FIFTEEN YEARS OF INVESTMENT IN CANCER RESEARCH IN CANADA, 2005–2019

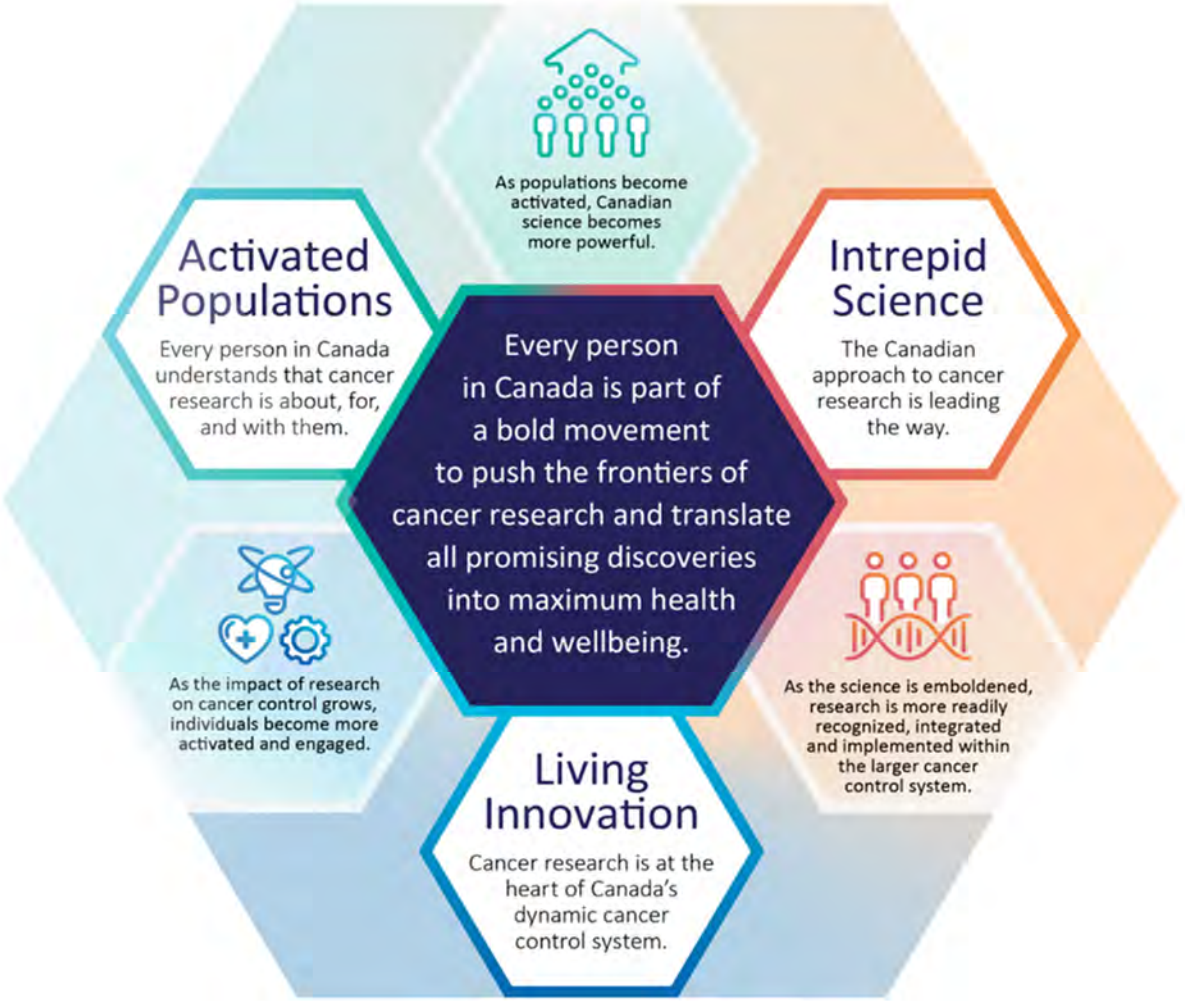
Canadian Cancer Research Alliance
Alliance canadienne pour la recherche sur le cancer

CANADIAN PARTNERSHIP AGAINST CANCER
PARTENARIAT CANADIEN CONTRE LE CANCER

JUNE 2022

Discovery Together

Canada's Vision for Cancer Research



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Suggested Citation: Canadian Cancer Research Alliance. (2022). *Fifteen Years of Investment in Cancer Research in Canada, 2005–2019*. Toronto: CCRA.

ISBN 978-1-927650-70-7 (PDF)

Aussi offert en français

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CELEBRATING A FIFTEEN-YEAR MILESTONE: MESSAGE FROM THE CCRA BOARD CHAIR & EXECUTIVE DIRECTOR

Paula Robson

The establishment of the Canadian Cancer Research Alliance (CCRA), led by Drs. Victor Ling, Philip Branton, and Gerald Johnston in the early 2000s, has become a forum that has fostered trusted, collegial relationships among Canada's research funding leaders, accelerated investment in translational research, and facilitated partnered funding on specific research platforms that will provide a continued legacy for cancer research. A fifteen-year window may not yet capture all the benefits yielded from the CCRA, but with recent federal investment coupled with the dramatic impacts of the pandemic, we feel that our ongoing commitment to partnership, collective action, and the ongoing tracking of research investments puts us in a favourable position to both monitor and respond to change.

