An Impact Brief
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The Land of Stranded Pilots

Challenges facing the health technology innovation system in Canada

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Contents

Summary

"The system design is flawed and must be fixed if we are to compete in health technology innovation."

This report examines the shape of the health technology (health tech) industry in Canada with a focus on three specific questions: Does Canada actually have a problem with health tech commercialization? If so, how extensive is that problem? And what is causing it?

Health technologies can be divided into three primary areas: health tech software, devices and equipment for health, and biotechnology, drug discovery and development. Our review of active health tech companies in Canada and the US can be summarized in Exhibit 1. We have sorted the firms by whether they are "starting" or "scaling", using $10 M as a cut-off between early-stage and growth (i.e. scaling) companies.

Health Technology Investment Capital Per Capita

Exhibit 1

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**57.0**	**66.8**	**298.6**	**939.9**	**2,930.2**
Scaling	Over $10 M	46.8	54.6	276.1	893.7	2,816.1
Starting	Under $10 M	10.1	12.3	22.5	46.1	114.1

The US has five times as much capital on a population basis available to both new and growing companies. The gap grows even further for more established businesses: our neighbour has six times as much investment capital for companies that are scaling. Within the US, Massachusetts is the clear winner at overall capital and in the scale-up of companies. Relative to Ontario, it has 43 times more total capital and 51 times more investment resources for growth companies.

Canada's underperformance, especially when we consider the wide margin in all areas of health technology, is astounding. For this reason, we will dedicate the remainder of this report to a systemic analysis of the innovation system and its components. Our analysis suggests three major factors in the underperformance.

1. There is no alignment of research dollars and researchers with commercialization objectives.
2. From the perspective of the entrepreneur, the system for commercializing health technology is a byzantine and flawed system with multiple overlapping, competitive, and duplicated parts with funding and assistance gaps.
3. The healthcare system is not aligned to purchase the innovation that comes out of the health tech system, and in fact, can act as a brake on innovation.

This brief is not intended to be a criticism of any organization in the system or the individuals that work for those organizations. We truly have a system and people within it

who are trying to do the very best job they can for their clients. Governments at all levels too are keen to develop solutions to problems in the system and have been launching new programs on a regular basis to fix problems that have been identified. All of the players are doing an excellent job meeting the needs for which they were established and addressing issues within their sphere of influence.

The problem is centered on the gradual evolution of the system as a whole. The piecemeal design over decades has created inefficiencies that no amount of hard effort by the participants in the system can change. The health tech innovation system has no measurable objectives and is plagued by misalignments, gaps, competition, and overlapping resources. The system design is flawed and must be fixed if we are to compete in health technology innovation.

Health Tech Commercialization

In a prior report entitled *Measuring Canada's Scaleup Potential* (Plant, March 2018), we noticed that Canada was facing challenges to create businesses capable of scaling to world-class size and competing on global markets. Further to this, our most recent report, *The Class of 2008* (Plant, May 2018), identified that Canada appeared particularly weak in creating and scaling health technology (health tech) companies. The objective of this report is to follow up on those findings focusing on three specific questions: Does Canada actually have a problem with health tech commercialization? If so, how extensive is that problem? And what is causing it?

First, let us define what we mean by health tech. We are primarily interested in technologies in three areas:

- health tech software,
- devices and equipment for health, and
- biotechnology, drug discovery and development.

We used CB Insights as a starting point to look at private companies in each health tech area, both in the aggregate and independently, to narrow down the issue. Please note that we did not include any public firms or companies that had been sold. We looked specifically at Canadian and US national numbers, along with separate results for Ontario, Massachusetts and California, which had been identified in prior reports as the strongest performers at the subnational level.

Exhibits 2 and 3 show the distribution of private companies per jurisdiction studied and the amount of capital received by these companies, respectively.

Number of Health Technology Companies

Exhibit 2

Stage	Capital	Canada	Ontario	US	California	Mass
World Class	Over $1 Billion	-	-	3	-	2
Scaleup	$100 M- $1 B	2	1	208	98	38
Growth	$10 M - $100 M	42	17	1,423	502	239
Emergence	$1 M - $10 M	86	43	1,769	423	187
Startup	Under $1 M	190	72	4,129	781	288
	Total	**320**	**133**	**7,532**	**1,804**	**754**

Data for all exhibits were sourced from CB Insights in May 2018.
Includes all private companies recorded by CB Insights as active as of that date.

Capital Deployed in Health Technology Companies

Exhibit 3

Stage	Capital	Canada	Ontario	US	California	Mass
World Class	Over $1 Billion	-	-	5,660	-	3,260
Scaleup	$100 M- $1 B	344	225	37,240	17,861	7,320
Growth	$10 M - $100 M	1,303	509	47,020	17,442	8,851
Emergence	$1 M - $10 M	331	156	6,921	1,757	756
Startup	Under $1 M	25	9	404	66	32
	Total ('000s)	**2,003**	**899**	**97,245**	**37,125**	**20,218**

As we are dealing with jurisdictions of different sizes, it is instructive to look at the number of companies created on a per-capita basis. To simplify the data, we have also sorted the firms by whether they are "starting" or "scaling", using $10 M as a cut-off between early-stage and growth (i.e. scaling) companies. The final results are displayed in Exhibit 4.

Number of Health Tech Companies Per Capita

Exhibit 4

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**9.1**	**9.9**	**23.1**	**45.7**	**109.3**
Scaling	Over $10 M	1.3	1.3	5.0	15.2	40.4
Starting	Under $10 M	7.9	8.6	18.1	30.5	68.8

Exhibit 4 shows readily that the US has 2.5 times as many companies as Canada in health tech and four times as many that are "scaling" to world-class levels. Even more alarming though is the fact that Massachusetts has 11 times as many companies as Ontario and 30 times as many that are in the process of scaling. In terms of capital deployed, Exhibit 5 further emphasizes the magnitude of this problem. The US has five times as much capital per population and six times as many growth companies. Massachusetts, the clear winner at both capital acquired and scaling, has 43 times as much capital as Ontario and 51 times as much for companies that are scaling. These data clearly illustrate our ongoing problem in creating and scaling health tech companies.

Health Technology Investment Capital Per Capita

Exhibit 5

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**57.0**	**66.8**	**298.6**	**939.9**	**2,930.2**
Scaling	Over $10 M	46.8	54.6	276.1	893.7	2,816.1
Starting	Under $10 M	10.1	12.3	22.5	46.1	114.1

Please refer to Appendix A for a breakdown of investment per subsector, covering health tech software, biotech, and medical devices separately. While Canada does not appear to lag the US significantly in the health tech software subsector, we are substantially weaker in biotech and medical devices. On a per-capita basis, the US has 3.7 times the investment in

biotech companies and 13.5 times the investment in medical device companies.

