, policies and regulations, and the impacts of COVID-19 on organizations).

Survey Respondents Locations



Figure 17. Locations of organizations (survey respondents).

Key Informant Interviews. ICTC conducted 26 key informant interviews with diverse expertise in the health tech field. Interviews were conducted between January to June 2021. Interviewees held influential positions within their organizations, including Founders, CEOs, Professors, Directors, and Physicians and Nurses. These interviews were tailored to collect information on general organization questions, trends in health technology and digital health in Canada, and labour and talent questions. Due to the nature of the health tech industry, a majority of interviewees were from organizations headquartered in Ontario and British Columbia.

Advisory Committee. ICTC hosted two advisory committee meetings of eight industry consultants. The data was presented with interactive activities on Jamboard. The advisory committee members met twice during the duration of the project, meetings occurred in March and June 2021. Advisory committee participants also held influential positions such as CTO, CEO, Professors, and Scientific Directors (in startups, large organizations, civil, academic, private, and healthcare sectors).

Type of Organization

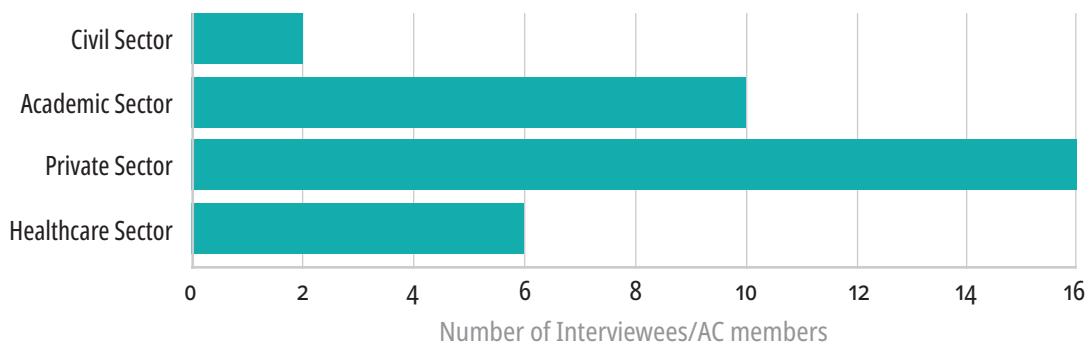


Figure 18. Types of organizations (interviewees and advisory committee).

Location of Interviewees and Advisory Committee Participants



Figure 19. Location of interviewees and advisory committee participants.

What are the impacts this barrier?

The ‘brain drain’ is the perpetual problem. The US remains a perpetual vacuum, but increasingly China, Singapore, Europe. Limits on potential (incl. data use) are at issue.

Solutions are not optimal or fully-realized due to a gap in talent. Emphasizing specialization instead of general knowledge and applicability.

When it comes to digital—that’s in all areas but also with a view to AI, ML, genomics, and other highly skill-based areas. We need to attract the best minds in these areas and then give them a platform to do their

Training is still rather silo’d, but this is getting better (at least in some institutions, and even then slowly).

Who are the key actors?

Universities, VC firms, Hospitals

Universities, start-ups, grass-roots movements, dynamic leaders

Again—government needs to invest in developing centres of excellence and make commitments to research funding as well as providing access to real-world living labs where this work can be trialed/tested.

+1

What needs to change to address this barrier?

“Own the podium” was cheesy 11 years ago, but we need to aim to be competitive. UHN (e.g.) shouldn’t aim to be “Top 5” but “#1”... somehow we need to reduce complacency

Public sector work environments—adapting/ changing to attract talented individuals over the private sphere

the previous sticky but—in addition to investment in research it’s also investment in the institutions and attracting international talent/collaborating internationally to ensure that we’re

Talent

Figure 20. Screenshot example of a Jamboard activity from the first advisory committee meeting in March 2021.