Sara Urowitz

This report shows that the cancer research investment in Canada dramatically increased from 2005, the first year the CCRA started to track the investment, until 2011, where a record $582M was invested. This increase was the result of commitments and ramped up investments in cancer research made by the Ontario government as well as large-scale infrastructure investments with a cancer component funded through the Canada Foundation for Innovation. The investments were not sustained and there is evidence that Canada's investment in cancer research has not kept pace with either the U.S. or the U.K. And then the pandemic struck. The trends noted in this report provide some insights into areas that the CCRA should prioritize for consideration in the coming years as we as we continue to navigate through a constantly changing landscape. Our next report will contain information about the first year of the COVID pandemic and its effect on cancer research funding. Watch for it in spring 2023.

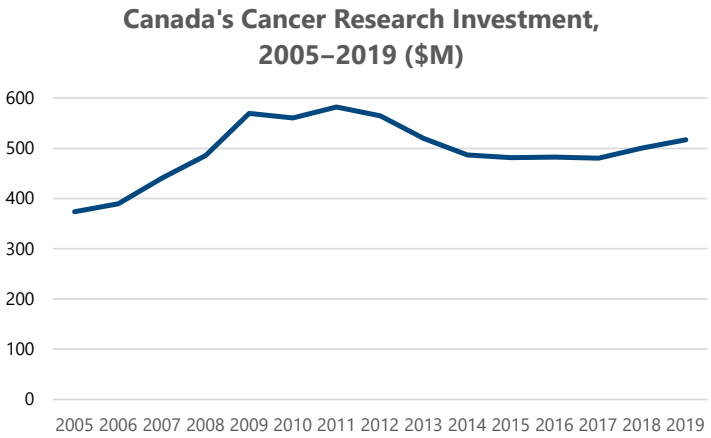
As always, we welcome your thoughts and comments as you review this report and look forward to continuing to track and report on the cancer research investment landscape and how it helps enable the priorities of the Canadian Strategy for Cancer Control. In particular, we will draw the connections on how a sustainable cancer research system focused on collaboration and strategic coordination helps accelerate the translation of research into policy and practice change and ultimately ensures equitable access to quality cancer care for all people in Canada.

Paula J. Robson, PhD
Chair, CCRA Board
Scientific Director, Cancer Research & Analytics
Cancer Care Alberta, Alberta Health Services

Sara Urowitz, PhD, MSW
Executive Director, CCRA
Director, Research and Innovation, Canadian Partnership Against Cancer

EXECUTIVE SUMMARY

Members of the Canadian Cancer Research Alliance (CCRA) are motivated by the belief that, through effective collaboration, Canadian cancer research funding organizations can maximize their collective impact on cancer control and accelerate discovery for the ultimate benefit of Canadians affected by cancer. Reporting on Canada's investment in cancer research has been a pillar of CCRA's work since its earliest days. This report highlights trends in that investment for the fifteen-year period, 2005 to 2019.



$7.4B was invested from 2005 to 2019. This investment covered different types of support through four main types of funding mechanisms.

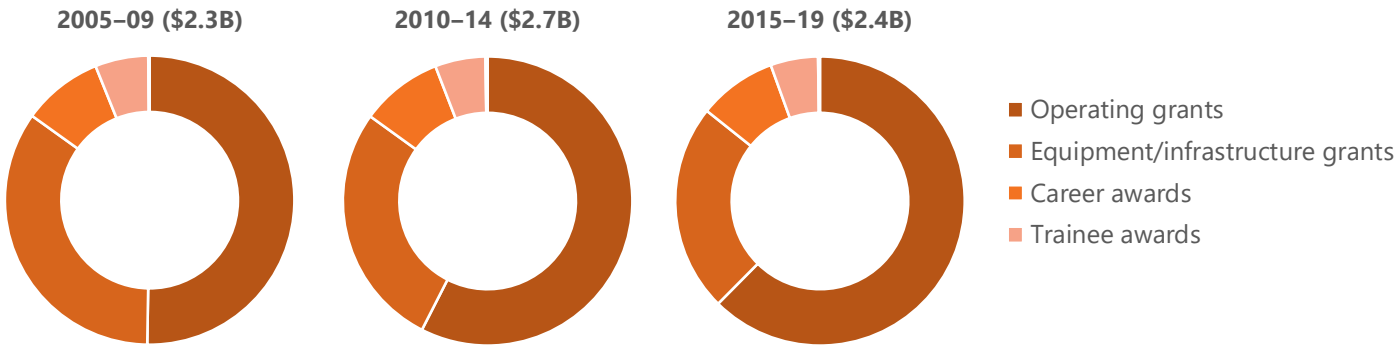
Over time, Canada lost ground in terms of its cancer research investment when compared with the U.K. and the U.S.

The fluctuating investment in major infrastructure drove peaks and valleys in the overall investment trend. Cancer researchers, however, retained their competitiveness.

The distribution of the investment in direct (operating grant) support shifted from fundamental cancer biology to early translational research. Targeted investments assumed a larger role.

Research to inform the cancer system and the priorities of the Canadian Strategy for Cancer Control is important for ongoing monitoring and to facilitate research uptake.

Support for trainees, especially those doing post-doctoral training, is needed. Ensuring that the next generation of cancer researchers reflects the broader society is vital for a robust research system.



1 INTRODUCTION

Investing in Research

Research remains a strong priority and a beacon of hope for people affected by cancer. Nearly half of Canadians are expected to receive a diagnosis of cancer in their lifetime and cancer remains the leading cause of death among Canadians (Brenner et al., 2020). Cancer is financially burdensome for both the people affected (Longo et al., 2021) and the health care system (de Oliveira et al., 2018). More recent analysis of Canada's cancer surveillance data demonstrates declining cancer rates because of prevention, screening, early diagnosis, and treatment advances, but substantial reductions in the impact of cancer will require ongoing investment in innovative research as well as the implementation of effective healthy public policies (Brenner et al., 2022). Tracking and reporting on Canada's cancer research investment provides indispensable insights on how the funding of cancer research has changed and where new investments and partnerships may be needed. It is an important source of information for decision makers, people affected by cancer, advocacy groups, and the broader public.