In particular, the results show that Massachusetts is the clear winner with a high concentration across all three health tech areas. The state outscores Ontario 44 to 1 overall on a per-capita basis.

Research Spending

According to the OECD (Organisation for Economic Co-operation and Development), the Government of Canada and the provinces together spent C$2.5 B directly on research and development in 2016. Additionally, the higher education sector spent C$13.4 B, all of which came from governments. According to the Naylor report (Advisory Panel for the Review of Federal Support for Fundamental Science, Fundamental Science Review, 2017), science spending by the federal government totaled C$2.7 B. Of the three granting councils, of which only CIHR is spending on healthtech, spending was allocated as follows:

Granting Council	Core Programming
NSERC	$470 M
SSHRC	$169 M
CIHR	$692 M

In terms of spending on commercialization, the Naylor report identified $594 M on innovation-linked spending. Of the three granting councils, the spending was allocated as follows:

Granting Council	Core Programming
NSERC	$284 M
SSHRC	$36 M
CIHR	$99 M

Using the ratios of spending of the three granting councils against total OECD spending one can determine that spending at all levels of governments and universities on health research and commercialization is C$7.3 B annually. However, this would not include health tech software as that sector does not receive research dollars through this system.

Economic Activity

While much of the health tech-related research supported by the two levels of government will be, and should, be directed to basic research, it is interesting to estimate the amount of

economic activity resulting from this research. Excluding software, there is $1.9 B of capital invested in private health tech companies (Source: CB Insights). The market value of listed research-based companies in this sector in Canada is $7.5 B (Source: TSX and SEDAR). Using public company multiples (Source: Google Finance) as a method of estimating the revenue of these companies results in about $3.5 B of revenue in the sector.

Thus, an annual expenditure of $7.3 B of health tech research winds its way through the system, gets augmented by privately funded research, of approximately $500 M (estimated using Google Finance), to produce about $3.5 B of revenue annually.

What do the data mean in aggregate? When we are outscored by such a wide margin in all areas of health technology, something is clearly flawed. In the remainder of this report, we examine the innovation system and its various components to determine potential causes of this breakdown.

The Public Health Tech Innovation System in Canada

There are two tracks on which health tech gets commercialized in Canada: private and public.

The **private track** is the one used for products that have a low regulatory requirement and typically involve a quicker conversion from research to innovation. Products developed in this path include assistive devices, non-regulated hardware, and some software, but do not typically include biotechnology, pharmaceuticals and medical diagnostics. The path to market for these products may be through patient care facilities such as nursing homes as well as community hospitals, both of which tend to be more externally focused on innovation and have people, processes, and systems that can accept innovation more rapidly. This path to market for products is significantly faster than the more highly regulated market for innovations derived from biotechnology, pharmaceutical, or diagnostics research.

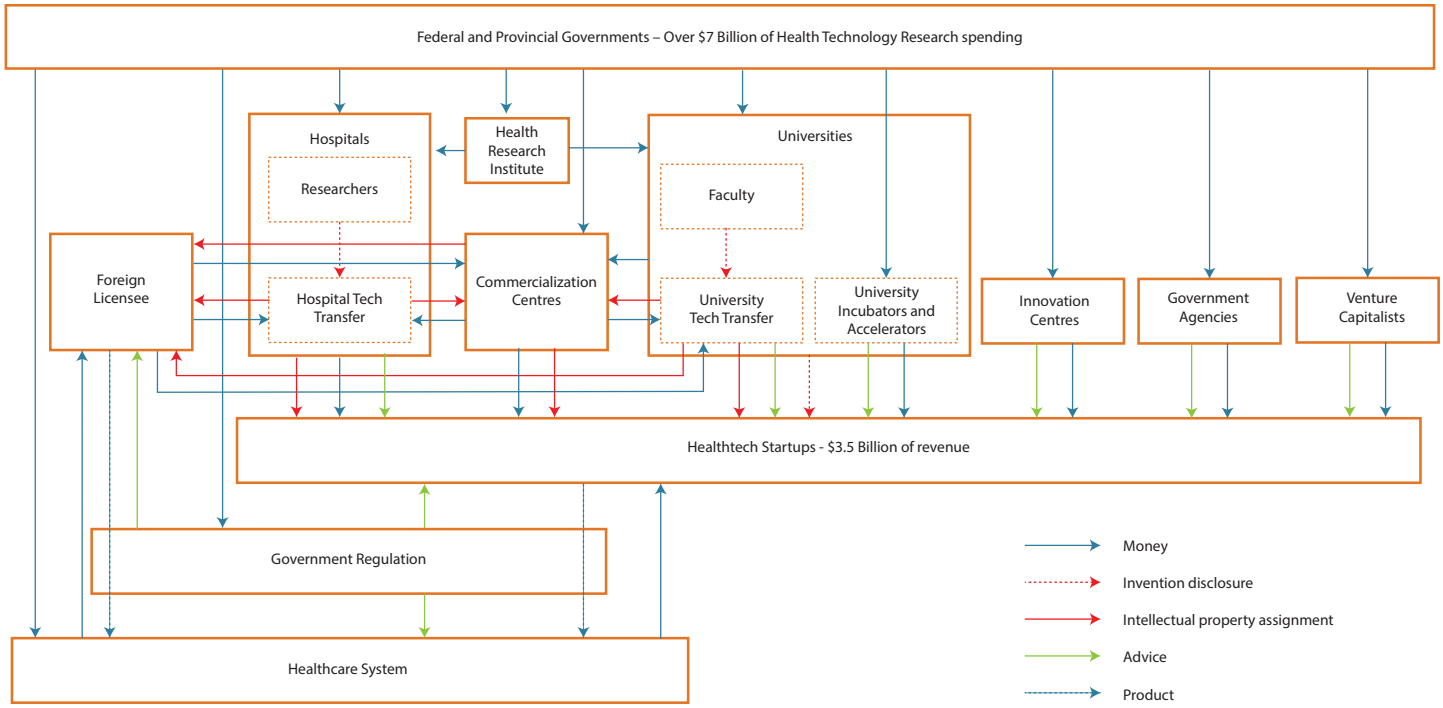
The other track is the **public track**. It begins with research carried out at universities and progresses through a complex system of publicly and privately funded development and regulatory approval until it emerges ready for the healthcare system. **This public track is the subject of this report.**

Exhibit 6 is an attempt to summarize the public health tech innovation system in Canada, and in Ontario in particular.

