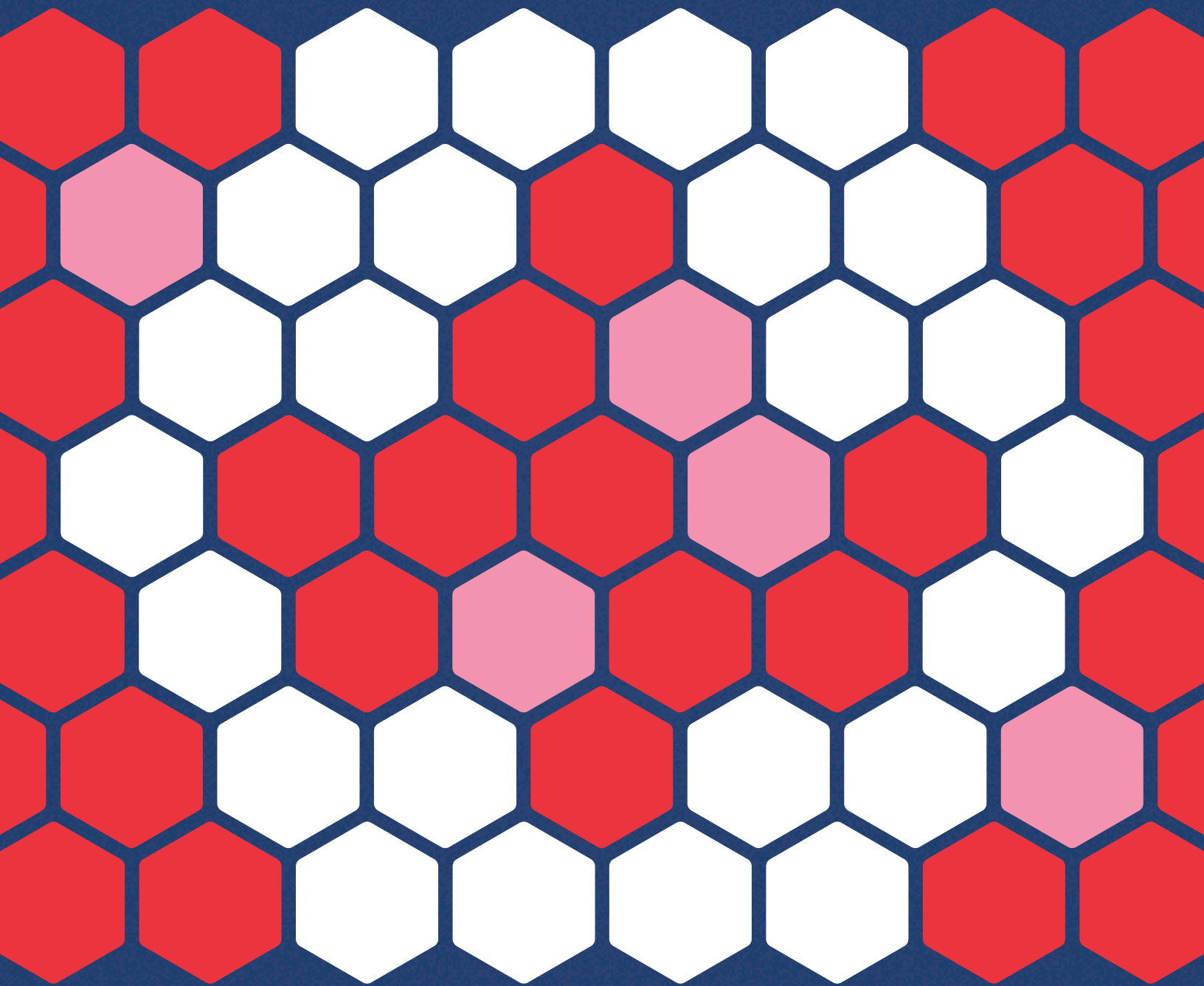


# Building Canada's Future AI Workforce

IN THE BRAVE NEW (POST-PANDEMIC) WORLD



March  
2021



Research by



The Information and  
Communications Technology Council

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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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Designed by Raymond Brand.



# Key Words

Artificial intelligence (AI)

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Key informant interviews (KII)

Labour market

Machine learning (ML)

Upskilling

Remote work

Startups

Talent

Technology

Upskilling

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# Executive Summary

Two cornerstones of any G7 nation are finance and healthcare: one reflects the economic health of the nation, the other health of its citizens. Recent advances in artificial intelligence (AI) applied in these areas show incredible potential for innovation—better customer and patient engagement, employee empowerment, greater operational efficiencies, and industry transformation. Accompanied by cloud computing, big data analytics, cybersecurity, and internet-of-things (IoT), AI is but one of many tools driving digital transformation. Its role is to operationalize the growing stockpiles of information increasingly available across all industries.

Within this context, a crucial requirement is the ability of a country to create and sustain a trained workforce that can lead its industries to flourish. The COVID-19 pandemic has exerted a paradigmatic shift in the workplace, with the emphasis on remote work (and work-from-home) accelerating both digital growth and adoption. At the same time, the negative impact of economic shutdowns has made it necessary for businesses to adopt new ways to optimize operations and making the workforce more effective. AI technology stands to play a pivotal role in the success of this realignment.

In this comprehensive report, ICTC explores the support needed for Canada's digital workforce to acquire AI skills through various training pathways: broad upskilling initiatives to target widely needed digital skills and strategic cross-training programs to address acute needs like those in the field of AI. The use of AI in healthcare and financial services requires highly experienced teams comprised of individuals with graduate-level education (e.g., either master's or doctorate levels) in AI, business, and domain-specific knowledge. A key finding in this report is the knowledge gap that exists between each of these subgroups on AI product development teams. In the healthcare and financial services industries, it is often the case that domain experts, AI/ML experts and business strategists lack a common understanding of each others areas of expertise, reducing their ability to collaborate effectively on AI products. Grounded in interviews with industry leaders in AI, in the financial services and healthcare sectors, this report proposes two new methods of skills training: targeted cross training between AI, business, and domain experts; and mentorship and support programs. Further, ICTC recommends the following calls to action:



- Businesses and organizations that develop AI products for use in the healthcare and financial services sectors should ensure that their development teams are adequately cross trained, with sufficient technical, domain, and business know-how. Industry should therefore prioritize multidisciplinary cross training within AI teams.
- Canada's strategy for AI skills development should include cross-training as a fundamental pillar in workforce development efforts. For example, government actors could include acute skill needs (such as the need for multidisciplinary cross training on AI teams) in future plans and programs stemming from the Workforce Development Agreements.<sup>1</sup>
- Canadian academic institutions should assess the availability (and accessibility) of AI-related courses in non-technical programs such as business, finance, or medical programs; and the availability of domain-specific courses in technical programs like data science or computer engineering.
- In light of the economic impact of COVID-19 on Canadian employment and the resilience of the tech sector over the course of the pandemic, the federal government should continue to prioritize and support remote upskilling programs to address broad information and communications technology (ICT) skill needs.
- Stakeholders in heavily regulated sectors like financial services and healthcare should work with the federal, provincial, and territorial governments to establish industry-wide data governance standards and secure data sharing mechanisms to enable greater and more secure data access.

Seen as an opportunity, government and employer investment in non-traditional training pathways can help infuse the digital economy with highly trained workers and springboard economic recovery.

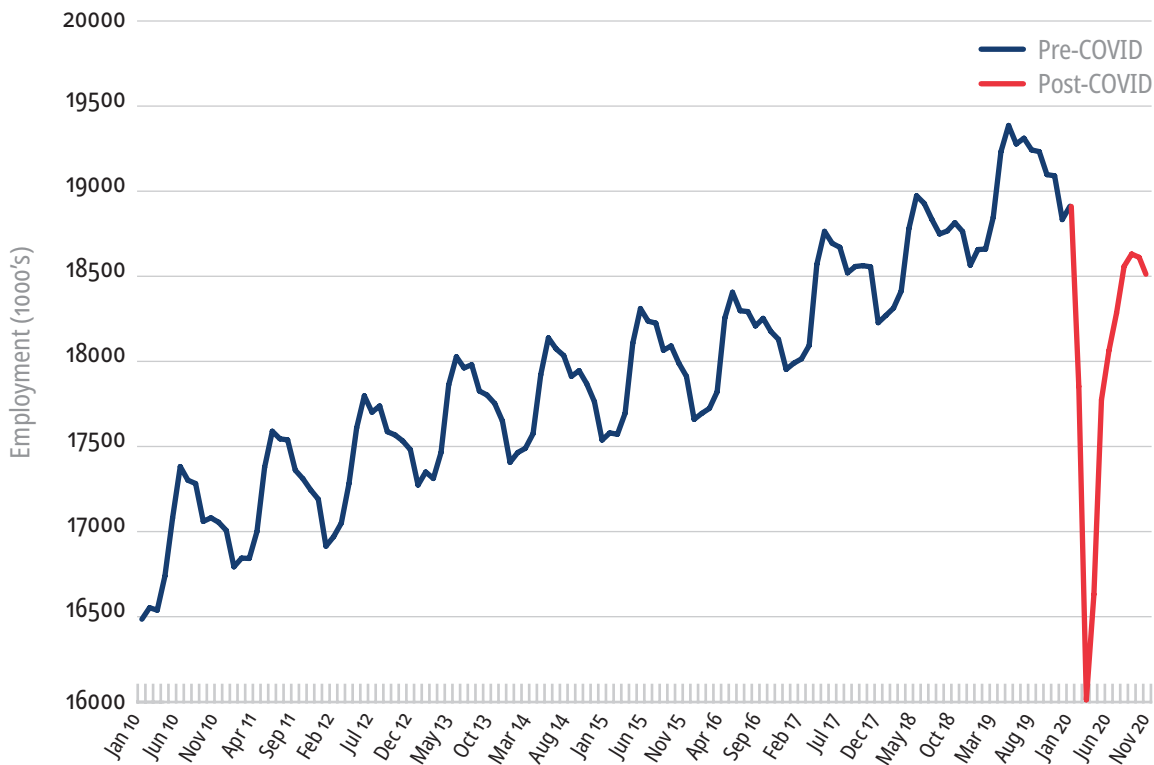
<sup>1</sup> About the Workforce Development Agreements program, Government of Canada, <https://www.canada.ca/en/employment-social-development/programs/training-agreements/workforce-development-agreements.html>

# Introduction

## Tech Resiliency and the Canadian Economy Amid COVID-19

To understand AI's pivotal role in Canada's post-pandemic economic recovery, further context about COVID-19's impact on the broader ICT is needed: this introductory section will provide a brief overview of the impact of the COVID-19 pandemic on the ICT sector and the Canadian economy generally, before moving on to discuss the role of AI. Now a year into the COVID-19 health crisis, Canadians are beginning to understand some of the mid- to long-term impacts on the Canadian economy. Like many countries, Canada's health response to the global pandemic (including social distancing orders and successive lockdowns) triggered the most rapid and significant drop in employment and gross domestic product (GDP) in Canadian history. As seen in *Figure 1*, employment dropped more than 15 percent in just a matter of months, from 18.9 million in February 2020 to 16 million in April 2020.