The Canadian Cancer Research Alliance

The Canadian Cancer Research Alliance (CCRA) is an alliance of organizations that collectively fund most of the cancer research conducted in Canada. Members include federal research funding programs/agencies, provincial research agencies, provincial cancer care agencies, cancer charities, and other voluntary associations. Member are motivated by the belief that, through effective collaboration, Canadian cancer research funding organizations can maximize their collective impact on cancer control and accelerate discovery for the ultimate benefit of Canadians affected by cancer.

The Executive Office is supported by the Canadian Partnership Against Cancer, funded by Health Canada to work with Canada's cancer community to implement the Canadian Strategy for Cancer to ensure people in Canada have equitable access to quality cancer care, fewer people in Canada develop cancer, more people in Canada survive cancer and people in Canada affected by cancer have a better quality of life. The Partnership is committed to supporting a sustainable cancer research system in Canada through its support of the CCRA and the CCRA's role in coordinating the cancer research funding system. As a member and funder of the CCRA, the Partnership collaborates with other member organizations in alignment with Canada's Vision for Cancer Research.

The Canadian Cancer Research Survey

In the earliest days of the CCRA, it was recognized that there was a need to systematically quantify and qualify the cancer research investment in Canada to enable more informed strategic planning and help to reduce duplication of effort and leverage key investments, and so, the Canadian Cancer Research Survey (CCRS) was initiated. The CCRS tracks the research investment in peer-reviewed research by over 40 of Canada's cancer research funding organizations/programs and is estimated to capture between 60 to 80% of the existing research investment.

At present, Canada is only one of two countries that routinely tracks and reports on research commitments for a broad swath of cancer research funders and the CCRS is recognized for the quality of its value-added coding and use of novel approaches to reporting. Data from the CCRS is contributed to the International Cancer Research Partnership, of which the CCRA is a long-standing member.

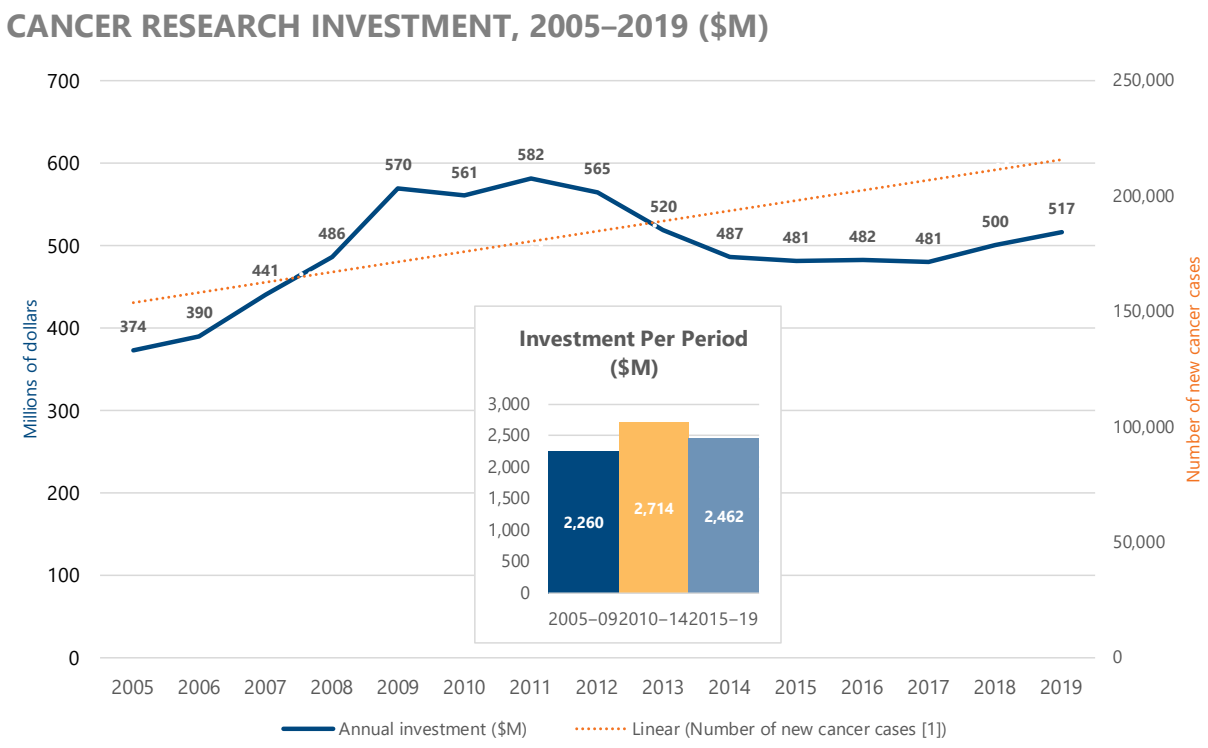
Overview

This report highlights trends in cancer research funding from 2005 to 2019. It supplements routine and special topics reporting available on the CCRA's website.[1] The proceeding chapters focus on specific types of research funding mechanisms and identify specific "calls to action" for the CCRA. Before delving deeply into the various aspects of cancer research funding in Canada, an overview of the investment is presented.