If this chart looks complicated, it does so because the system is marked by "byzantine complexity". Since the system has so many moving parts (adding to the complexity), we have been unable to reflect all variations and nuances although this should suffice as a summary. (In Appendix B, we have attempted to describe the role of each participant in this system along with the challenges faced in that particular role.)

According to experts, there are differences across provinces largely due to different purchasing regimes. Industry insiders argue that the commercialization of health tech in the public system is substantially easier in Alberta, British Columbia, and the Maritimes. This report primarily uses Ontario as an example although many of the issues apply to other provinces as well. For the next portion of the report, we focus on the perspectives of three stakeholders: researchers, companies, and purchasers.

The Public Health Tech Innovation System
Exhibit 6



Researchers

Health technology research is conducted in universities and hospitals throughout the country. While the hospital or university funds the researcher's salary, other costs are funded by grants from various agencies and health research institutes. The Naylor Report reviewed the federal system of supports for research conducted outside governments and agencies and focused on basic and applied peer-reviewed science, not commercialization or innovation. Their report concluded that:

> "Despite high levels of talent, expertise, and dedication on the part of those serving each agency, there is evidence to suggest that the overall stewardship of the federal research ecosystem needs to be strengthened. Coordination and collaboration among the four agencies is suboptimal, with variations in governance, administrative practices, and funding priorities within and across agencies that are not explicable either by disciplinary differences or by the needs of the relevant research communities. Investments in infrastructure and related operating costs are not consistently aligned, and funding for areas such as international partnerships or multidisciplinary research is uneven." (p. xi)

Researchers engage their teams in basic and applied research, and upon discovering something novel, they are expected to disclose that discovery to their institution's technology transfer office. While this system seems perfectly reasonable on the surface, it is not aligned to produce research that can then be commercialized. Issues similar to those identified in the Naylor report exist in the commercialization system.

- Government funding sought by researchers to support their research is targeted primarily toward basic and applied research in the early stages of development, the objective of which is not to create commercializable technologies.
- The purpose of hospitals is patient care. Research forms part of their activities wherever it can be used to enhance their core mandate of care. However, they are not mandated to commercialize this research.
- The purpose of universities is education and research. Similar to hospitals, they do not have an explicit mandate to commercialize research and often consider technology transfer as a service to society.
- University researchers are paid to teach and to perform research although many are personally driven to commercialize in order to see their research benefit society. They receive promotions through academic ranks, salary increases, and tenure resulting primarily from their research and in part from their teaching. In many institutions, they receive little to no academic or career benefits from pursuing commercialization activities (although this is certainly changing to some extent). In most cases, commercialization can take time away from other activities that could lead to promotion and tenure, serving as a major deterrent for researchers.
- Hospital researchers are paid for their work in patient care and in research. Similar to university professors, they do not receive any benefit from commercializing. In fact, this can take time away from other activities that could lead to promotion and will again disincentivize individual researchers interested in that path.
- Technology transfer offices, viewing their role often as transferring technology to society, can meet their operational goals by licensing a technology rather than forming a company around it. Licensing is substantially less complex and less costly than patenting and company formation. But, in choosing the licensing option, we must question who the major beneficiaries of this practice are. As an example, we noted in our report entitled *Canada's Patent Puzzle* (May 2017) that 58 per cent of patents granted to Canadian inventors were assigned to companies in other countries. Would this pattern hold if we looked at university-derived patents? Would many of the patents filed be assigned to foreign entities, with the benefits of commercialization lost to other countries? (Please stay tuned for a future Impact Brief, in which we will examine trends in patent assignees pursued by various universities.)

This description suggests that the first problem with the system is an inherent misalignment of objectives. If our goal as a nation is to improve our economic condition through commercialization of university research, then our research system, deeply rooted in its academic values and core mandate of research and teaching, will certainly not be equipped or ready to respond fully, if a commercialization objective were thrust on it from the top down. Without alignment, no amount of research money pushed into the system will result in commercialization efforts unless commercialization becomes a priority, and this objective is aligned with the purpose of each player in the system.

Companies

A company seeking to commercialize hospital or university-based research will have its relation first with the university. Then it will reach out to other players, each of whom receives some funding from the federal or provincial governments, including:

- university-based incubators for mentoring, space and/or financial support (typically for startups affiliated with the academic institution),
- community-based organizations such as Communitech for advice,
- sector-based organization like the Ontario Bioscience Organization (OBIO) for advice and program funding,
- MaRS for market Intelligence and a range of other services such as embedded executives,
- the Ontario Centres of Excellence (OCE) for funding and some advice along the way,
- Business Development Bank of Canada (BDC),
- Export Development Canada (EDC),
- Global Affairs Canada,
- National Research Council's Industrial Research Assistance Program (IRAP),
- and a host of other publicly funded programs for more advice and funding.

If a company is overwhelmed by the program choices, it may turn to IRAP's Concierge program to help it navigate the system. In addition, both the Ontario Government through the Ontario Investment Office and the federal government through the Accelerated Growth services will coordinate government services for the company.

At some point, the company may start to receive investment capital from organizations such as BDC and MaRS' Investment Accelerator Fund (IAF).

For each contact with what could be easily more than ten entities in the system, the company will have:

- a person responsible for their account,
- a separate application to fill out,
- a separate set of metrics to report on,
- advice from multiple players with potentially varying perspectives,
- one avenue to choose amongst overlapping programs that may not be aligned, and
- many programs at its disposal that support R&D, but few to none for other functions such as sales and marketing.

This complexity has also been recognized by the stakeholders in the system. There are regular meetings between organizations to try to coordinate their activities with a client. The collective programs have become so complicated for beneficiaries to navigate that there are three bodies to help companies navigate the system: IRAP's Concierge system, Accelerated Growth services from Innovation, Science and Economic Development Canada (ISED), and the Ontario Investment Office.

The Expert Review Panel Report on the Ontario Network Of Entrepreneurs (Remers et al., 2017) recognized the complexity of the system in their recent review. They concluded, among other things that:

> "Our inquiry uncovered a system that has grown organically over the last decade, resulting in an unwieldy tool to deal with the accelerating pace of technological change. The network needs a philosophical shift to meet the challenges ahead, focusing more directly on Ontario's core strengths and connecting companies to global networks. Doing so will require making changes to the way the current network is organized and governed." (p. 4–5)

Purchasers

In their report on Ontario's health commercialization gap (OBIO, 2018), OBIO reported that: "[t]he absence of a supportive local infrastructure for technology trial and development followed by adoption and dissemination" was a major barrier to scaling up the health technology sector (p. 6).

The main purchaser in the system is the healthcare system itself, which is almost entirely financed by the governments that fund the research and fund the innovation system through which the research must pass to reach the healthcare system.