### Canadian Employment — Seasonally Unadjusted



**Figure 1.** Canadian Employment (Seasonally Unadjusted).<sup>2</sup>

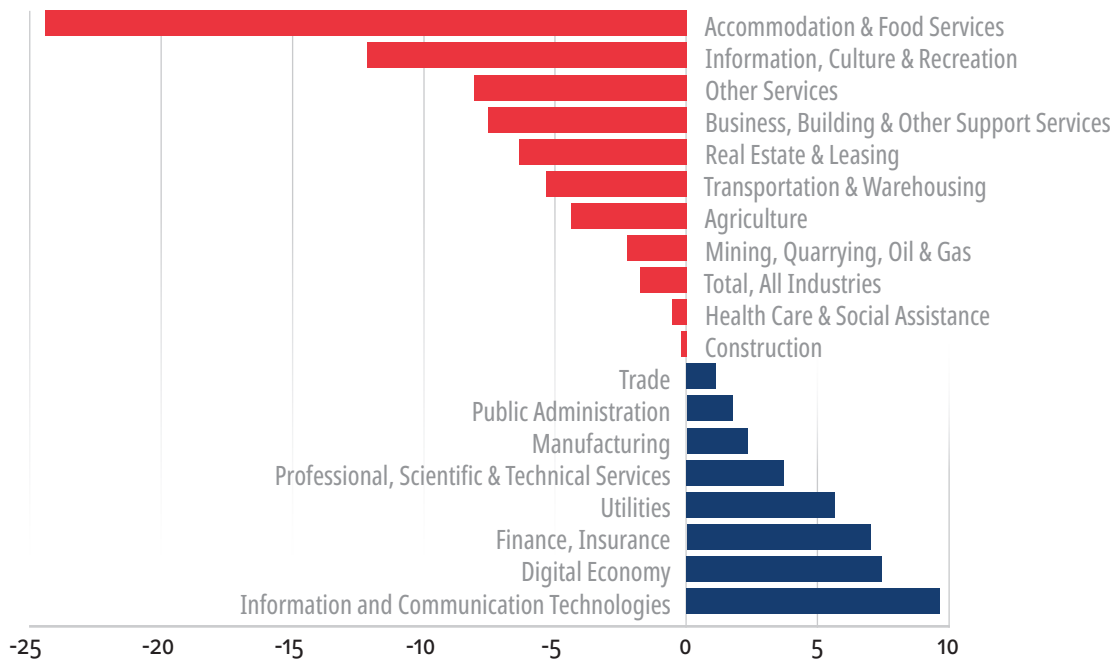
<sup>2</sup> About the Workforce Development Agreements program, Government of Canada, <https://www.canada.ca/en/employment-social-development/programs/training-agreements/workforce-development-agreements.html>



From April onwards, employment in Canada recovered rapidly: as of December 2020, overall employment was modestly below pre-crisis levels. However, upon closer look, we see that the employment gains since April 2020 are not evenly distributed. Today, Canadians aged 15 to 24 and 65 or older are more likely to be unemployed, as are women and Canadians who earned a low wage prior to the pandemic.<sup>3</sup> Perhaps the most troubling aspect of this employment trend is that by December 2020, employment in the top two-thirds of wage earners had actually increased. Meanwhile, all persistent job losses were concentrated among the lowest wage earners in Canadian society, demonstrating that the most economically vulnerable Canadians suffered the most labour market disruption.<sup>4</sup>

COVID-19 also impacted each sector of employment differently. Some sectors, such as the accommodation and food services sector, were impacted more directly by social distancing orders and economic lockdowns and therefore saw greater employment loss (employment in the accommodation and food services sector fell 24.4% from January to December 2020). Likewise, real estate and building was significantly impacted by the sudden transition away from office buildings to remote work. Alternatively, sectors that were (a) considered essential services and stayed open despite lockdown orders (e.g., utilities, construction); (b) needed for the COVID-19 pandemic response (e.g., health care and social assistance, manufacturing); or (c) particularly well-suited to teleworking (e.g., ICT, finance and insurance) saw less employment loss and, in some cases, employment gains (see *Figure 2*). As such, Statistics Canada data shows that employment in the ICT sector increased by 9.7% from January to December 2020, while overall employment dropped by 1.8%. Similarly, LinkedIn data shows that the 10 most in-demand jobs throughout the course of the pandemic have been tech related.<sup>5</sup>

### Employment Percent Change—January to December



**Figure 2. Employment Percent Change (January to December).**<sup>6</sup>

<sup>3</sup> Ryan McLaughlin, *January 2021 Economic Update*, Medium, January 2021, <https://medium.com/digitalthinktankictc/2020-economic-update-25f234f33739>

<sup>4</sup> Ryan McLaughlin, *January 2021 Economic Update*, Medium, January 2021, <https://medium.com/digitalthinktankictc/2020-economic-update-25f234f33739>

<sup>5</sup> LinkedIn, <https://opportunity.linkedin.com/skills-for-in-demand-jobs>

<sup>6</sup> Statistics Canada, Table 14-10-0287-01 *Labour force characteristics, monthly, seasonally adjusted and trend-cycle, last 5 months*  
DOI: <https://doi.org/10.25318/1410028701-eng>

As with employment, Canadian GDP dropped drastically from March to April to below 2011 levels; by October, it had recovered to just 3.5% below October 2019 levels. Again, the pandemic's impact on GDP was not felt equally across the Canadian economy, instead varying significantly between sectors. In the ICT sector, GDP was initially only set back by about one year but, by October, had realized year-over-year gains (see Figure 3). Together, the GDP trends and employment data demonstrate just how resilient the tech industry has been throughout the pandemic.

### Canadian and ICT Sector Gross Domestic Product—Monthly

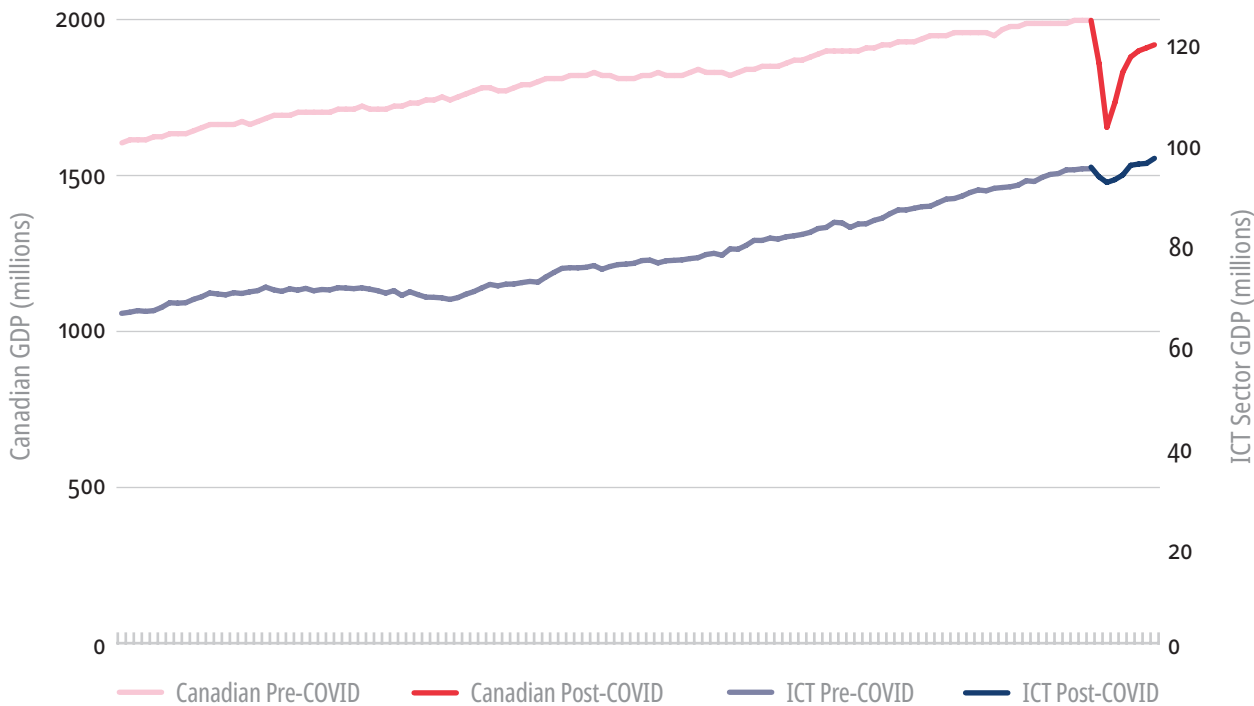


Figure 3. Canadian GDP.<sup>7</sup>

## COVID-19 and Increased Digital Adoption

Prior to the pandemic, digital adoption was already driving better customer engagement and operational efficiencies, with leaders in the space generating an average of US \$100 million in additional operating income each year.<sup>8</sup> That said, there was also already fierce competition for widely sought digital skills. Across Canada, ICT companies were experiencing significant labour shortages and a moderate to severe gap in the skills needed to exploit new and emerging tech. In 2020, three Canadian cities were named among the 15 fastest growing ICT markets in the world, and