**Do you identify or agree with these comments?
Are there any that you disagree with?**

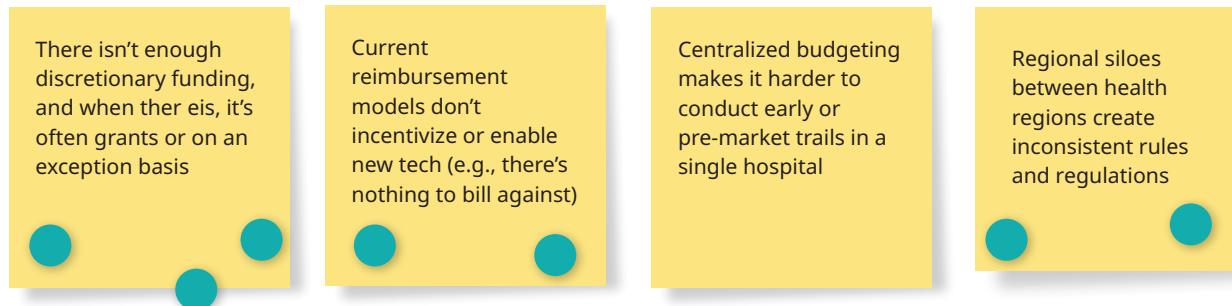
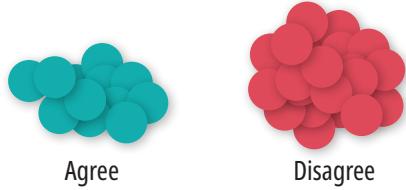


Figure 21. Screenshot example of a Jamboard activity from the second advisory committee meeting in June 2021.

Secondary Sources

Company-level data. ICTC curated a list of companies in the Canadian health technology industry using Pitchbook. Companies were included if they operated in the health tech and digital health technology verticals and had an office or headquarters located in Canada. The list was vetted for inaccurate data, and inactive companies were removed.

Jobs and skills data web scraping. ICTC used web scraping techniques to identify key job positions and skills that are important for the health tech industry. Sources used for web scraping included publicly available information from job aggregation websites.

Job postings. Health tech-related job postings in Canada were collected from January to June 2021.

Existing literature. The qualitative and quantitative portions of this project were supported by a thorough review of available literature. The literature review helped shape research methods and questions and provide information to help further validate findings in the report. The initial literature review helped identify interviewees, advisory committee participations, and form a methodology for the quantitative portion of the research. Additionally, ICTC accessed publicly available data sources including the Health Infoway Canada, the Commonwealth Fund, Canadian Medical Association, Health Canada, and medical journals.

Appendix B

Research Limitations

While efforts were made to mitigate potential biases, there are certain limitations that may be inevitably embedded in this study.

Key Informant Interviews. ICTC conducted 26 interviews with individuals from organizations across Canada, a sample that is too small to be considered representative of the entire health tech industry. Further, ICTC was not able to conduct interviews from organizations in every province in territory. The study was conducted with participants in British Columbia, Ontario and Quebec in the following cities: Toronto, Ottawa, Waterloo, Montreal, Vancouver, and Victoria.

Company data and data acquired from web scraping. The data should be considered as a representative sample but not a full data set.

Appendix C

Healthcare and ICT Amalgamated NOCs and NAICs

Health/Biotech NAICS

NAICS Code	Description
3251	Basic chemical manufacturing
3254	Pharmaceutical and medicine manufacturing
3259	Other chemical product manufacturing
5112	Software publishers
5413	Architectural, engineering, and related services
5416	Management, scientific, and technical consulting services
5417	Scientific research and development services
5419	Other professional, scientific, and technical services
5621	Waste collection
5622	Waste treatment and disposal
5629	Remediation and other waste management services
6211	Offices of physicians
6212	Offices of dentists
6213	Offices of other health practitioners
6214	Out-patient care centres
6215	Medical and diagnostic laboratories
6216	Home healthcare services
6219	Other ambulatory healthcare services
6221	General medical and surgical hospitals
6222	Psychiatric and substance abuse hospitals
6223	Specialty (except psychiatric and substance abuse) hospitals
6231	Nursing care facilities
6232	Residential developmental handicap, mental health, and substance abuse facilities
6233	Community care facilities for the elderly
6239	Other residential care facilities

Health/Biotech NOCS

NOCS Code	Description
0014	Senior managers - health, education, social and community services, and membership organizations
0211	Engineering managers
0213	Computer and information systems managers
0311	Managers in healthcare
0411	Government managers - health and social policy development and program administration
2111	Physicists and astronomers
2112	Chemists
2121	Biologists and related scientists
2134	Chemical engineers
2161	Mathematicians, statisticians, and actuaries
2171	Information systems analysts and consultants
2172	Database analysts and data administrators
2173	Software engineers and designers
2174	Computer programmers and interactive media developers
2211	Chemical technologists and technicians
3211	Medical laboratory technologists
3212	Medical laboratory technicians and pathologists' assistants
3215	Medical radiation technologists
3216	Medical sonographers
3217	Cardiology technologists and electrophysiological diagnostic technologists, n.e.c.
3219	Other medical technologists and technicians (except dental health)
3223	Dental technologists, technicians, and laboratory assistants
3237	Other technical occupations in therapy and assessment
3414	Other assisting occupations in support of health services
4165	Health policy researchers, consultants, and program officers