The purpose of the healthcare system, comprised of the hospitals and doctors that serve patients is to deal with the health problems of Canadians. The objective of the system is quality health care rather than innovation or the purchase of innovation. The system has been designed to protect patients. As a publicly funded system, it must act to be fiscally responsible. As a result, the system has been set up in a way that may actually discourage the purchase of innovation:

- New technologies and drugs require approval. Many Canadian startups comment that it often does not make sense for them to obtain product approval in Canada until after they have received it in the US. Canadian approval is expensive and time-consuming, deterring startups to incur expenses here for a new market.
- Even if technologies are approved and undergo successful trials, the hospitals that provide positive clinical evaluation may still not be able to purchase because of budgetary issues and billing codes.
- Getting devices paid for by the system requires that they be approved for procurement, but commentators also state obtaining that approval is a difficult task.
- The funding process for hospitals makes it difficult to innovate because the way the money flows to hospitals is slow and may not align with an innovation agenda in an effective manner.
- Hospital innovation systems are often islands, without linkages to procurement
- The purchasing system has so many rules and procedures that it too acts as a brake on innovation. It is often much easier for Canadian companies to obtain approval for purchase by US hospitals.

The net result of the issues in healthcare system purchasing is that Canada becomes what we call the "land of stranded pilots". It is possible (although slow and costly) for an entrepreneur to get a pilot for a new technology as there are systems and processes in place for conducting trials but there are few systems in place to turn those trials into regularly purchased products, thus creating gaps and "stranded trials". These difficulties, along with the challenges of obtaining capital for early-stage ventures, make it much easier for companies to do business in the US; and some choose to move across the border to improve their chances of success.

The Canadian healthcare system is one of the largest globally, and Ontario and Quebec in particular are two of the largest single-payer systems in the world. While the system acts as a brake on innovation, it could instead drive innovation through its purchasing power. Given its heft, it 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. If the system were better designed and implemented, it could work jointly with the rest of the innovation system to generate economic and health benefits for all Canadians.

Why is the System Flawed?

Given the problems covered in this report, one must ask why the health tech innovation system has been so poorly designed. Some evidence for the cause of this problem comes from a recent report released by the Advisory Council on Economic Growth (*Unlocking Innovation to Drive Scale and Growth*, February 2017). Their report summarized the bottlenecks in the innovation ecosystem contributing to Canada's underperformance in three bullet points:

- "a gap between invention and revenue-generating commercialization
- a struggle to scale up successful start-ups and small and medium-sized enterprises (SMEs)
- no burning platform for corporate adoption of innovation." (p. 4)

With C$7 B of research producing an estimated C$3.5 B of revenue, there certainly appears to be a gap "between invention and revenue-generating commercialization." The report explains that:

> "The country does not benefit as much as it should from the intellectual property that it generates. Neither government, business, nor academia has completely solved this conundrum and none will be able to solve it on its own. Several indicators suggest that these groups are not interacting as much as they could. For example, in 2012, Canadian higher-education institutions created approximately 16 licences per institution compared with about 35 in the United States. Furthermore, Canada's ranking on business-university R&D collaboration declined to 19th place in 2015. The reasons for this are complex and interrelated, including a lack of local R&D-intensive corporations to develop and adopt inventions, a lack of qualified staff within universities and companies to build relationships and broker collaboration, and insufficient funding to support early and risky commercialization activities." (p. 4)

Fundamentally, the Advisory Council has neglected to dive deeply into the problem to ask "why". They have made several half-hearted attempts to explain why but the language they use indicates that they do not really know the reasons why these problems are occurring, best encapsulated in statements such as:

> "The reasons for this are complex and interrelated, including…" (p. 4)

The Council released eight recommendations for "resetting Canada's growth trajectory" (December 2017). Its fourth recommendation was to:

> "Unlock innovation and support its commercialization by establishing business-led innovation marketplaces (superclusters), creating additional pools of growth capital for promising companies, leveraging strategic government procurement to help innovators identify a 'reference customer,' reviewing and rationalizing government innovation programs, and expediting entry for top talent." (p. 6)

Without thoroughly understanding the nature of the problem and without researching in depth the causes of underperformance, the recommendation reflects a long tradition in Canada's innovation system: and that is to create yet again one more program striving to fix one problem of the puzzle. Over time, these additions have created a complex and layered system contributing to the tremendous challenges that entrepreneurs face in the health tech innovation system. The result is a program-rich system with gaps, duplication, and competition.

The Council's report resulted in the creation of superclusters, a C$950-M fund for five superclusters located in key regions across the country. When the math is broken down by supercluster per year over five years, the funding disbursed to each amounts to roughly C$40 M per year per cluster. That is the amount that a reasonably successful California- or Massachusetts-based startup receives. Note that this is only one startup, and not a cluster.

At this stage, it is not clear what will constitute success for the superclusters program. The government does not appear to have established a clear goal, a way to measure where we are now in relation to that goal, or a way to measure progress and attainment of the goals. Without metrics, it will be difficult for the superclusters to improve commercialization, to measure progress, and to determine eventual success.

One might notice from the list of funded projects that there is no health tech supercluster. The superclusters cover digital technology, protein industries, advanced manufacturing, AI-powered supply chains, and oceans. The software side of health tech is mentioned as a small part of the digital technologies supercluster, but there are no references to biotechnology, pharma, or medical and assistive devices (except that perhaps the last two could be a small part of advanced manufacturing). Not only is there no health tech cluster, but health also did not even make the shortlist of applicants.

The recommendation given by the Advisory Council also included a reference to the "leveraging of strategic government procurement to help innovators identify a 'reference customer'" (p.6). But this strategy may not work in the health tech field; the federal government does not play a role in health tech purchasing, which is under the purview of the provinces.

The last point made in the fourth recommendation revolved around the need to "review and rationalize government innovation programs." While this is a laudable aim, they can't do it alone as the provincial government are responsible for the coordination of activity in universities and hospitals.

What this indicates is that the Council has not done adequate research to be able to categorically state, by reference to such research, what the causes of Canada's poor performance actually are. Instead they appear to have relied on anecdotal evidence as to the nature of the problems. The resulting "reasons" have been cited in policy narrative on Canada's underperformance for decades, without significant change. Without identifying the actual pain points through research (which ironically governments fund in excess of C$15 B per year), we are doomed to repeat our mistakes.

Implications for Funders and Supporting Agencies: Developing a Client-based System

From the perspective of the entrepreneur, the system for commercializing health technology can certainly be considered "byzantine" and flawed.