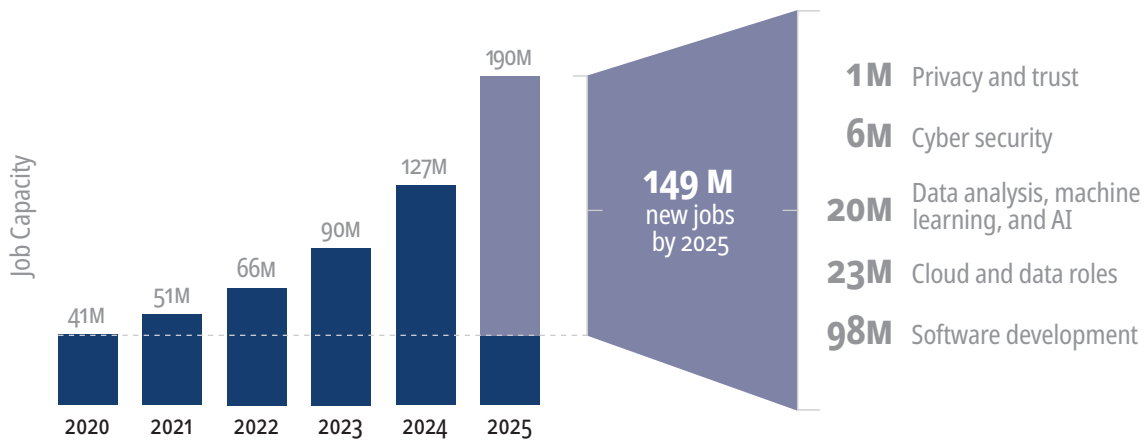
<sup>7</sup> Statistics Canada. Table 14-10-0287-01 Labour force characteristics, monthly, seasonally adjusted and trend-cycle, last 5 months  
DOI: <https://doi.org/10.25318/1410028701-eng>

<sup>8</sup> Your Roadmap for a digital-first business, Transformation at Microsoft, Microsoft, <https://info.microsoft.com/rs/157-GQE-382/images/dynamics365-en-digital-transformation.pdf>

Toronto was declared the fastest growing ICT job market globally.<sup>9</sup> At the same time, approximately 50% of all information technology (IT) departments in North America identified as either short-staffed or understaffed with respect to ICT roles.<sup>10</sup>

Since the pandemic, digital adoption has further increased. A July 2020 survey of 800 business executives found that just five months after the onset of the COVID-19 pandemic, 38% of businesses had already accelerated the digitation of their supply chains; 48% had increased the digitization of their customer channels; and 85% had increased the digitization of employee interactions and collaboration.<sup>11</sup> Meanwhile, Canadians have started using more technology in all areas of their lives: to attend a local government consultation or town hall; meet with a financial advisor;<sup>12</sup> and for work and school.<sup>13</sup> In the last year alone, Canadian employment in ICT roles grew by 9.7%, and LinkedIn data suggests that looking forward, global employment in digital roles will increase another by another 363 %—led by jobs in software development, cloud technologies, and data analysis, machine learning (ML), and AI (see *Figure 4*).<sup>14</sup>

### Digital Job Capacity from 2020–2025



**Figure 4.** “The Great Lockdown will accelerate digitization,” Source: Microsoft, 2020.<sup>15</sup>

<sup>9</sup> 2019 Tech Talent Analyzer, CBRE, 2019, <https://mapping.cbre.com/maps/Scoring-Tech-Talent-2019/>

<sup>10</sup> In-demand technology and IT jobs in 2021, Randstad, 2019, <https://www.randstad.ca/best-jobs/best-it-and-technology-jobs/>

<sup>11</sup> What 800 executives envision for the post pandemic workforce, McKinsey & Company, September 2020, <https://www.mckinsey.com/featured-insights/future-of-work/what-800-executives-envision-for-the-postpandemic-workforce>

<sup>12</sup> Note: “Prior to COVID-19, only 11 per cent of Canadians had spoken to a bank advisor via video call, but more than four in 10 (44 per cent) said they would be willing to do so when branches reopen, and 29 per cent said they would prefer video calls to face-to-face meetings.” Banking Consumer Study: Making digital more human, Accenture, December 2020, <https://www.accenture.com/ca-en/insights/banking/consumer-study-making-digital-banking-more-human?src=SOMS>

<sup>13</sup> Canadian workforce of the future survey, PwC, <https://www.pwc.com/ca/workforcesurvey>

<sup>14</sup> Brad Smith, Microsoft launches initiative to help 25 million people worldwide acquire the digital skills needed in a COVID-19 economy, Microsoft, June 2020, <https://blogs.microsoft.com/blog/2020/06/30/microsoft-launches-initiative-to-help-25-million-people-worldwide-acquire-the-digital-skills-needed-in-a-covid-19-economy/>

<sup>15</sup> Ibid.

Crucial to any company's transformation plan is a unique combination of digital tools, including cloud, cybersecurity, IT, big data, and AI.<sup>16</sup> As more companies start on their way to *becoming digital*, skills related to these tools will continue to see increased demand. If Canada is to sustain current levels of ICT sector growth, both industry and government will have to engage in comprehensive efforts to mould the Canadian workforce: this will require a range of initiatives, including broad upskilling programs, targeted cross training and mentorship, and the attraction of top foreign talent.

## Current Labour Market Challenges

As discussed, the COVID-19 pandemic has generated high unemployment in some sectors of the Canadian economy, creating an urgent need to assist job seekers in finding new roles. Meanwhile, increased digital adoption has resulted in two urgent labour market challenges: the sweeping need for talent with widely sought digital skills in areas like software development, data analysis, and digital marketing (which coincides with the need to address unemployment); and the need for highly skilled, mid- to senior-level talent to guide digital adoption and innovation in key industries like healthcare and financial services. These challenges are unique, meaning they will need to be addressed in different ways. For example, broad digital skill needs can be addressed by attracting foreign ICT talent to Canada; encouraging future talent to pursue education in ICT fields; and creating new ways for non-ICT talent to develop in-demand digital skills. Alternatively, the need for mid- to senior-level skill needs could be addressed through strategically focused cross training.

### Addressing Broad Skill Needs with Upskilling

LinkedIn data shows that, globally, the 10 most in-demand jobs during the pandemic are tech related. Some of these roles are technical, including software developers, data analysts, IT administrators, project managers, and graphic designers; others are tech adjacent, including project managers, IT support staff, sales representatives, customer services specialists, digital marketers, and financial analysts.<sup>17</sup> Statistics Canada data further identifies which ICT roles have seen increased demand in Canada. This list includes web designers and developers, information systems testing technicians, and software engineers and designers (see *Figure 5*).

In June 2020, in response to this growing demand, Microsoft, LinkedIn, and Github together launched a global skills initiative to help 25 million people around the world obtain new skills for in-demand jobs.<sup>18</sup> The initiative focuses on teaching the technical and soft skills needed to gain employment in one of the 10 most in-demand roles

<sup>16</sup> IoT devices to capture and transmit valuable information in real time; big data to provide structure to large amounts of information; cloud technologies to store and process information efficiently and at scale; cybersecurity tools to ensure the protection and integrity of IT systems; and AI to interpret and operationalize data.

<sup>17</sup> LinkedIn, <https://opportunity.linkedin.com/skills-for-in-demand-jobs>

<sup>18</sup> Brad Smith, Microsoft launches initiative to help 25 million people worldwide acquire the digital skills needed in a COVID-19 economy, Microsoft, June 2020, <https://blogs.microsoft.com/blog/2020/06/30/microsoft-launches-initiative-to-help-25-million-people-worldwide-acquire-the-digital-skills-needed-in-a-covid-19-economy/>

identified by LinkedIn. According to Microsoft, these roles have not only had “the greatest number of job openings” and “steady growth over the past four years” but also pay a livable wage and require skills that can be taught and learned in online environments.<sup>19</sup> More recently, in November 2020, the Government of Canada also announced an additional \$1.5 billion of investments in provincial and territorial Workforce Development Agreements, which highlights the ongoing importance of skills training initiatives in Canada.<sup>20</sup>

### Normalized Employment Change in Core Digital Occupations

January to December 2020

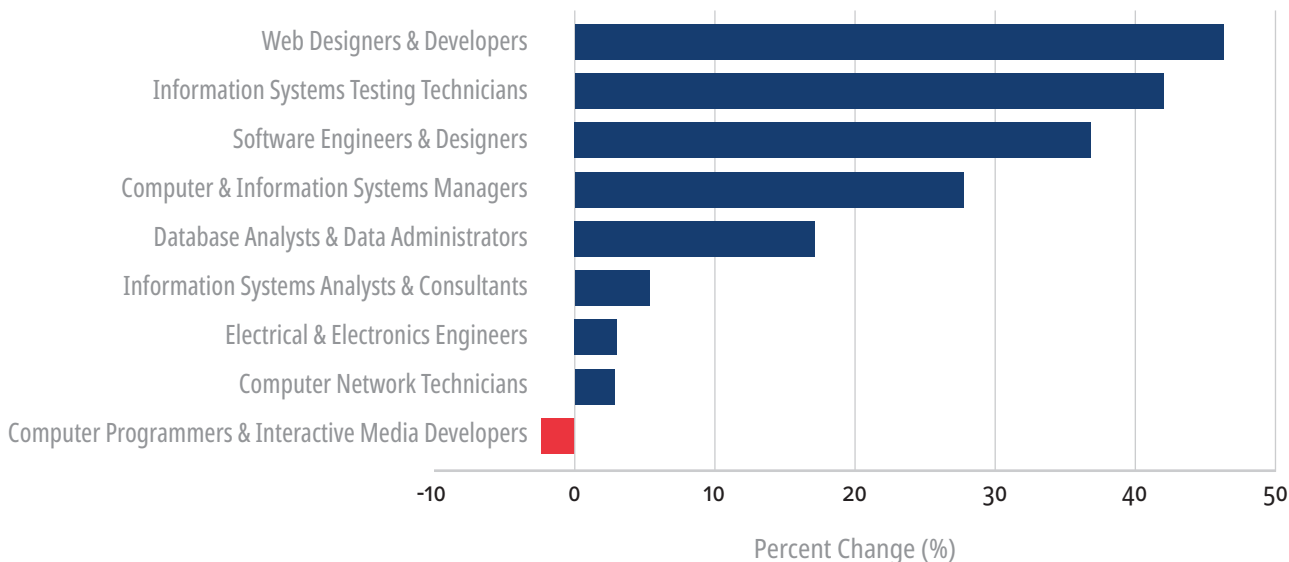


Figure 5. Normalized Employment Change in Core Digital Occupations (Percent Change in Employment from January to December 2020).<sup>21</sup>

### Addressing Acute Skill Needs with Cross Training

Understandably, not all labour market needs are well-suited to upskilling initiatives. The remaining sections of this report discuss the acute need for multidisciplinary mid- to senior-level talent in the field of AI. Unlike broad digital skill needs, this acute need is not sufficiently addressed through upskilling initiatives and will require targeted cross training on AI development teams. Highly skilled AI professionals were already in demand prior to the pandemic. Since then, the adoption of automation and artificial tools has further accelerated.<sup>22</sup> In response to the pandemic’s impact, businesses are looking for new ways to optimize their operations while making their workforces more effective, and AI technology stands to play a pivotal role in this