Overall Investment Trend

Canada's investment in cancer research—from all funders and funding programs tracked in the CCRS—is shown in Figure 1. It reveals dramatic growth from 2005 to 2009, a decline that started in 2011, and a smaller uptick since 2017. The inset graph shows the investment for the three five-year periods. Grouping the fifteen years into three equal periods is an easy way to identify trends in the data, especially when more variables of interest are presented. In contrast, the number of new cancer cases had a linear, upward trend.

FIGURE 1



[1] Linear trend of estimated number of new cancer cases. Data based on figures reported by Statistics Canada (years 2005 to 2010) and in the Canadian Cancer Statistics (years 2011 to 2019).

While the pattern of the cancer research investment is dissected in the forthcoming chapters, it is worth highlighting that the growth in the earliest years was fuelled by investments made through large-scale infrastructure programs and the ramp up of the Ontario Institute for Cancer Research (OICR), reflecting Ontario's major commitment to cancer research.

[1]See https://www.ccra-acrc.ca/reports/ and https://www.ccra-acrc.ca/tools/.

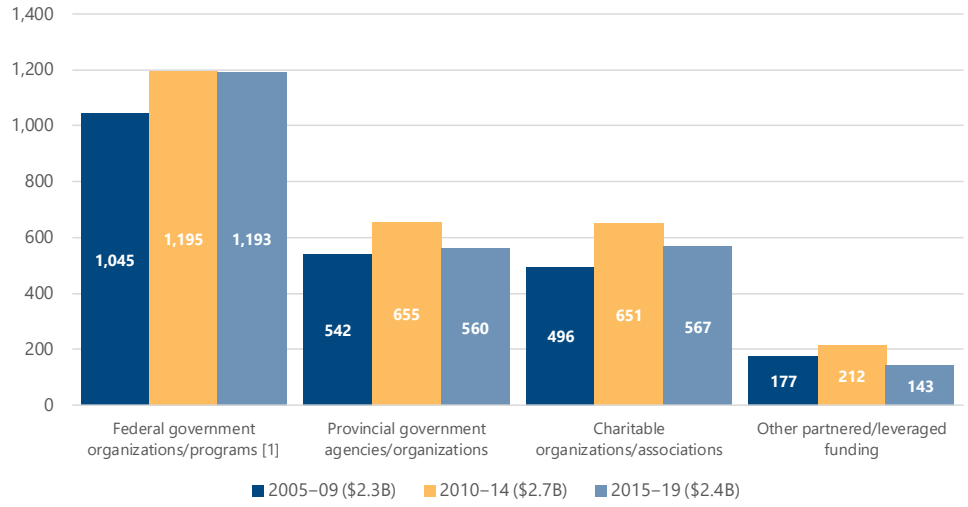
Research Funders

Cancer research is funded by various federal government agencies, provincial government agencies, charitable and non-profit organizations, as well as academic institutions and for-profit entities. The funding organizations tracked in the CCRS fall into the first three groups and the other groups that partner on specific research projects are captured in the "Other partnered/leveraged funding" category.

Like the trend in the inset graph in Figure 1 above, the contraction in the cancer research investment from the second to the third five-year period was due to reductions in research funding in all but the federal government sector (Figure 2). While federal research support is a key pillar, a robust research environment depends on the support of all sectors. Partnerships and complementary funding streams help maintain and build critical infrastructure and researcher capacity.

FIGURE 2

INVESTMENT BY FUNDING SECTOR, THREE PERIODS ($M)



[1] This figure does not include estimates of the federal Research Support Fund.