We must note that this brief is not intended to be a criticism of any organization in the system or the individuals that work for those organizations. We truly have a system and people within it who are trying to do the very best job they can for their clients. They are all doing an excellent job meeting the needs for which they were established or employed. Governments at all levels too are trying to do their best by looking for problems, identifying flaws, and developing programs to address those flaws.

The problem is centered on the gradual evolution of the system as a whole. Historically, the tendency to perpetually fill gaps and to correct each flaw individually has inadvertently created the complexity we face today. The piecemeal design has created inefficiencies that no amount of hard effort by the participants in the system can change. The health tech innovation system has no measurable objectives and is plagued by misalignments, gaps, competition, and overlapping resources. Certainly, the whole is not the sum of the parts. The system design is flawed and must be fixed if we are to compete in health technology innovation.

If we are to solve this problem, we need one coherent, coordinated strategy. A redesigned system should be:

- designed with the clients in mind,
- driven by clear measurable goals,
- highly specialized to enhance quality,
- simple and fast to navigate,
- without gaps,
- have no overlaps or competing parts, and
- cost-effective.

We need to break down, or at least optimize, the current patchwork of institutions and programs and start anew, designing the system with the entrepreneur and the end-user in mind.

Appendix A: Subsector Analysis

Healthtech Software

We now look at each specific area of health tech, beginning with health tech software. Exhibits A1 and A2 highlight the number of health tech companies in software and the total investment dollars, respectively. These exhibits show that the Canada-US gap in health tech software is relatively large but not as problematic as in other health tech areas (refer to subsequent sections).

Health Tech Software Companies per Capita

Exhibit A1

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**0.9**	**1.3**	**1.7**	**3.0**	**7.7**
Scaling	Over $10 M	0.09	0.22	0.22	0.61	1.45
Starting	Under $10 M	0.83	1.04	1.50	2.41	6.23

Health Tech Software Investment Capital Per Capita

Exhibit A2

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**2.3**	**5.2**	**11.9**	**33.7**	**129.7**
Scaling	Over $10 M	1.7	4.4	10.3	31.0	121.9
Starting	Under $10 M	0.6	0.8	1.6	2.7	7.9

Biotech and Pharmaceutical Drugs

Relative to certain US states, Canada's performance in biotech and drug development is substantially weaker than in software. Exhibits A3 and A4 show the firm numbers and

investment per capita for starting and scaling companies.

Biotech Companies per Capita

Exhibit A3

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**5.5**	**4.8**	**9.6**	**19.9**	**59.7**
Scaling	Over $10 M	0.88	0.82	2.98	8.66	28.26
Starting	Under $10 M	4.58	4.02	6.57	11.22	31.45

Biotech Investment Capital Per Capita

Exhibit A4

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**46.1**	**49.9**	**171.0**	**498.7**	**2,140.2**
Scaling	Over $10 M	39.6	43.9	159.5	475.2	2,069.6
Starting	Under $10 M	6.5	6.0	11.5	23.5	70.7

Although Canada is outscored by the US by a factor of "only" 1.75 in terms of company creation, we are significantly weaker in scaling. In terms of investment dollars, we are outscored 3.7 to 1. Massachusetts is once again the clear winner, outperforming Ontario on every single measure on a per-capita basis:

- 12.4 to 1 in company creation,
- 34.5 to 1 in scaling companies,
- 42.8 to 1 in dollars invested in companies, and
- 47.1 to 1 in dollars invested in scaling companies.

Medical Devices and Equipment

And so we turn to the last area, medical devices and equipment, the gap grows even further (Exhibits A5 and A6).

Canada is outscored by the US by a factor of 4.4 to 1 and 6.5 to 1 in company creation and scaling, respectively. In terms of investment dollars, we are outscored 13.5 to 1. Massachusetts is once again the clear winner. They outscore Ontario on a per-capita basis

across the following metrics:

- 11.2 to 1 in company creation,
- 35.7 to 1 in scaling companies,
- 56.4 to 1 in dollars invested in companies,
- 99.0 to 1 in dollars invested in scaling companies,

Massachusetts beat Ontario 99 to 1 in terms of dollars invested in scaling medical device and equipment companies! This gap is surprising given the activity of Ontario's medical device industry.

Medical Device and Equipment Companies per Capita

Exhibit A5

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**2.7**	**3.8**	**11.8**	**22.8**	**41.9**
Scaling	Over $10 M	0.28	0.30	1.81	5.92	10.72
Starting	Under $10 M	2.44	3.51	10.03	16.86	31.16

Medical Device and Equipment Investment Capital Per Capita

Exhibit A6

$ Thousands		Canada	Ontario	US	California	Mass
Capital per 1M population		**8.5**	**11.7**	**115.6**	**407.5**	**660.2**
Scaling	Over $10 M	5.5	6.3	106.2	387.6	624.6
Starting	Under $10 M	3.0	5.4	9.4	19.9	35.6

Appendix B: Health Tech System Participants

Government	
Role	To coordinate and provide funding for the health tech innovation system
Examples	Government of Canada, Governments of Ontario, BC, Quebec, and other provinces
Funding received	From taxpayers as part of general revenue
Technology received	Not applicable
Funding provided to	Hospitals for operating grants Institutes of health research for program funding Universities for operations Innovation centres for program funding and operations Centres of Excellence in the Commercialization of Research (CECR) for program funding and operations Campus Linked Accelerators (CLAs) for program funding and operations Venture capitalists for program funding
Technology provided	Not applicable
Advice provided	Not applicable

Commentary	The Canadian and provincial governments spend over $10 B a year to foster the innovation system in the country. Over $3 B is spent in the form of tax credits, over $6 B in the form of grants for research conducted by universities and hospitals, and over $1 B in program spending. Much of this funding is allocated towards basic research, and one would not expect this research to result in commercialization. However, a major portion of the funding is targeted towards research and commercialization of health technologies. It would be interesting to see what effect it has on the economy because clearly, it is not resulting in major wins in health tech commercialization. For over 50 years, governments have been developing programs to improve the commercialization of health technology innovations in Canada. Considerable effort has been targeted towards the identification of gaps and the development of programs to fill gaps. Even with all this effort and all of this spending, Canada lags much of the OECD at important metrics such as R&D spending, patenting, and productivity. Commentators frequently blame our poor results on lack of industry spending. Perhaps though, poor industry spending, and specifically in the health tech area, is a result of a dysfunctional system that due to challenges, creates and scales an insufficient number of companies.
Challenges	The result of the effort in overcoming poor results has been the creation of numerous overlapping programs and entities. It has also not completely filled gaps as programs do not have the flexibility to cover unmet needs that arise from changes in the nature of commercialization carried out. The system has evolved as a program-centric rather than a client-centric model. It appears that no one is looking at the system as a whole, developing a seamless path for the commercialization of health technologies. Even though governments fund the system that create the technologies, they do not do a good job of enabling the companies they have created to sell their innovations back into the system. Thus, one part innovates while the other part creates roadblocks.