<sup>19</sup> Brad Smith, Microsoft launches initiative to help 25 million people worldwide acquire the digital skills needed in a COVID-19 economy, Microsoft, June 2020, <https://blogs.microsoft.com/blog/2020/06/30/microsoft-launches-initiative-to-help-25-million-people-worldwide-acquire-the-digital-skills-needed-in-a-covid-19-economy/>

<sup>20</sup> Fall Economic Statement 2020 Supporting Canadians and Fighting COVID-19, Government of Canada, <https://www.budget.gc.ca/fes-eea/2020/report-rapport/toc-tdm-en.html>

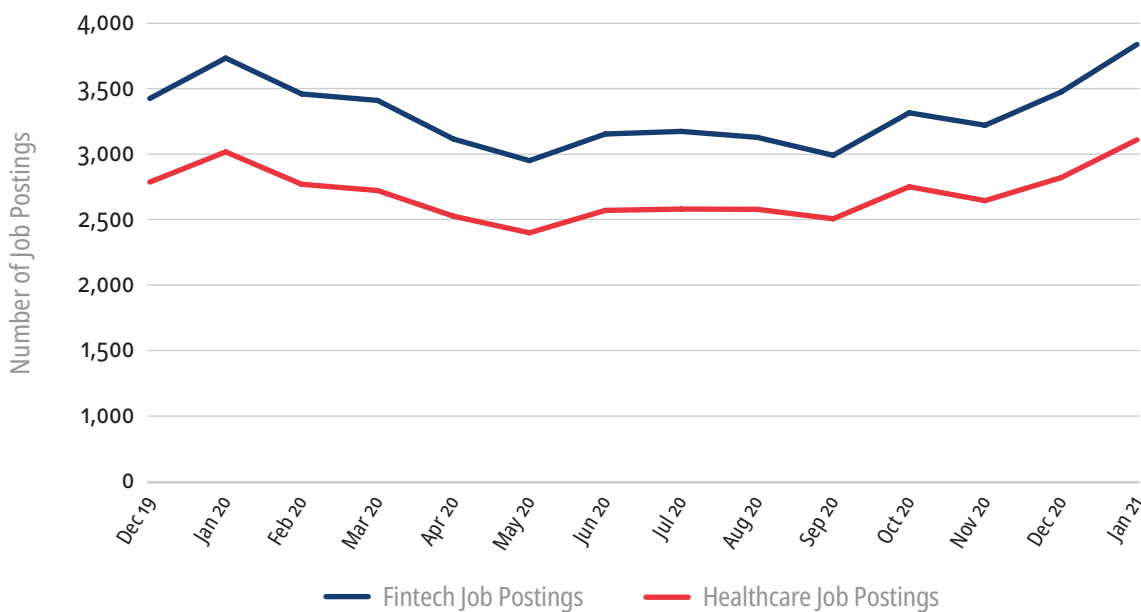
<sup>21</sup> Statistics Canada. Table 14-10-0287-01 Labour force characteristics, monthly, seasonally adjusted and trend-cycle, last 5 months DOI: <https://doi.org/10.25318/1410028701-eng>

<sup>22</sup> What 800 executives envision for the postpandemic workforce, McKinsey & Company, September 2020, <https://www.mckinsey.com/featured-insights/future-of-work/what-800-executives-envision-for-the-postpandemic-workforce>

process: a workforce that not only embraces AI but understands and can design AI solutions is crucial. As such, this report looks at acute talent needs in two key Canadian sectors: financial services and healthcare.

From December 2020 to January 2021, AI and ML (machine learning) roles in the financial services and healthcare sectors saw moderate growth. From May 2020 to January 2021, unique job postings in these categories grew by 35% (even amid the economic slowdown during COVID-19), driven primarily by new job postings in Ontario, Quebec, and British Columbia (see *Figure 7*). Amid this growth, AI has been transforming healthcare through cost reduction and improved outcomes for both healthcare providers and patients. For example, Toronto-based company Analytics 4 Life is combining AI with mathematical modelling to improve diagnostics for diseases like coronary artery disease (CAD). Traditional testing methods for CAD require costly devices that are predominately only available in major urban centres. CorVista, on the other hand, facilitates less-costly, non-invasive diagnosis by scanning the body, transmitting the acquired data to a secure cloud, performing analysis, and producing a report for physician assessment.<sup>23</sup> CorVista reduces physician diagnostic times as well as patient wait times, and can even increase accuracy of diagnosis. In financial services, companies like Mylo are using natural language processing (NLP) and ML to power interactive chatbots and “robo-advisors” that not only assist with generic service and information requests but provide personalized financial advice and self-help solutions to clients.<sup>24</sup>

### AI and ML in Financial Services and Healthcare: Unique Job Postings



**Figure 6.** AI and ML Fintech and Healthcare Unique Job Postings Amid COVID-19.<sup>25</sup>

<sup>23</sup> Analytics 4 Life, <https://www.analytics4life.com/press-release/analytics-4-life-to-present-new-clinical-data-on-novel-cardiac-imaging-technology-using-machine-learned-algorithms-at-the-transcatheter-cardiovascular-therapeutics-tct-2017-scientific-symposium/>

<sup>24</sup> Arthur Bachinskiy, *The Growing Impact of AI in Financial Services: Six Examples*, Towards Data Science, February 2019, <https://towardsdatascience.com/the-growing-impact-of-ai-in-financial-services-six-examples-da386c0301b2>

<sup>25</sup> ICTC, 2021.



## Fintech and Healthcare AI/ML Unique Job Postings by Regions

December 2019 to January 2021

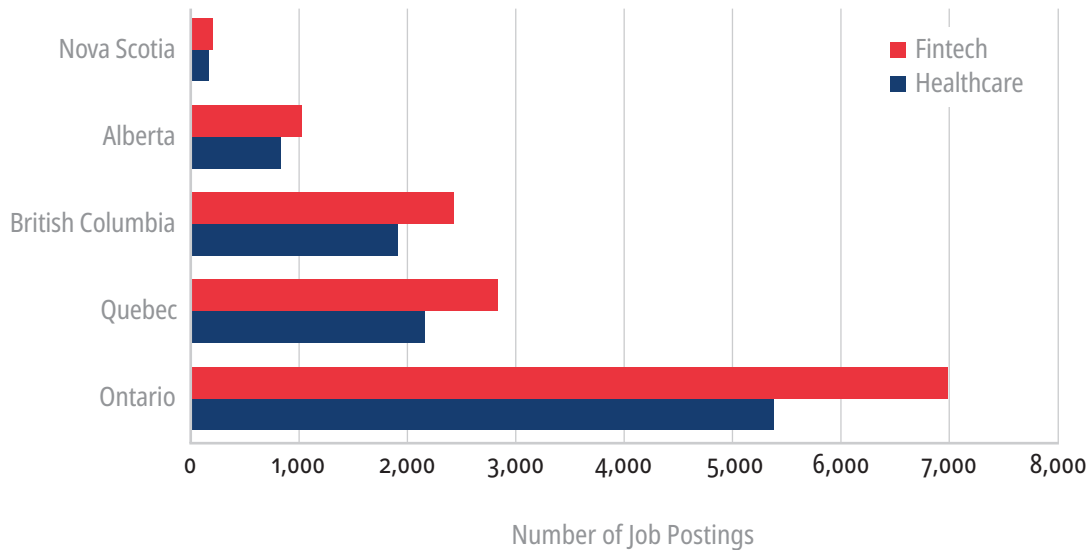


Figure 7. Fintech and Healthcare AI/ML Unique Job Postings by Regions (December 2019 to January 2021).<sup>26</sup>

Despite these benefits and the success of Canada’s AI startups and AI research hubs, there are still clear gaps in Canada’s ability to leverage AI to its full potential in niche and complex regulatory spaces like financial services and healthcare.<sup>27</sup> The use of AI in these sectors requires highly experienced teams consisting of three subgroups: graduate-level experts in AI, business professionals, and individuals with extensive domain-specific knowledge. The core challenge is that many development teams face an acute knowledge gap between these subgroups. Lacking a common understanding of each others’ areas of expertise inhibits their ability to communicate and collaborate on AI products. Focusing on solutions to bridge these gaps through initiatives like cross training and mentorship programs is key, and programs that provide some method of preparation for the next generation are critical.

Sections I and II of this report discuss the use of AI in the financial services and healthcare sectors in more detail, providing key insights on current and future uses of AI in each sector, and the talent, training, and educational pathways that are available. Section III then looks at what is needed to build an AI product development team, including the key roles and skill sets that are required over the course of the product development lifecycle. This section highlights in more detail the need for an expertise intersection between AI experts, domain experts, and business development professionals. Finally, Section IV provides a solution to the discussed challenges. It presents the opportunity for cross training on AI product development teams and applies the solution to a relevant health sector case study.

<sup>26</sup> ICTC, 2021.

<sup>27</sup> AI Looks North: Bridging Canada’s Corporate Artificial Intelligence Gap, McKinsey&Company, 2018, <https://www.mckinsey.com/~/media/mckinsey/featured%20insights/artificial%20intelligence/ai%20looks%20north%20bridging%20canadas%20corporate%20artificial%20intelligence%20gap/ai-looks-north-bridging-canadas-corporate-artificial-intelligence-gap.aspx>

# Section I

## AI in Financial Services

The Financial Services sector encompasses banking and finance, asset and wealth management, credit, insurance, and financial technology industries. It contributes approximately 7% to Canada's GDP and employs more than 800,000 Canadians.<sup>28</sup> Financial services are dispersed throughout Canada, with large clusters of activity in Toronto, Montreal, Calgary, and Vancouver.<sup>29</sup>

AI—particularly ML, deep learning, and NLP—presents many benefits and opportunities for the financial services sector in Canada. In the United States, AI has already become a vital ingredient for success: financial service companies that are implementing AI solutions are not only outperforming their competition but have reported revenue growth of up to 19% directly attributable to AI.<sup>30</sup> New AI initiatives have resulted in cost reductions, productivity gains, revenue enhancement, and better customer engagement, including customer acquisition, satisfaction, and retention.<sup>31</sup> Given the adverse economic impact of the pandemic, this is an ideal opportunity for companies to use AI technology to improve efficiencies in operations or distance themselves from competitors by leveraging and incorporating advanced AI techniques into all aspects of their day-to-day business.<sup>32</sup>

Financial services companies are relying more and more on AI to make predictions and inform decision-making. As application areas for AI increase and diversify, so too do the types of data used to inform AI. Common data types range from historical data (such as transaction or market data) to client data and unstructured data such as social media activity or news trends. At the same time, improved integration and more natural human-computer interfaces are making AI easier to deploy and apply in the field. More technologically advanced financial services firms are taking improved integration and more natural human-computer interfaces to the next level, focused on building single-window portals capable of accessing many varied AI functionalities while exploiting more data across operational verticals.