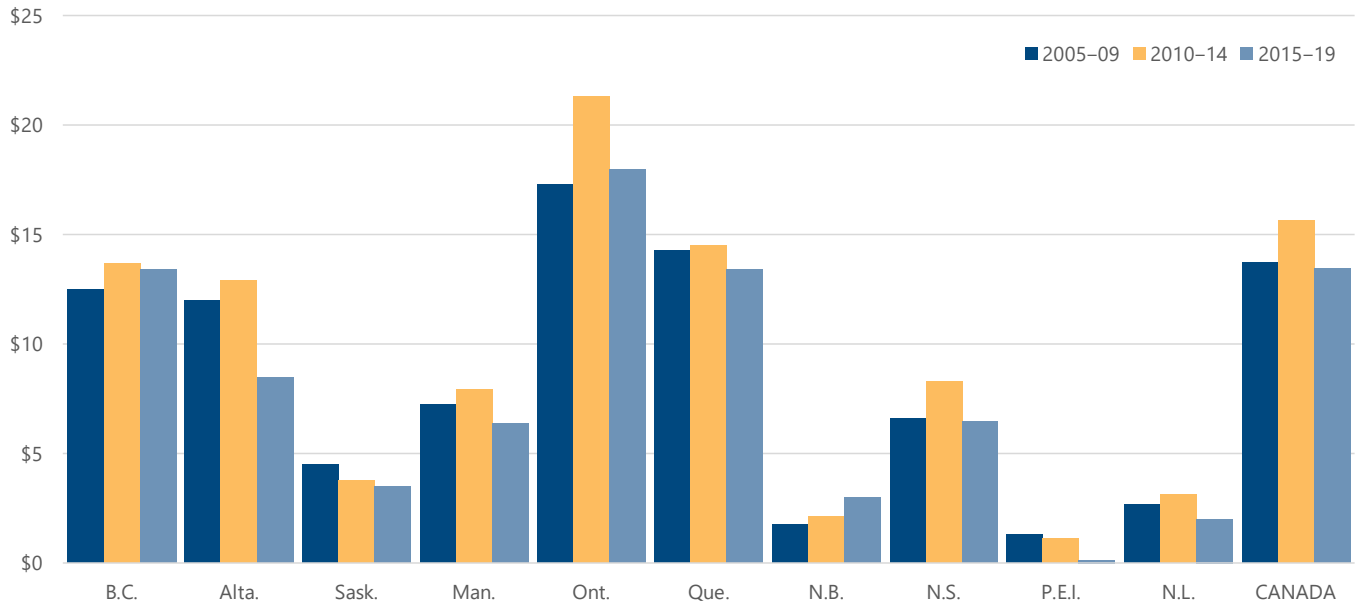
Where Cancer Research is Being Done

Research funding is typically flowed to the institution (most often an academic centre) where the principal researcher, known as the "nominated principal investigator," works. In Figure 3, the investment is shown by the province of the institutional affiliation of the nominated principal investigator. The investment figures were adjusted by the provincial populations ("data normalization") and this helps to compare relative funding when population sizes are different. Each bar in the graph represents the cancer research investment on a per person basis for that specific province during the five-year periods.

For most provinces, the highest investments were found in the 2010-14 period, resembling the overall trend found in Figure 1. Of note, Saskatchewan and Prince Edward Island showed a declining trend over the three periods, while New Brunswick showed an increasing trend, highlighting the province's capacity building efforts in cancer research since 2008.

FIGURE 3

PER CAPITA CANCER RESEARCH INVESTMENT BY PROVINCE OF NOMINATED PRINCIPAL INVESTIGATOR, THREE PERIODS ($) [1,2]



[1] Excludes trainee awardees studying outside Canada.
[2] Provincial population figures from Statistics Canada, Table 17-10-0005-01 - Population estimates on July 1st, by age and sex (accessed 2021-06-19)

Research Investment on Specific Cancers

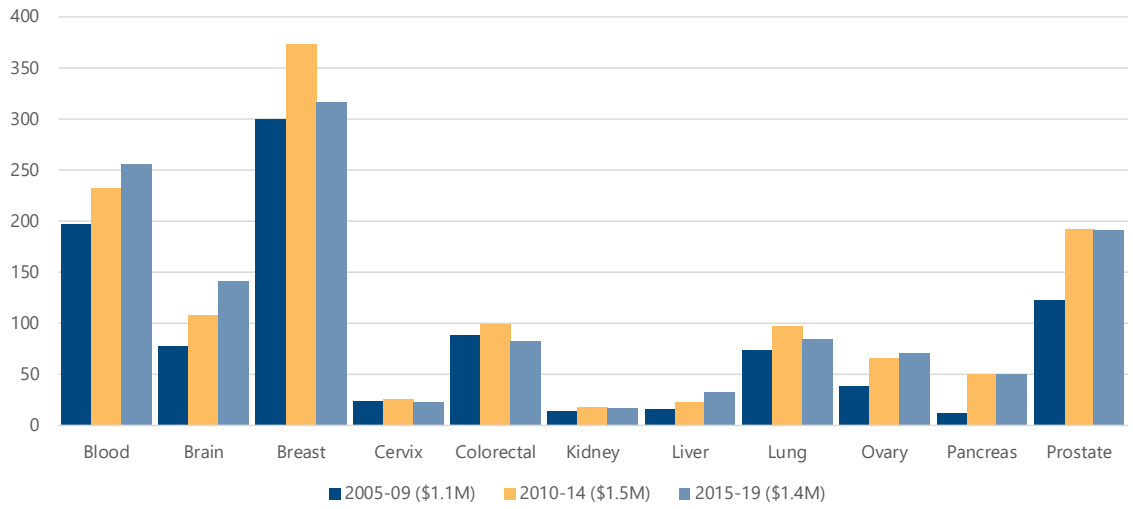
Not all cancer research is focused on specific cancers. Fundamental science may explore basic biological mechanisms that have relevance to all cancers and likewise research designed to develop and test programs and other supports for people with cancer and their families may not be site-specific. Nearly half of the research investment in the fifteen years was not specific to a given cancer, but applicable to cancers broadly.

In Figure 4, the cancer research investment that was relevant to selected cancer sites[2] is presented. While breast, colorectal and lung had the largest investments in the 2010-14 period—consistent with the overall research investment trend—investments in pancreas and prostate cancer research grew substantially from the first to the second period while research investments grew for each successive period for blood, brain, liver, and ovarian cancers.

[2]For further details on the research investment for all 24 cancer sites captured in the CCRS, please consult the supplementary data (Excel file) found at https://www.ccra-acrc.ca/reports/. An analysis of the investment relative to the cancer burden is provided for selected cancer sites. In addition, a data visualization tool on childhood and adolescent cancers is available at https://www.ccra-acrc.ca/tools/childhood-and-adolescent-cancers-visualization/ and one on metastatic breast cancer is available at https://www.ccra-acrc.ca/tools/metastatic-breast-cancer-research-visualization/.

FIGURE 4

CANCER RESEARCH INVESTMENT BY CANCER SITE [1], THREE PERIODS ($M)



[1] Selected sites. Blood cancers includes Hodgkin lymphoma, Leukemias, Multiple myeloma, and Non-Hodgkin lymphoma. There are 24 site groupings used in the CCRS.