Institutes of Health Research	
Role	To fund scientific research
Examples	Canadian Institutes for Health Research, Ontario Brain Institute
Funding received	From federal and provincial governments for program funding and operations
Technology received	Not applicable
Funding provided	Hospital researchers and university faculty to do basic and applied research and to startups to advance R&D
Technology provided	Not applicable
Advice provided	Not applicable
Commentary	Through its 13 institutes, CIHR is spending over $1 B annually on health research. Much of the work they do is focused on fundamental research that is not expected to result in commercialization. However, these Institutes do fund applied research from which one would expect some emphasis on commercialization.
Challenges	The attitude of the Institutes is largely oriented towards basic science, not to the commercialization of science. CIHR has tried to drive the concept of "knowledge translation", which includes clinical research, public health, and commercialization. They have not developed programs that tie into the innovation systems to commercialize the technology that they fund. The funding to one popular initiative, the Proof-of-Principle Program, was cut. As commercialization is not a priority, there is little funding or incentive for researchers to commercialize the results of their science. This is not to say that the government should be cutting back on basic research, but that perhaps some attention can be paid to commercialization, if such potential exists.

Universities	
Role	To educate students and undertake research through faculty
Examples	University of Toronto, McGill University, University of British Columbia
Funding received	For teaching, administration, research, and operations
Technology received	Not applicable
Funding provided to	Salaries for faculty and technology transfer staff Program funding for technology transfer offices Operations funding for some university-affiliated CECRs Operations funding for Campus Linked Accelerators
Technology provided	Not applicable
Advice provided	Not applicable
Commentary	AUTM, the Association of University Technology Managers report for 2016 notes that collectively, Canadian universities spent C$6.1 B on research, made 1,697 invention disclosures, earned C$72 M in license revenue, and created 100 companies. This spans all areas of science and not just health tech, but it does go to show the magnitude of the effort. For example, the University of Toronto's Faculty of Medicine spent C$850 M on health tech-related research, made 192 disclosures, filed 43 patents, and created 11 companies in the five years leading up to 2017. The purpose of these grants is specified by the granting agency and must be spent as per funding agreement. These grants are not made with commercialization in mind. Canadian universities patent disclosures at a rate much lower than that in the US due to funding constraints. While the rate of patenting is lower, Canadian universities have a higher rate of success in obtaining patents (as measured by the rate of application to issuance).

Challenges	Universities were not established to commercialize research. They were established to teach and conduct research. As commercialization is not an objective, there is little to no external incentive for faculty to commercialize the results of their research. This may even impact the filing of invention disclosures. For many researchers though, there is an intrinsic motivation to commercialize so that the results of the research can benefit society. Furthermore, there is little incentive to focus on the creation of world-class companies that may evolve from the research conducted in academic institutions. Since the core university mandate is research, commercialization is the "icing on the cake". Commercialization remains a contentious topic in universities. Faculty members are not hired to commercialize, nor are they trained to do so. For that reason, government should not be expecting to create commercializable technologies. Governments should not be developing programs to commercialize knowledge from the universities if the universities are not aligned with this objective.

Hospital Researchers	
Role	Undertake basic, translational and applied research that may or may not result in new innovative processes and products
Examples	Research staff at the University Health Network (UHN), St Paul's Hospital, Montreal General Hospital
Funding received	Researchers' salaries are funded by the hospital. Research and some salaries are funded by government granting agencies such as CIHR, the Ontario Institute for Cancer Research (OICR), and by industry.
Technology received	Not applicable
Funding provided	Not applicable
Technology provided	Researchers disclose new inventions that result from their work to the technology transfer office of the organization they work for.
Advice provided	Not applicable
Challenges	As there is little incentive and almost no rewards for commercialization through disclosures, patents, and product or company creation, the time spent on this by researchers can take away from activities such as conducting research and creating publications, serving as a major disincentive for commercializing.

University Faculty	
Role	Undertake basic and applied research that may result in new innovative process and products
Examples	Professors in the University of British Columbia, McGill University, and U of T's Faculty of Medicine
Funding received	Salaries are funded by the university. Research is funded by government granting agencies such as CIHR, OICR, and by industry.
Technology received	Not applicable
Funding provided	Not applicable
Technology provided	Faculty disclose new inventions that result from their work to the technology transfer office of the university.
Advice provided	Not applicable
Challenges	As there is little incentive and almost no rewards for commercialization through disclosures, patents and product or company creation, the time spent doing this by faculty can take away from their main jobs of research. Teaching, and creating research publications, offering a disincentive for pursuing commercialization. Many faculty are not aware of the process of commercialization, and are not trained to make decisions regarding innovations. Despite outreach activities by technology transfer activities, many faculty members also do not disclose inventions because of a lack of awareness of the system and the benefits of disclosure. For some faculty, there is an intrinsic motivation to commercialize so that the results of the research can benefit society.

Hospital Technology Transfer Office	
Role	To license technology from the researcher to existing healthcare companies or to startups that can be built based on the technology
Examples	University Health Network (UHN) Technology Development and Commercialization Office
Funding received	Operations and programs are funded by the hospital. Income is also received from the licensing of technology to startups or more established licensees. This is intended to be a profit-making venture whereby license revenue should generate positive cash flow to the hospital and pay for the operation of the tech transfer office.
Technology received	Hospital policies usually dictate that the hospital is the owner of any invention made as part of a researcher's work. Hospitals receive invention disclosures from researchers.
Funding provided	Hospitals often provide funding to patent select inventions made by researchers.
Technology provided	They license inventions and rights to technology to startups formed around the technology or to existing companies.
Advice provided	Commercialization advice provided to researcher-led startups.
Challenges	Restrictive intellectual property ownership rules make for a lengthy process to license research to scientists for the purpose of company formation. In the case of UHN for instance, the ownership requirements can take up to two years to resolve and can often result in the orphaning of promising technology.