<sup>28</sup> Edenhoffer, Klaus, "Toronto on the Global Stage: 2018 Report Card on Canada and Toronto's Financial Services Sector," December 4, 2018, Conference Board of Canada, <https://www.conferenceboard.ca/e-library/abstract.aspx?did=10009>

<sup>29</sup> Financial Services, Invest in Canada, 2017, [https://www.international.gc.ca/investors-investisseurs/assets/pdfs/download/vp-financial\\_services.pdf](https://www.international.gc.ca/investors-investisseurs/assets/pdfs/download/vp-financial_services.pdf)

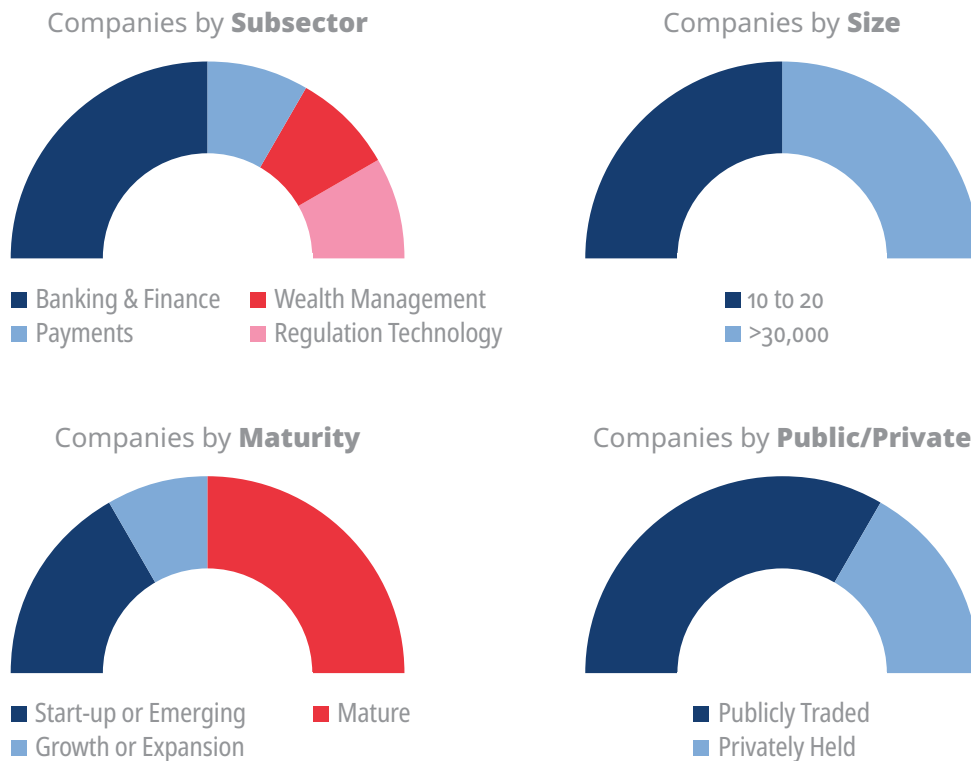
<sup>30</sup> Nikhil Gokhale et al., AI leaders in financial services, Deloitte, August 2019, <https://www2.deloitte.com/us/en/insights/industry/financial-services/artificial-intelligence-ai-financial-services-frontrunners.html?id=us:2di:3em:4di4687:5awa:6di:MMDDYY:&pkid=1005552>

<sup>31</sup> Ibid.

<sup>32</sup> T. Babina, et al., Artificial Intelligence, Firm Growth, and Industry Concentration, November 2020, <https://ssrn.com/abstract=3651052>

## Engaging with Experts: Financial Services

This report is informed by qualitative interviews with high-ranking individuals from Canada's financial services industry. Individuals with titles such as Chief Executive Officer, Founder, Vice President, Director of AI, and AI Lead were responsible for overseeing a team of data scientists and software engineers as well as developing new AI functionalities, products, or services. These teams ranged from three to 42 people in size. Interviewees were selected based on their respective companies, subsectors, and company headquarters, while companies were chosen according to their size, revenue, maturity, and status as either a privately held or publicly traded company. The underlying goal was to acquire a diverse set of perspectives. To the end, interviewed individuals and companies varied significantly (see *Figure 8* below).



*Figure 8. Breakdown of Companies Interviewed for the Financial Services Sector. ICTC, 2020.*

Subsectors were prioritized based on their relative size and prominence in Canada. Banking and finance (Canada's largest and most prominent financial services subsector) supplied exactly half of the interviewees. The remaining interviewees were sourced evenly from the subsectors of payments, wealth management, and regulation technology (see *Figure 8* above). Likewise, Toronto, ON, and Vancouver, BC, were the primary locations from which financial sector interviewees were sourced, due to their distinguished positions in the North American financial ecosystem: Toronto and Vancouver rank 2nd and 8th in North America on the Global Financial Centre Index.<sup>33</sup> St. John, NB, was chosen alongside Toronto and Vancouver to achieve greater diversity in perspectives (see *Figure 9* below).

<sup>33</sup> Global Financial Centre Index Ranking, Long Finance, 2019. <https://www.longfinance.net/programmes/financial-centre-futures/global-financial-centres-index/gfci-26-explore-data/gfci-26-rank/>

## Financial Services Key Informants by Location of Employment



Figure 9. Financial Services Key Informants by Location of Employment. ICTC, 2020.

### Key Insights

#### The Future of AI

All interviewees see an increased focus in the next three to five years on adopting AI and ML capabilities either through expansion of their products or refitting existing product lines with analytical functionality. Product lines that previously supported predictive modelling will adopt state-of-the-art techniques and algorithms (for example, moving beyond simple linear regressive techniques to deep learning models). Further, many interviewees believe they need to better exploit their own customer data to create more compelling data products (e.g., customer trends relating to spending, borrowing, and saving, online banking habits, instances of fraud, etc.). Consequently, data governance is a priority for improving management of data assets in a single, consolidated repository.

Data governance and improved data collection were key concerns in achieving interviewees' strategic short-term visions. Adept and high-quality data is crucial to ML applications, and concern was raised as to whether business units are collecting the data necessary to support modelling. A further issue comes from the need to generate sufficiently large, quality training datasets to produce the models: bootstrapping approaches do not always scale well for real world, enterprise applications. Information security and privacy, especially in cloud environments, were also top-of-mind concerns: cybersecurity attacks are often leveraged against larger platforms.

## Using AI Technology

Key AI technologies in use are mostly in ML based on neural networks—often referred to as deep learning. Typical financial services applications among report interviewees include algorithmic trading, prediction (of defaults, credit worthiness, possible fraud, cash flows, etc.), time series analysis, and NLP.

Ethical issues are the biggest challenge of this technology—specifically data selection for training the models. Interviewees recognize that historical data can contain biases, and at times it simply may not be applicable. A second concern is being able to explain how ML models arrive at particular outcomes. Some algorithm decision-making is more amenable to explainability than others, and this is an active area of research in academic and industrial circles.

## Talent, Training, and Education

Core AI teams within the financial sector typically consist of two levels: technical leads with PhD training, responsible for guiding the research and architecture design; and software developers with strong ML, math, and coding skills. Given the technical nature of the industries, domain knowledge is also crucial. Whether as a developer or architect, the required skills must be at a high level. Within these teams, a key role is that of Data Engineer, who is able to analyze variables in the datasets and combine them to create new features that improve model accuracy.

To a great extent, the AI and ML world is populated by technocrats. Interviewees recognize that there is a pressing demand for technical experts who have business acumen and interpersonal skills needed to interact comfortably with clients and customers, whether those clients are internal or external. Roles similar to that of Product Manager are being recognized as essential to guiding and leading technical groups, product strategies, and meeting with clients.

The financial services sector brings together many different disciplines, including economics, finance, and banking. Each is founded on extensive theoretical frameworks. Interviewees expressed that the norm is to hire outside talent, rather than upskill existing employees. For lead positions that require domain knowledge or AI, companies hire highly educated employees; many companies require a doctoral degree or, at minimum, some post-graduate education. In technical positions such as Software Developers, the requirement calls for significant industry or enterprise-level experience, having worked on teams that built products. It is now widely recognized that soft skills such as communication and presentation are critical, given the multidisciplinary nature of AI product development, which requires much collaboration both internally and with clients.

Development teams consist of highly experienced software developers. For specific AI positions, the expectation is that post-doctoral candidates can be upskilled if necessary, as they have a capacity to learn and master the material. The preference is for candidates with multiple years of experience in the domain, including in an academic environment. Similarly, developers are expected to have proven experience in creating ML models in an industry development environment.

# Section II

## AI in Healthcare

AI in healthcare often refers to the use of AI in detection and diagnosis, patient treatment, and service delivery.<sup>34</sup> The integration of intelligent innovations and technology in healthcare are expected to transform the healthcare sector, including the nature of healthcare occupations and its larger economic impact. AI technology will enable information gathering, processing, and analyzing at faster speeds and evidently with greater accuracy and precision, potentially allowing for improvement in the health of the population. The use of AI in healthcare is expected to increase along with the broad digital transformation of many industries. This can enable digital health through affordability, accuracy, and accessibility.<sup>35</sup> AI technology complements healthcare by enhancing clinician work and is distinct from the terms “automation” or “robotics.” The COVID pandemic has underscored benefits that AI and communication can bring. A prime example is remote counselling, providing at-risk patients peace of mind while ensuring care access and, subsequently, reducing the strain on an overburdened healthcare system.

### Engaging With Experts: Healthcare

Individuals were selected for healthcare sector interviews based on the size of their company or organization, their subsector, and location. Study participants held roles within their companies and organizations such as Founder and Co-Founder, CTO, Researcher, and Director. Companies ranged in size from startups to more mature companies in clinical trials or those selling products and services. Forty percent of the companies interviewed are currently in clinical trials or are refining their proof-of-concept before entering fundraising. Another 40% have paying customers for products or services offered, and the remaining 20% are organizations either in the development phase or involved in healthcare education.

Interviewee locations were regionally diverse: 30% from Toronto, 20% from Vancouver, and the remaining 50% from Calgary, Edmonton, Ottawa, Montreal, and Halifax (each contributing 10%; see *Figure 11* below). Toronto, Montreal, and Edmonton are well-known hubs for AI in Canada, and are home of the Vector Institute, Montreal Institute for Learning Algorithms (MILA), and Alberta Machine Intelligence Institute (AMII) respectively.