This Report

Contextualizing the Data - Organizational Changes

There have been changes among the organizations funding cancer research and these have played a role in shaping the research investment. In terms of provincial research funding:

- The ramp up of operations of the Ontario Institute for Cancer Research (OICR), founded in 2005, has helped to drive the translational research agenda and built significant research capacity in Ontario.
- The New Brunswick Health Research Foundation was initiated in 2008, providing support to build capacity in the province.
- The Beatrice Hunter Cancer Research Institute was created in 2009 and works with funding partners across Atlantic Canada to support trainees and researchers.
- Provincial governments in Alberta, Manitoba and Nova Scotia have merged their research funding administration and oversight into single organizations (Alberta Innovates, Research Manitoba, and Research Nova Scotia, respectively) and these organizations cover the full spectrum of their provinces' research activities.
- Quebec is in the process of a multi-year, major re-structuring of its cancer research entities that will improve coordination, facilitate greater collaboration, and optimize research spending.
- The Michael Smith Foundation for Health Research and the BC Academic Health Science Network joined forces in late 2021 to create an integrated health research organization now known as Michael Smith Health Research BC to support BC's research and life sciences sectors.

There have also been changes in the charitable sector.

- The Canadian Breast Cancer Foundation and Prostate Cancer Canada, both significant site-specific research funding organizations, merged operations with the Canadian Cancer Society (CCS) and have enriched the funding profile of this major national charity.

- Charities have increasingly looked at partnerships with others to leverage their investments, with the Cancer Research Society (CRS) leading the way on this front and enabling smaller-sized charities to fund mandate-aligned research.
- Several smaller-sized charities have significantly increased their research investments and have made significant strategic shifts in their research funding priorities.

Data Caveats

While the CCRS is a unique and valued resource, there are several methodological conventions and caveats to consider:

- Investment figures are shown in CAD unless otherwise noted. Figures are not adjusted for inflation.
- This database contains funded research and not research applications.
- Projects included are those that involve some form of peer review.
- Project-level research funding from the institution-specific foundations (e.g., hospital foundations), federal and provincial government programs for which health research is only a small component of their funding, and industry (i.e., industry-sponsored R&D) are not included, although it should be noted that a portion of this investment is reflected under partnered/leveraged funding, where the investment and partner has been specified by a data contributor. Of note, substantial increases in hospital foundation revenues for many large institutions have occurred during the fifteen years covered in this report. Industry funding of clinical trials is a major omission.
- Research funded by organizations outside Canada is not within the scope of the survey. It is recognized that researchers in Canada do receive operating grants, trainee support, and infrastructure support from organizations in the U.S. and elsewhere and that this support can be substantial for some research projects.
- Provincial breakdowns are based on institutional affiliation of the nominated principal investigator (PI). This is less than ideal and may not reflect how grant monies are distributed across multiple PIs working from institutions in different provinces.
- Coding (area of science, cancer site, etc.) is based on the quality of the descriptive information provided for a research project. In some cases, this information is comprehensive; in other cases, it is very limited. In cases where the information provided in the original submission is limited, coding may be modified if new information about the project becomes available.
- Coding is based on the research proposal—changes in direction, funding, timelines, and project leadership are not captured.
- Real-time reporting is challenged by the time taken to receive, collate, code, and de-duplicate the data from all organizations tracked. Substantial effort is deployed to disambiguate information related to research personnel.

Diving Deeper

The analyses presented in the subsequent chapters provide more detail and in some cases third-party data are used to illuminate key findings. Presented are:

- cancer research investment from a global perspective, where Canada's cancer research investment is compared with those made in the United States and the United Kingdom

- the investment in infrastructure – both major infrastructure and support provided to individual researchers/laboratories
- direct (operating grant) support to cancer researchers and the role of targeted research investments
- investments in research designed to help to inform Canada's cancer system
- investment in cancer researchers through research chairs and other funding supports

These analyses suggest calls to action for members of the CCRA, and these are summarized in Table 1 below. In the final chapter of this report, the major events since 2019 that have and will continue to shape the cancer research landscape going forward are discussed.

TABLE 1

CCRA CALLS TO ACTION

Action area	The CCRA needs to…
Canada's cancer research investment from a global perspective	work to increase cancer research investment across the research spectrum to close the gap with our global comparators
Infrastructure supporting cancer research in Canada	ensure that infrastructure support is provided to researchers starting their independent careers, and develop viable recommendations/ strategies to sustain critical platforms beyond their development/establishment phase
Direct (operating grant) support to cancer research in Canada	continue to monitor the investment trend in operating grants in cancer biology to ensure that the cancer research ecosystem is not jeopardized
Investment in cancer research designed to inform Canada's cancer system	identify where strategic funding needs to be deployed to address the urgent needs of the cancer control system and ensure research is a key enabler to impactful system change
Canada's investment in cancer researchers	develop initiatives to build a diverse cancer researcher workforce and look at ways to improve supports offered to trainees, particularly, postdoctoral fellows