Commercialization Centres	
Role	To facilitate research and advance its commercialization through a number of roles, including as an investor, incubator, or service provider. It may license technology from hospitals and universities to existing healthcare companies or form startups centered on the technology.
Examples	MaRS Innovation, Centre for Commercialization of Regenerative Medicine (CCRM)
Funding received	Operations are supported by the Networks of Centres of Excellence CECR program, industry, universities, or hospitals. Governments or private-sector partners may provide investments for nascent technologies. Funding is also received from the license of technology to startups or licensees. This is intended to be a profit-making venture whereby license revenue should generate positive cash flow to build sustainability for the CECRs and pay for their long-term operations.
Technology received	Certain CECRs such as MaRS Innovation have agreements with hospitals and universities stating their right to pick from the technologies disclosed in institutions. If they choose, they can elect to take over the commercialization of the technology.
Funding provided	CECRs provide funding to seed the creation of businesses.
Technology provided	They license inventions and rights to technology to startups formed around the technology, or to existing companies.
Advice provided	Commercialization advice may be provided to researcher- or faculty-led startups.
Commentary	MaRS Innovation, a CECR affiliated with U of T, has reviewed 1,500 disclosures and created 60 companies in 8 years of its activity,
Challenges	Generalist CECRs must have enough expertise on hand to understand the commercial potential of underlying technologies they are evaluating through the disclosure process. The CECRS were established with the requirement that they become self-sustaining. This may prove a distraction to the activities as they may be forced to conduct their operations that are perhaps not in the best interests of the entities they are serving. To top it all off, their core funding from the federal government is on five-year cycles when long-term patience should be required with strong and clear milestones instead. Becoming successful at technology transfer is a long and hard process. The Government of Canada, in creating these entities have established five-year sunset clauses, thus requiring them to spend significant amounts of time in the last two years of a refunding cycle trying to obtain funding for the next five years. In contrast, the Small Business Innovation Research (SBIR) program in the US has remained intact for 30 years.

University Technology Transfer Office	
Role	To license technology from faculty to existing healthcare companies or to form startups based on the technology
Examples	UBC University-Industry Liaison Office, U of T Innovations and Partnerships Office, McMaster Industry Liaison Office
Funding received	Both operations and program funding are typically derived from the university. Funding is also received from the license of technology to startups or licensees. While each tech transfer office has its own mission, there is often an expectation for them be profit-making ventures whereby license revenue should generate positive cash flow to the university.
Technology received	Universities receive invention disclosures from researchers. University policies usually dictate that the university is a partial owner of any invention made as part of a faculties' work. Each university has a different tech transfer policy.
Funding provided	Universities usually subsidize the cost of a patent for a small number of inventions made by researchers. Some universities provide small seed funding to startups created to commercialize the technology.
Technology provided	The tech transfer offices license inventions and rights to technology to startups formed around the technology or to existing companies.
Advice provided	Commercialization advice provided to researcher-led startups.
Challenges	Since tech transfer offices are not funded by the government, but by the university, they compete with other areas of the university for funding—until they can develop a flow of cash from licensing. Tech transfer offices receive a bewildering array of complex disclosures and often, without specific experience in an area, must assess a path for commercialization. While a small team of venture capitalists facing an equally bewildering array of technologies can spend considerable time on research and will make few decisions in a year, tech transfer staff are constrained by time, experience, and funds to do full justice to each disclosure.

University-associated Incubators/Accelerators	
Role	To provide awareness and engagement on entrepreneurship and assist students in the creation of companies, some of which may be based on the research carried out by the students.
Examples	Charles Chang Innovation Centre (Simon Fraser University), Dobson Centre (McGill University), Impact Centre (University of Toronto)
Funding received	There is a diversity of funding models for incubators/accelerators. While some have operations and program funding provided by the university, others may receive income from private donors. In Ontario, the provincial government provides funding for Campus Linked Accelerators through the Ontario Centre of Excellence.
Technology received	Not applicable
Funding provided	Often provide space for the incubation of companies and sometimes provide small amounts for seed funding or prizes for innovation contests
Technology provided	Not applicable
Advice provided	Provide courses and mentorship to clients
Challenges	These organizations are university-based, and the number of programs provides prospective entrepreneurs with substantial choice. While choice is beneficial, incubators/accelerators can be competitive with each other, particularly for clients, leading to reporting difficulties and double-counting . Ineffective metrics makes the evaluation of efficacy difficult. Startups often shop advice around, using all resources in the system, thus adding to the cost of the system without improving performance. While it is good to have this choice, the proliferation of choices mean that we have too many underfunded programs. Many centres have developed their own educational programs. The end result is a waste of funding to develop overlapping and duplicated programs throughout the system. Startup funding and prize money is often available, with some organizations even offering access to venture capital funding. But this creates a conflict between the advice and the capital, with companies seeking the advice as a route to capital.

Regional Innovation Centres	
Role	Regional innovation centres have been established throughout the country to encourage entrepreneurship, to provide education, mentorship and funding and to serve as hubs for local ecosystems.
Examples	Centre for Ocean Ventures and Entrepreneurship, MaRS, Communitech, Innovation Saskatchewan
Funding received	Operations and program funding is often provided by the various levels of government.
Technology received	Not applicable
Funding provided	Innovation Centres often provide space for the incubation of companies and sometimes provide small amounts for seed funding or prizes for innovation contests. They also sometimes administer funding for smaller government programs.
Technology provided	Not applicable
Advice provided	Provide courses and mentorship to clients
Challenges	In many cases, these organizations are community-based, meaning that their expertise is not in a particular technology, but in the overall process designed to serve a local population. But commercializing cleantech is different from health tech. And health tech software is different from medical devices, which is different from diagnostics. As a result, the type of advice given is often general in nature. Like university-based incubators/accelerators, innovation centres are also competitive with each other, competing for clients and often claiming the same set of clients as another local centre. Startups, particularly in the Toronto area, often shop advice around, using all resources in the system, thus adding to the cost of the system without improving performance. Many innovation centres have developed their own educational programs despite a potential lack of experience in program development. The end result is a set of overlapping and duplicated programs throughout the system. Furthermore, ill-defined or ineffective metrics across centres makes systemic evaluation of efficacy extremely challenging. Many centres have developed their own educational programs. The end result is a waste of funding to develop overlapping and duplicated programs throughout the system. Startup funding and prize money is often available, with some organizations even offering access to venture capital funding. But this creates a conflict between the advice and the capital, with companies seeking the advice as a route to capital.

Government Programs	
Role	To provide research funding and advice to fuel the growth of technology firms.
Examples	IRAP, BDC, OCE
Funding received	Program and operations funding received from governments
Technology received	Not applicable
Funding provided	Specific funding programs for salaries or equipment primarily to support company research
Technology provided	Not applicable
Advice provided	Provide courses and mentorship to clients
Challenges	An individual starting this journey is faced with a bewildering array of government funding programs, all of them well-meaning but extremely difficult to navigate. They are so difficult to navigate that the federal government has instituted two programs to help companies navigate the system. The first is the Concierge system at IRAP which has a website and representatives who will work with companies to find programs that meet their needs. ISED, which funds IRAP, has another complete program for companies that are scaling. Instead of putting the two programs together, they continue to operate independently, each trying to solve a problem, which by their separate existence, they have taken part in creating. Often, in order to get funding, a program requires the recipient to attend a training course regardless of whether a similar course has already been taken. Program staff often have no experience in developing educational programs, and they are inadvertently creating a publicly funded set of overlapping and duplicated programs. In addition, many programs often need to justify their existence by the number of clients, not by the time spent with each client or the quality of advice delivered.