<sup>34</sup> Jinesh Maloo, *Artificial Intelligence, Machine Learning & Deep learning, Becoming Human*, October 2018, <https://becominghuman.ai/artificial-intelligence-machine-learning-deep-learning-df6dd0af500e>

<sup>35</sup> Rob Casella, *Artificial Intelligence is the great healthcare equalizer*, *Phillips*, April 2019, <https://www.phillips.com/a-w/about/news/archive/blogs/innovation-matters/20190402-artificial-intelligence-is-the-great-healthcare-equalizer.html>



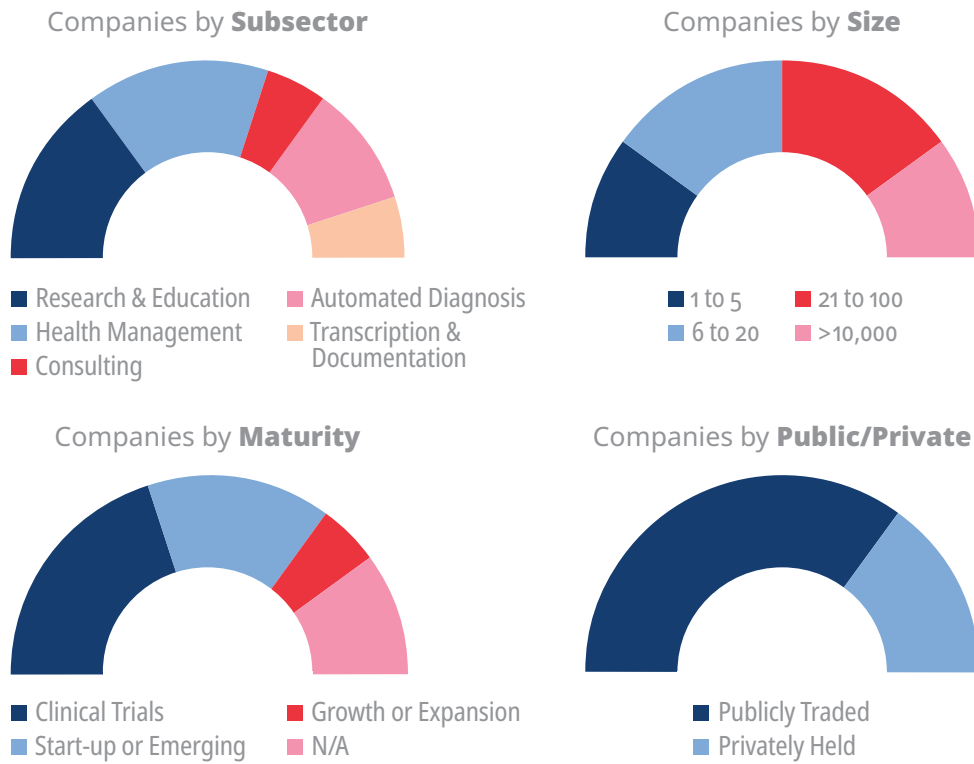


Figure 10. Breakdown of Companies and Organizations Interviewed for the Healthcare Sector. ICTC, 2020.

### Healthcare Key Informants by Location of Employment



Figure 11. Healthcare Key Informants by Location of Employment. ICTC, 2020.

## Key Insights

### The Future of AI

All interviewees expect AI and ML to continue expanding into diagnostics (such as medical imaging and analysis) over the next three to five years and playing an important role in AI-guided treatments, such as radiation therapy. Interviewees clearly identified a need for collaboration and cross-disciplinary understanding between medical practitioners and AI experts to ensure proper implementation of AI. As with any AI and ML approach, data collection is a key concern especially in training medical ML applications.

An overarching concern is that of data privacy, governance, and security; additionally, governmental regulation is an important focus area. Interviewees emphasized understanding the regulatory pathway for AI and noted that, even at this time, Health Canada rules and regulations are still under development.

Public acceptance and confidence in AI-driven healthcare is a primary concern as well. Wider public acceptance will require overcoming concerns over personal data usage and suspicions of data monetization. Ethics in data collection and control over inherent biases in training sets were also underscored: interviewees worried that system development and deployment was outpacing the ethical frameworks that are necessary but still not fully formed.

### Using AI Technology

Interviewees identified two clear directions for AI in healthcare: deep learning for image processing and analysis, and NLP. Image processing and analysis is used primarily in assistive tools used by radiologists, while NLP is used in patient case analysis and diagnostics. Cloud platforms were identified as a core component of clinic and hospital infrastructure, delivering AI solutions through Software-as-a-Service (SaaS).

With respect to these technologies, almost all interviewees were concerned with compliance and proper adherence to public privacy models. This includes how datasets are generated—either collected or created synthetically for ML training purposes.

### Talent, Training, and Education

Conventional roles such as computer scientists, systems engineers, software developers, and AI or ML specialists were identified as key to AI teams. However, interviewees also pointed toward a need for ethicists, human factors specialists, and government representatives to help consult on policy and regulations. Additionally, graduate-level trained employees such as health informaticians and health services researchers are needed. The role of Chief Privacy Officer is required to address pressing concerns on privacy and to instruct engineers on privacy policies. Interviewees also identified the need for ethnographers versed in qualitative research methods to conduct detailed studies of cultural groups.

The healthcare sector emphasizes cross-disciplinary teams, consisting of domain and technical experts. Upskilling can be used to train experts on complementary fields and to help them gain an understanding of the different components of the development team. Upskilling is a way to provide insight and basic competency in an area but does not create experts. Overwhelmingly, employees are at minimum university educated.

Interviewees introduced a healthcare-centric skill set similar to that of an expert in *knowledge translation*, defined as “the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people’s health.”

Again, as with financial services, experience and expertise expectations are quite high, given the need to adhere strictly to regulatory and policy constraints. Software developers need to be knowledgeable and perform at a high level. AI specialists are post-graduate-level educated in ML, providing deep knowledge of ML and mathematics. Given this training, employers generally regard these high performers as “easy to upskill when necessary.”<sup>36</sup>

The typical ML profile is an employee who has studied in the domain for multiple years, either in a university setting (i.e., research requiring the development of new models and interpretation of models and research), or employees who have experience executing ML implementations in industry.

<sup>36</sup> This sentiment was echoed by the KII participants in the primary research phase.

# Section III

## Building an AI Team

### Key Roles and Skill Sets

Given the highly specialized nature of healthcare and financial services—and the regulatory and privacy stakes involved—it is no surprise that ideal teams typically consisted of graduate-level trained domain experts, experienced developers, or developers with some technical undergraduate degree. This core team forms the technical nucleus of an AI/ML product development group (see *Figure 12*).



#### Domain Expert

Deep expertise in domain, and some knowledge of possible technological approaches for implementation.



#### Business Expert

Extensive market knowledge, sufficient knowledge in domain and technology to understand market and plausibility of product.



#### AI/Systems Expert

Expertise in technology, with sufficient knowledge of domain to accurately develop the AI model.

*Figure 12. The Core Components of an AI Team.*

An intricate understanding of AI is crucial to advancing technical solutions in financial services or healthcare. Adherence to regulatory constraints is important, therefore understanding what the algorithmic techniques are doing is essential; when taking privacy and ethics into account, knowing what data can be used and how is key. Technical abilities typically involve deep learning architectures or other methods such as gradient boosting.<sup>37</sup> With respect to AI/ML, the prevalent approaches are neural networks, gradient boosting, and linear regression. These techniques imply a mathematical background that includes linear algebra, calculus, probability theory, and optimization. For system development, enterprise-level expertise is required in large-scale applications, web-based platforms, and programming languages such as Python, Java, C/C++ (see *Figure 13*).

<sup>37</sup> Gradient boosting is a ML technique which produces a prediction model in the form of an ensemble of weak prediction models, typically decision trees.



## AI/ML Skill Set

### Technical expertise in:

- Neural networks
- Gradient boosting
- Linear regression

### Implied mathematical background:

- Linear algebra
- Calculus, probability theory
- Optimization



## Development Skill Set

### Enterprise-level expertise in:

- Large-scale applications
- Web-based platforms
- Programming languages

PYTHON  
JAVA  
C/C++

Figure 13. Required AI/ML and Development Skill Set

## Education and Experience

### Building an AI Team



### Domain Expert PHD

#### Educational Track

##### Year One

Acquire domain background

##### Year Two

Acquire domain background + thesis proposal

##### Year Three

Thesis research, thesis creation

##### Year Four/Five

Thesis completion, publication, defense



### Business Expert MBA

#### Educational Track

##### Year One

Acquire business background (market research, business marketing, project management, product management)

##### Year Two

Thesis or project proposal, completion, defense

#### Experience Track

##### Experience

Participation in 3–5 projects, 2–5 years of experience



### AI/ML Systems Expert UNDERGRAD/MSC

#### Educational Track

##### Year One

Basic programming, logic and foundational mathematics, data structures

##### Year Two

Advanced data structures, algorithms, mathematical

##### Year Three

Advanced algorithms, platforms

##### Year Four/Five

High-performance computing, advanced forms of development and research project

#### Experience Track

##### Junior Developer

Participation in 1–3 projects, 1 year of experience

Q/A testing, user interface, simple bug fixes, small features (non-mission critical)

##### Intermediate Developer

Participation in 3–5 projects, 2 years of experience

(Small) team lead, severe bug fixes, non-trivial features (mission control)

##### Senior Developer

Participation in more than 5 projects, 3+ years of experience

Architect, highly-experienced group lead, mission-critical/product-critical architecture and development

Figure 14. Education and Experience: Cumulative Years of Investment are Required to Build an “Ideal” AI Team. ICTC, 2020.

## Product Cycle

Each expert plays a specific role in product development throughout the product development cycle. For each product development phase, there is a primary driver, required set of knowledge and skills, and supporting cast. The genesis of any AI product typically follows a series of phases defined by a cycle of refinement: the product is generally conceived after some market research identifies a particular opportunity and market share potential. This phase requires some knowledge of state-of-the-art AI and a technical background identifying the practical plausibility of development and implementation (see *Figure 15*).

The second phase might entail detailed research, pushing the market idea ahead to determine the limits of the concept and how novelty can be brought into development. Again, business expertise is used to manage the research direction, to ensure market relevance, while technical expertise ensures that the technical foundation is plausible, with an implementation based on commodity technology (see *Figure 16*).

### Market Research and Product Viability



*Figure 15. Product Concept.*

### State-of-the-Art Research



*Figure 16. Determining in State-of-the-Art.*

### AI/ML Research and Model Development



*Figure 17. Development.*

Finally, the technical experts design and develop the product system, with domain expertise ensuring proper implementation, and business expertise guiding the costs, usability, and deployment validation (see *Figure 17*). This research design and deployment cycle may follow several iterations, as the model is validated and tested, both internally and in limited production.