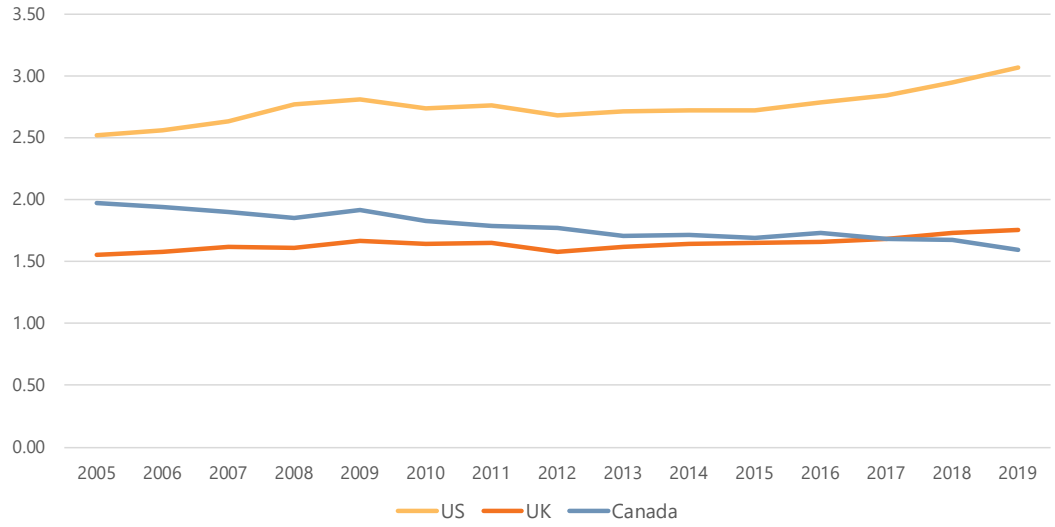
2 CANADA'S CANCER RESEARCH INVESTMENT FROM A GLOBAL PERSPECTIVE

The CCRA needs to work to increase cancer research investment across the research spectrum to close the gap with our global comparators.

As reported by the Organization for Economic Co-operation and Development (OECD), Canada's annual research and development investments have been on a downward trajectory since 2005 (Figure 5). Applying this same methodology and using proxies for the cancer research investment in two comparator countries—the United States and the United Kingdom—Canada's investment in cancer research ramped up to 2011 and then started a decline that found Canada, a leader in 2009 (Canada's cancer research investment represented 1.89% of the total R&D investment in 2009), at levels well below our comparator countries (Figure 6). Although there are limitations to these analyses, they do suggest that there is a need for Canada to address its diminishing research investments.

FIGURE 5

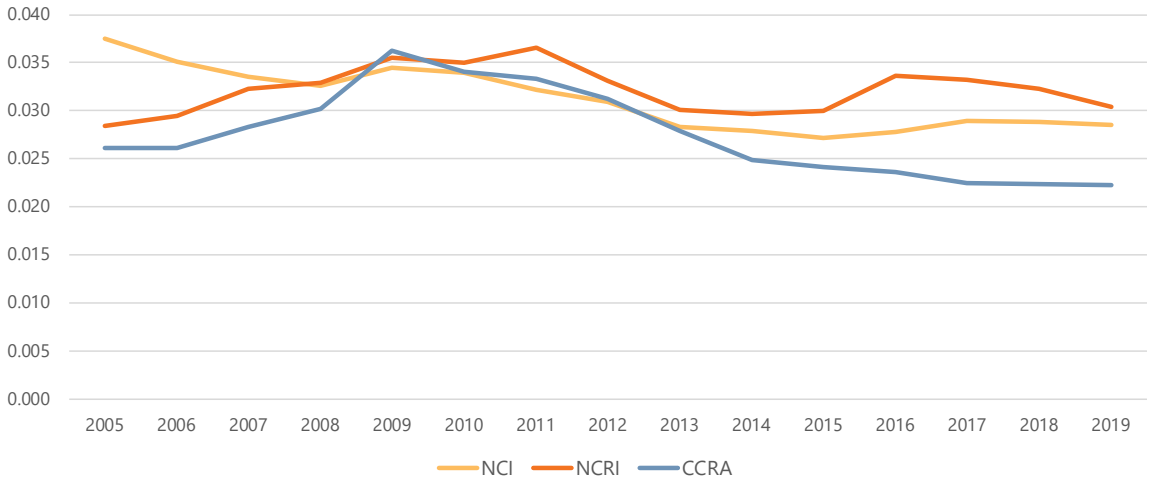
RESEARCH SPEND AS % OF GDP [1]



[1] OECD (2021), Gross domestic spending on R&D (indicator). Available at: https://doi.org.10.1787/d8b068b4-en (accessed on 05 November 2021)

FIGURE 6

CANCER RESEARCH SPEND AS % OF GDP [1,2,3,4]



[1] National Cancer Institute (NCI) data used as a proxy for cancer research spend in the United States. Data are from: https://www.nih.gov/about-nih/what-we-do/nih-almanac/appropriations-section-1

[2] National Cancer Research Institute (NCRI) data used as a proxy for cancer research spend in the United Kingdom. Data are from: https://www.ncri.org.uk/how-we-work/cancer-research-database/

[3] CCRA data (from the CCRS) used as a proxy for cancer research spend in Canada.

[4] Data were converted to USD constant prices using 2015 base year and Purchasing Power Parities (PPPs) and as percentage of GDP as per the research spend per GDP calculated by the OECD.

On the positive side, while larger countries may have a comparative advantage when it comes to research investment (i.e., more money, more researchers), Canada's output in terms of academic publications within the cancer sphere is among the global leaders across a range of research areas (Table 2). In some areas, like oncolytic virus research, Canada has been a leading contributor to the published literature (Mozaffair Nejard et al., 2021).

TABLE 2.