Regulatory Bodies	
Role	To regulate health technology innovation to protect the public
Examples	Patent Office, Health Products and Food Branch, Government of Canada
Funding received	Operations funding received from government
Technology received	Not applicable
Funding provided	Not applicable
Technology provided	Not applicable
Advice provided	Product approvals
Challenges	The system has been designed to protect the public, not to promote the development of innovative new technologies. It can be as stringent or more stringent in its requirements than the US Food and Drug Administration (FDA). Since Canada is a small market and funding is difficult to obtain for launching new products, companies frequently bypass Canada in the certification process or delay it until certification and market viability are obtained elsewhere.

Venture Capitalists, Angels, and Other Investors	
Role	To provide funding to fuel the growth of health tech firms
Examples	BDC, MaRS IAF, other venture capitalists sponsored by the federally funded Venture Capital Catalyst Initiative (VCCI)
Funding received	Investment funds and operations funding from governments and other limited partners
Technology received	Not applicable
Funding provided	Investments in the form of convertible debt or equity to startups and scaling health tech companies
Technology provided	Not applicable
Advice provided	Mentorship
Commentary	We reviewed all health tech companies that had received venture capital funding in 2017. These companies had received funding over the lifetime of funding from 75 Canadian investors and 73 foreign investors. Of the total dollars received, we have estimated that less than 35 per cent of the capital came from Canadian investors and over 65 per cent was derived from foreign sources.
Challenges	VCs, angels, and other investors will typically not want to invest in very early-stage technology, at least not until the technology has proven efficacy and some measure of market traction. But creating health technologies requires considerable time and expense. Without sufficient capital provided through government programs, we are creating a "valley of death" where no funding is available in the right amounts. This delays initial funding of organizations by investors. Venture capitalists in the health field in Canada are underfunded. Portfolio theory requires them to spread out their funding among a large number of companies. As a result, too little funding is available per company. Late funding and the provision of amounts that are considerably smaller than in the US leads to companies suffering from slow business growth that do not attract later-stage capital to fuel their growth to world-class status. As a result, they are eventually sold, typically to foreign buyers.

Tax System	
Role	To provide research funding support to health technology firms.
Examples	Scientific Research and Experimental Development (SR&ED) tax incentive
Funding received	Funded through government operations
Technology received	Not applicable
Funding provided	Tax credits to support research
Technology provided	Not applicable
Advice provided	Not applicable
Challenges	Because SR&ED program is controlled by the federal Department of Finance, not ISED, there is no integration of its work with that of economic development. The SR&ED program also only provides incentives to technology companies for conducting R&D, sending the message to beneficiaries that other marketing and sales and other functions instrumental to growth are unimportant. As a result, many organizations delay expenditures on marketing and sales until a product is launched. This delays their market introduction and their ultimate growth. The tax program is a "post funder", meaning that companies can only apply for the incentive after its tax-year end. Any delays in obtaining funding on first application impact the companies' cash flow. As a result, a number of SR&ED lenders have cropped up to eliminate the expense-to-reimbursement gap. The system for application has becomes so complex and rules-oriented that individual entrepreneurs can no longer attempt to complete the application themselves. This has created another industry of SR&ED consultants, who for a percentage of the claim, will complete the filing work necessary for a company. The end result is that companies get money late, in smaller amounts, and not necessarily for the expenditures that will fuel their growth.

Health Tech Startups	
Role	To commercialize health technology
Examples	
Funding received	Small amounts from university programs, seed capital from CECRs, prizes and specific programs from CLAs or Innovation centres, tax credits, specific government programs and a whole host of potential investors
Technology received	From students, faculty, public inventors, tech transfer offices and CECRs
Funding provided	Not applicable
Technology provided	Final technology sold to hospitals, health care providers and individuals
Advice provided	Multiple organizations
Challenges	The system is a byzantine path through countless organizations and programs, none of which line up with each other perfectly. Obtaining ownership of the underlying technology can be a lengthy process and be subject to lengthy negotiations. Protecting the technology is complex, time-consuming, and expensive with many stakeholders willing to help (if they can be quickly identified). Funding can be derived from a myriad of sources, including the popular pitch competitions, which are time-consuming and do not generate other significant benefits to the organization. Government programs each require separate applications and often matching of funds. The programs are not always in line with business needs, but many companies devote substantial time and effort on such unessential activities for small amounts of support. In many cases, startup funding also comes with advice and an educational requirement, regardless of the actual need. Companies end up getting advice from over a dozen organizations, all well-intentioned but potentially conflicting. Angels and VCs will not invest until a technology is more proven in the marketplace, and yet there are early-stage programs that require matching funds from VCs.

Healthcare System	
Role	To purchase innovative healthcare solutions in order to improve hospital operations and patient outcomes
Examples	University Health Network, St. Paul's Hospital, Montreal General Hospital
Funding received	From hospital operating budgets
Technology received	Medical and diagnostic devices, healthcare software, and pharmaceutical drugs from healthcare technology providers
Funding provided	Purchase technology from healthcare technology providers
Technology provided	Not applicable
Advice provided	Can provide advice through participation in trials.
Challenges	Hospital buyers are disincented to try or purchase innovative health technologies due to extremely strict purchasing requirements, many of which are established by the very same governments that fund the innovation. Thus, while governments pay for innovative research as well as contribute to its commercialization, they act as a brake on the system by not developing a fast and simple platform that will enable hospitals to trial new technologies with little risk or expense.

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About the Impact Centre

Science to Society

We generate impact through industry projects and partnerships, entrepreneurial companies, training and research.

We bridge the gap between the university and industry to accelerate the development of new or improved products and services based on physical technologies. We work with graduate students and researchers to help them commercialize their discoveries. We provide undergraduate education and training for students at all levels to ease their transition into future careers.

The Impact Centre conducts research on all aspects of innovation, from ideation and commercialization to government policy and broader themes such as the connection between science and international development. We study how companies of all sizes navigate the complex path between a discovery and its market and how their collective innovations add up to create a larger socioeconomic impact.

Our objective is to understand how we can improve our ability to create world-class technology companies, how governments, companies, and academia can identify and adopt best practices in technology commercialization.

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