## Expertise Intersection

The diagrams illustrate the emphasis on relevant expertise within a given development cycle. In each phase, a prime expert is the controlling focus of the activity while drawing upon the supporting knowledge from the other two domain experts. There is a crucial need for collaboration, teamwork, and most importantly some functional understanding of the other knowledge domains specific to the product.

The intersection of knowledge is made possible through collaborative teamwork and upskilling. For example, the domain expert needs to understand technological limits while researching the limits of the product concept in an effort to find the novel (the competitive advantage, colloquially referred to as the “secret sauce”). Additionally, domain experts must have sufficient understanding of the market and business client’s interests to not venture too far afield into pure research. Similar arguments apply to technical domain experts and business experts.

Intersectional knowledge can be acquired effectively through upskilling.<sup>38</sup> Employees with advanced training in some domain will have a facility for acquiring new knowledge quickly and be able to assimilate it in a practical setting to better understand the components of the other domains.

In rare cases, there are employees who have experience in all three areas. These are generally domain experts who have extensive development experience in an enterprise environment and have an understanding of the business climate and the future trends. This special class of employee is usually older, as gaining this depth of knowledge and experience is a function of years in industry and academia.

<sup>38</sup> KII participants in the primary research phase noted, from experience, that team members with advanced (graduate-level) degrees were strongly amenable to self-directed skills acquisition.

# Section IV

## Fostering an AI Talent Pipeline

### “Cross Training” vs. “Upskilling”

Fostering an AI talent pipeline for the financial services and healthcare sectors in Canada essentially means building more “ideal type” AI teams, and the most effective way to accomplish this is through cross training and mentorship programs. Programs would target the three subgroups of the product development (domain, business, and AI experts) and build on an existing technical background or some form of advanced undergraduate training. The goal would be to cross train each expert in the relevant subject matter of the other two, the curriculum defined by the intersections of their work. The resulting team would comprise the following: business experts with an understanding of the domain scope and technical implementation challenges; domain experts with an understanding of the business, market relevance, and technical implementation challenges; and technical experts with sufficient domain knowledge to create accurate and feasible AI/ML solutions, and sufficient business understanding to inform cost estimates and satisfy client needs.

#### Domain Cross Training

The upskilling landscape is replete with online courses and university certificates covering various aspects of business and computer science, from high- to low-level programming languages, to a broad range of software development tools. The same cannot be said for courses or certificates that teach specific domain knowledge, for example, specific domain knowledge related to primary care practice or to credit risk assessments.<sup>39</sup> Though math, ML, and programming skills are crucial to developing AI capabilities, in the healthcare and financial services sectors, domain knowledge is equally important. Without domain knowledge, the resulting AI tools and capabilities may be blind to important regulatory and legal requirements, disconnected from real-world problems, and at times even ineffective.

Domain upskilling programs should be broad enough to tackle all relevant regulatory and legal frameworks and provide understanding of the sector at large, however, tailored enough to drill down on product-specific knowledge and research trends. These tensions are further explained in the case studies below.

<sup>39</sup> Future students, University of Waterloo, <https://uwaterloo.ca/computing-financial-management/future-students>

## Business Cross Training

Unlike traditional upskilling for business, which covers a wide range of topics—communication, leadership, management and project management, business analysis and strategy, client relations, and product management—upskilling in this context should focus primarily on product- and client-related work. For example, identifying and defining business problems, product management, quality assurance, and client relations are each important for developing relevant and suitable AI capabilities and products. An important aspect of this is up-to-date market research and domain application and product trends.

## AI/ML Cross Training

There exists a severe gap in upskilling opportunities when it comes to AI/ML: bootcamps are too watered down and assume no real level of expertise; graduate-level certificate courses are too costly, both financially and in terms of time; and massive open online courses (MOOCs) have little to no consistency or quality control. To fill this gap, cross training in AI/ML focuses only on the core components of AI/ML that are important to healthcare and financial services applications. In the healthcare sector, for example, of importance is learning how to train ML models on ambulatory, inpatient, and adjudicated claims data from electronic medical record systems. The objective in this context is to discern which data points correlate to the rates of health events in a population, the history of disease, and the most successful treatments. This assumes requisite understanding of the following:

- Math, including calculus, statistics, and probability

- General software development concepts, such as data structures and algorithms

- General data concepts, such as data acquisition and cleaning, feature selection, and feature engineering, and

- ML techniques, such as linear regression, logistical regression, and deep learning

## Regulatory, Ethics, and Legal Cross Training

Beyond technical, business, and domain courses, teams will require training in legal, ethical, and regulatory matters specific to their domain, including privacy and security concerns. Specific course content will depend heavily on the sector and subsector, and the associated jurisdiction. Some sectors are provincially regulated, others federally, and others subject to both government levels.

## Mentorship

Mentorship programs would be beneficial alongside cross-training program courses to facilitate on-the-job knowledge and experience. These programs would apply among the development group to foster cross-trained talent internally. The mentorship initiative would see a designated AI/ML, business, or domain lead as the mentor assigned by HR to a recent hire or new team member for guidance and knowledge transfer for the duration of two or three projects until sufficient competence and confidence is achieved.

## Challenges

The most pressing challenge is devising courses that are sufficiently comprehensive while ensuring they can be delivered quickly. Of importance is determining which delivery method is best suited to this type of skill set acquisition and which is the fastest way to facilitate the resulting courses. Additionally, it is important to minimize the overall learning curve without oversimplifying the material. As discussed, AI in healthcare and financial services is non-trivial, meaning the courses need to be detailed, comprehensive, and accurate.

In this market, more online training is expected, and this training will vary in quality. The opportunity will develop for quality, industry-certifiable training courses to differentiate between programs developed and delivered by companies with domain expertise and simple those taking advantage of the market. In regulatory-heavy industries such as healthcare and fintech, adherence to legislative frameworks is critical.

## Case Study

To illustrate the aforementioned AI talent pipeline, consider a hypothetical company in the healthcare sector developing a product in the area of epidemiology and seeking to cross-train its existing talent pool. To do this, the company would need to identify an existing domain expert and have them cross-train in the remaining knowledge areas: AI/ML, business, and regulatory, ethics and legal. The sample courses below could be used to cross-train individuals in the three subgroups to establish competent knowledge supporting collaboration and teamwork:

Course title	Description
<b>Predictive Modelling for Health Data</b>	<p>Integrate data mining and statistical theories (i.e., probability, regressions, ANOVA) to forecast health outcomes, using R, SAS, and Python</p> <ul style="list-style-type: none"> <li>• Perform techniques in survival analysis including Kaplan-Meier estimator, Log rank test, proportional hazards model</li> <li>• Risk analysis to make informed decisions</li> </ul>
<b>ML for Health Data and Healthcare</b>	<p>Apply data science principles to datasets (i.e., health administrative data, clinical registries, electronic health records, etc.) to help identify and improve processes in hospitals, identification of diseases, and create personalized treatments streamline</p> <ul style="list-style-type: none"> <li>• Fit ML models to data to interpret health results</li> <li>• Determine ML methodology for given problems</li> </ul>
<b>Computational Epidemiology</b>	<p>Computer simulation models to devise patterns to help predict possible health outcomes (i.e., cancer, disease, etc.)</p> <ul style="list-style-type: none"> <li>• Utilize geographic information systems (GIS) to better understand spread of disease</li> <li>• Apply simulation models and techniques to understand outcomes</li> </ul>
<b>AI, Ethics, and Regulations</b>	<p>Ethical dilemmas and implications that emerge from using AI in health sector and in healthcare setting, as well as data privacy and regulations</p> <ul style="list-style-type: none"> <li>• Ethical issues at different levels in healthcare settings</li> <li>• Identify ethical issues with AI in healthcare settings</li> <li>• Apply research ethics in study design</li> <li>• Legal principles and legislation in Canada</li> </ul>
<b>Epidemiological Research Methods</b>	<p>Fundamental concepts in epidemiology such as incidence rates, prevalence, relative risks, odds-ratios; differentiating different types of bias; as well as study design</p> <ul style="list-style-type: none"> <li>• Discuss, understand, and build study designs through randomized control trials, cohort studies, cross sectional studies and case control studies</li> <li>• Advanced survey design</li> <li>• Differentiate different types of epidemiological bias (i.e., selection bias, information bias, and confounding)</li> </ul>

**Table 1.** Sample Courses in Epidemiology with Cross Training in Knowledge Areas that include AI/ML, Business, Regulatory, Ethics, and Legal.

# Conclusion

Overall, this report serves to highlight opportunities to develop and foster an AI talent pipeline in Canada. Given the complexity of AI technology and the specialized nature of healthcare and financial services (and their stringent privacy and regulatory requirements), high levels of expertise in a team environment is key. Experts typically include those who have graduate-level education, either master's or doctorate levels.

A key insight from study interviews is the recognition of a knowledge gap between subgroups within AI product development teams. In the healthcare and financial services industries, it is often the case that domain experts, AI/ML experts, and business strategists lack a common understanding of one another's area of expertise.

The bootcamp training approach provides too superficial an understanding, while graduate-level certification is too specific and takes too long to acquire. Adjusting to the new normal imposed by the COVID pandemic, online training is expected to become *de facto*.<sup>40</sup> <sup>41</sup> The business opportunity will develop for quality, industry-certifiable, training courses to differentiate between programs developed and delivered by companies with domain expertise and those simply taking advantage of the market. Initiatives such as Microsoft's ambitious program that aims to train 25 million people worldwide are a step in the right direction for filling the demand pipeline.<sup>42</sup>

The intersection between domain experts, AI/systems experts, and business experts is made possible through cross training between the three areas and collaborative teamwork. Devising curriculum for maximum impact is possible by integrating ethics, cybersecurity, programming and AI/ML foundations. Businesses are then able to leverage and integrate AI/ML to make more informed decisions and accurate business plans.

<sup>40</sup> S. Gallagher and J. Palmer, *The Pandemic Pushed Universities Online. The Change Was Long Overdue*, Harvard Business Review, 2020, <https://hbr.org/2020/09/the-pandemic-pushed-universities-online-the-change-was-long-overdue>

<sup>41</sup> Secretary-General of the OECD, *Education responses to covid-19: Embracing digital learning and online collaboration*, OECD, 2020, <https://www.oecd.org/coronavirus/policy-responses/education-responses-to-covid-19-embracing-digital-learning-and-online-collaboration-d75eb0e8/>

<sup>42</sup> Microsoft, *Microsoft launches initiative to help 25 million people worldwide acquire the digital skills needed in a COVID-19 economy*, 2020, <https://blogs.microsoft.com/blog/2020/06/30/microsoft-launches-initiative-to-help-25-million-people-worldwide-acquire-the-digital-skills-needed-in-a-covid-19-economy/>

## Call to Action

Businesses and organizations that develop AI products for use in the healthcare and financial services sectors should ensure that their development teams are adequately cross trained, with sufficient technical, domain, and business know-how. Industry should therefore prioritize multidisciplinary cross training within AI teams.

Canada's strategy for AI skills development should include cross-training as a fundamental pillar in workforce development efforts. For example, government actors could include acute skill needs (such as the need for multidisciplinary cross training on AI teams) in future plans and programs stemming from the Workforce Development Agreements.<sup>43</sup>

Canadian academic institutions should assess the availability (and accessibility) of AI-related courses in non-technical programs such as business, finance, or medical programs; and the availability of domain-specific courses in technical programs like data science or computer engineering.

In light of the economic impact of COVID-19 on Canadian employment and the resilience of the tech sector over the course of the pandemic, the federal government should continue to prioritize and support remote upskilling programs to address broad information and communications technology (ICT) skill needs.

Stakeholders in heavily regulated sectors like financial services and healthcare should work with the federal, provincial, and territorial governments to establish industry-wide data governance standards and secure data sharing mechanisms to enable greater and more secure data access.

<sup>43</sup> About the Workforce Development Agreements program, Government of Canada, <https://www.canada.ca/en/employment-social-development/programs/training-agreements/workforce-development-agreements.html>



# Appendix A

## Methodology

The research methodology used in the development of this report consisted of a combination of primary and secondary research, which are described below.

### Primary Research

ICTC conducted 16 interviews with individuals from the financial services and healthcare sectors. Interviews were conducted between January 2020 and February 2020. The financial services interview list consisted of six individuals, while the healthcare interviews comprised 10. Interviewees held influential positions within their companies and organizations: CEO, CTO, Founder, Director of AI, AI Researcher, etc. Following these interviews, an advisory council of experts (drawn from both industries and senior positions) validated the qualitative research findings and provided feedback and insight on the results.

The objective of the primary research was to obtain detailed, accurate information on the use of AI in the financial services and healthcare sectors in Canada to identify clear cross-training strategies and build out educational pathways and directions for industry, academia, and policy makers. This information was sought from key influencers and decision-makers from each of the sectors. The line of questioning sought AI industry trends, and infer what skills are necessary to build the workforce.

Interviewees were selected based on their titles, type of company or position in the financial services or healthcare industry, and the availability of sufficiently high-ranking participants. Similarly, companies and organizations were chosen according to their location, size, revenue, maturity, and status as either a privately held or publicly traded company. The underlying goal was to acquire a diverse set of perspectives, and as such, individuals and companies varied significantly with respect to these attributes.

### Secondary Research

The primary research component of this project was supported by a detailed review of available literature on this topic by government, industry, and academia.

## Limitations of Research

While ICTC attempted to ensure that the research process for this study was as exhaustive as possible, there are inevitable limits in such a study. The first is the relatively small sample pool of interviewees (16). This means that these responses must be regarded as insights and cannot be taken as objective “trends” that represent the whole country. To mitigate this limitation, interviews were selected from across Canada. The second limitation is that, although equal representation of both sectors was attempted, ICTC was only able to successfully source six interviews from the finance sector and 10 from the healthcare sector, due to the interest and availability of respondents.

# Appendix B

# AI–Data Science

# Team Skill Set

## Education

While there are exceptions, a very strong educational background is usually required to develop the depth of knowledge necessary to be competent in data science. The most common undergraduate education of data scientists are Mathematics and Statistics, Computer Science, and Engineering—a degree in any of these areas provides the training and skills necessary to process and analyze big data. Among senior data scientist roles, industry statistics show 80% possess at least a master's degree and over 40% have PhDs.

## Development

Domain knowledge is not sufficient: in-depth training in analytical tools and development languages is crucial. The programming languages are Python, Java, C/C++ for enterprise development, and R for prototyping and data exploration.

Additionally, it is necessary to have understanding in database architecture, creation, and querying. This includes being able to write and execute complex queries in SQL (Structured Query Language), understand NoSQL concepts, and data lake platforms (a centralized repository that allows storage of structured and unstructured data at any scale) for large-scale data exploration, filtration, sampling, and summarization.

## Platform Deployment

Familiarity with cloud tools such as Amazon S3 can also be beneficial. A recent study found approximately 4,000 LinkedIn data science jobs ranked Apache Hadoop as the second most important skill for a data scientist.<sup>44</sup> Frameworks such as Apache Spark are specifically designed to run complex algorithms efficiently and handle massive unstructured datasets.

## ML and AI

Data science involves having fundamental understanding of neural networks,

<sup>44</sup> Rohan Singh, "Data Science-New Buzz in the Industry", Coding Blocks, June 2019, <https://blog.codingblocks.com/2019/data-science-a-new-phd-for-engineers/>

reinforcement learning, adversarial learning, decision trees, logistic regression etc. to ensure the appropriate algorithm or framework is used for specific dataset and problem characteristics.

### Data Visualization

Data visualization tools to help convert complex results to a format that will be easy to comprehend by all audiences, often non-technical C-level stakeholders.

### Unstructured Data

Unstructured data is undefined content that does not fit into database tables, for example, videos, blog posts, customer reviews, social media posts, video feeds, audio etc. It is critical to be able to work with unstructured data.

## Non-Technical Skills

### Business Acumen

A solid understanding of the industry is necessary, as is the identification of the business problems to be solve, and finding new ways the business should be leveraging its data assets.

### Communication Skills and Teamwork

Data scientists must be able to convey their technical findings clearly and fluently to a non-technical teams in, for example, marketing or sales. They must enable the business to make decisions by providing quantified insights and understand the needs of their non-technical colleagues to manage data appropriately. Storytelling is a critical skill in effectively communicating a narrative reflecting company interests and objectives.

Data scientist teams never work in isolation and need to interact with company executives to develop strategies, product managers and designers to create better products, marketers to launch high-conversion campaigns, and client and server software developers to create data pipelines and improve workflow.

# Appendix C

## Detailed Curriculum Information

Though a detailed course plan is outside the scope of this project, ICTC has put together a list of potential topics to be included in course curriculum, if developed.

The Canadian Healthcare Landscape: Topics on privacy, ethics, and regulation

<b>Laws and regulations</b>	<p>The regulatory approval process for medical devices, governed by the Medical Devices Bureau and Health Canada dose</p> <p>Requirements and best practices in clinical trials</p>
<b>Ethics</b>	<p>Ethics boards: university ethics boards; Health Canada and the Public Health Agency of Canada's Research Ethics Board</p> <p>Ethics and codes of conduct in professional practice:</p> <ul style="list-style-type: none"><li>• The Canadian Nurses Association Code of Ethics</li><li>• The CAMRT Code of Ethics</li><li>• The CMA Code of Ethics and Conduct</li></ul>
<b>Privacy</b>	<p>Provincial Privacy Acts of Quebec, British Columbia, and Alberta, which apply to provincially regulated commercial organizations in those provinces.</p> <p>PIPEDA, which applies to commercial organizations in all provinces and territories apart from Quebec, British Columbia, and Alberta, and federally regulated commercial organizations in Quebec, British Columbia, and Alberta.</p> <p>The provincial health information statutes, which apply to healthcare information custodians in British Columbia, Alberta, New Brunswick, Newfoundland, North West Territories, Nova Scotia, Quebec, Ontario, Saskatchewan, and Yukon.</p> <p>Changes in the privacy landscape: such as the OPC Consultation on AI</p>

**Laws and regulations**

Accounting: federal and provincial tax law and compliance

Financial Planners and/or Advisors: relevant provincial laws

Banking: The Bank Act and associated regulatory bodies

Credit and Lending: borrower and lender rights and responsibilities

Fraud: fraud law and concepts; types of fraud: debit and credit card fraud, investment fraud, real estate fraud, tax fraud, money laundering

When working with government: The Government Directive on Automated Decision-Making

**Ethics**

Ethics and codes of conduct in professional practice, such as:  
The FP Canada Code of Ethics and Rules of Conduct  
The CPA Ontario Code of Conduct

**Privacy**

Provincial Privacy Acts of QC, BC, and AB, which apply to provincially regulated commercial organizations in those provinces

PIPEDA, which applies to commercial organizations in all provinces and territories apart from Q.C., B.C., and AB, and to federally regulated commercial organizations in QC, BC, and AB, such as banks

Changes in the privacy landscape, such as the OPC Consultation on AI

## Business for AI Development

<b>Product and Market Research</b>	Market research Case studies Identifying trends, best practices, and other standards Applying trends, best practices, and other standards
<b>Product Management and Client Relations</b>	Product Management: identifying and defining business problems Product Management: defining and documenting user requirements Product Management: product testing and quality assurance Client Relations: bridging the client (internal and external) and solutions team Client Relations: communication

## Domain Expertise: Financial Services

<b>Accounting</b>	Audit and tax concepts Application areas for AI Compliance management tools Risk management tools
<b>Financial Planning or Advice</b>	Performance analysis and key performance indicators Financial planning concepts: value of money, capital budgeting, cost of capital, security issuance, capital structure, payout policy and dividends, short-term finance, risk management Common application areas for AI: know your client, analyzing client data, NLP, prediction, cash flow prediction
<b>Lending</b>	Common application areas for AI: Fraud, credit lending, client data, NLP, prediction (defaults, credit worthiness), time series analysis
<b>Fraud</b>	Common application areas for AI: prediction (fraud), client data, NLP, time series analysis Types of fraud and ways of detecting fraud: debit and credit card fraud, investment fraud, real estate fraud, tax fraud



## ML/AI

<b>Prerequisite knowledge</b>	Calculus Linear algebra Probability Statistical theory
<b>AI-specific knowledge</b>	Big data structure, architecture, and tools Algorithm analysis Statistical modelling Predictive analytics ML algorithms: random forests, gradient boosting, neural networks; data preparation, model selection, and evaluation Artificial and deep neural networks Evaluating and combining models

## Math for AI

<b>Pre-requisites</b>	Linear Algebra Calculus Probability Applied Statistics Risk modelling and mathematical risk theory
<b>AI-specific math</b>	Mathematical finance Actuarial science Computing and financial management Quantitative finance Risk modelling Portfolio optimization