REPRESENTATION BY COUNTRY OF ORIGIN FOR CANCER-RELATED ACADEMIC PUBLICATIONS

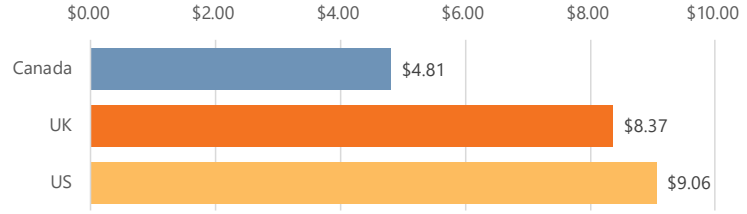
Topic of Academic Publication	Timeframe	Metric [1]	Canada	US	UK	Reference
Breast cancer prediction using machine learning	2005-2019	Percent of articles	6	27	7	Salod & Singh (2020)
Cardio-oncology	1970–2019	Percent of articles	7	44	3	Wei et al. (2020)
Cervical cancer radiotherapy	1964-2019	Percent of top cited papers	8	38	7	Zhao et al. (2020)
Drosophila cancer research	1968-2019	Percent of articles	5	52	12	Kamdem et al. (2020)
Oncolytic virus research for cancer therapy	2000-2020	Percent of articles	9	38	6	Mozaffair Nejad et al. (2021)
Pan-cancer studies on breast cancer	2006-2020	Percent of articles	9	48	10	Zhang et al. (2021)
Patient-derived xenograft (PDX) cancer research	1968-2019	Percent of articles	8	60	8	Kamdem et al. (2020)
Prostate cancer brachytherapy	1999-2018	Percent of articles	10	61	8	Tang et al. (2020)
Radiotherapy/chemoradiotherapy for cervical cancer	1990–2020	Percent of top cited papers	13	47	13	Wang et al. (2021)
RCTs of colorectal cancer	2008-2018	Percent of articles	7	33	11	Wang et al. (2020)

[1] Data are not adjusted by research investment or other normalization factors.

Notwithstanding the limitations of measuring outputs solely in terms of bibliometrics (a major caveat that has been well documented—see Braithwaite et al., 2019 and sidebar), we normalized outputs via research investment using data on the number of cancer publications by country (as reported by Cabral, da Graça Derengowski Fonseca and Mota in 2018 and used as the numerators) and cancer research investment estimates as shown above for years 2012-2017 (denominators). An estimated publication cost per USD100,000 research investment was computed. These data suggests that Canada gets more 'bang for its buck'—spending much less to generate a publication than its comparator countries (Figure 7).

FIGURE 7

COST (USD) PER CANCER PUBLICATION BY COUNTRY, 2012–2017 [1,2]



[1] Publication totals from: Cabral BP, da Graça Derengowski Fonseca M, Mota FB. The recent landscape of cancer research worldwide: a bibliometric and network analysis. Oncotarget. 2018 Jul 17;9(55):30474-84. https://doi.org/10.18632/oncotarget.25730

[2] Normalized data based on calculations used in Figure 2. Cost per USD100,000 investment in cancer research.

IMPACTS OF CANCER RESEARCH

Canada has been a global leader in advancing the knowledge base on research impact assessment since the seminal work led by Dr. Cyril Frank under the auspices of the Canadian Academy of Health Sciences was completed in 2009 (see https://cahs-acss.ca/wp-content/uploads/2011/09/ROI_FullReport.pdf).

For a further delve into research impact assessment specific to cancer research, please see the recent systematic review: Hanna CR, Boyd KA, Jones RJ. Evaluating cancer research impact: lessons and examples from existing reviews on approaches to research impact assessment. Health Res Policy Syst. 2021 Mar 11;19(1):36. https://doi.org/10.1186/s12961-020-00658-x

Another article focused on translational cancer research identified relevant indicators using a modified Delphi technique with a group of participants from the EurocanPlatform network, a consortium of cancer centres and cancer research institutions in Europe. See: Thonon F et al. Identifying potential indicators to measure the outcome of translational cancer research: a mixed methods approach. Health Res Policy Syst. 2015 Dec 3;13:72. https://doi.org/10.1186/s12961-015-0060-5

3 INFRASTRUCTURE SUPPORTING CANCER RESEARCH IN CANADA

The CCRA needs to ensure that infrastructure support is provided to researchers starting their independent careers and develop viable recommendations/strategies to sustain critical platforms beyond their development/establishment phase.

The investment in research infrastructure (which ranges from building, renovating and equipping research facilities to acquiring new research equipment, technologies, and services and supporting major research networks) was a large component of the overall fifteen-year investment in cancer research. "Research infrastructure is the underpinning foundation of a project-driven research system and requires long-term, sustained funding and capital investment to maintain scientific and technological expertise" (Zakaria, Grant & Luff, 2021). In this chapter, the $2.1 billion investment in infrastructure supporting cancer research from 2005 to 2019 is examined in greater detail.

The Canada Foundation for Innovation (CFI) is a not-for-profit corporation created by the federal government in 1997 to build Canada's capacity to undertake world-class research and technology development. It is the primary federal funder for large-scale research infrastructure. CFI funds both facilities and equipment at eligible higher-education institutions within the framework of its agreements with Innovation, Science and Economic Development Canada. In general, the CFI funds up to 40% of a research infrastructure project's cost with institutions securing the remaining 60% in partnership with provincial governments (in general up to 40%) and other public, private, and non-profit organizations. CFI dispersed approximately $360M per year between fiscal periods 2014-15 and 2018-19.

From: Innovation, Science and Economic Development Canada. *Evaluation of Innovation, Science and Economic Development Canada's (ISED) Contribution to the Canada Foundation for Innovation.* (2021) https://www.ic.gc.ca/eic/site/ae-ve.nsf/eng/h_03928.html (accessed September 21, 2021)

In the initial five-year period (2005-2009), there were substantial investments through the Canada Foundation for Innovation (CFI) in terms of major facility investments as well as grants awarded to individual researchers/laboratories working in cancer-related areas (Figure 8 – orange lines). As expected, we see an fluctuating pattern to major facility investments (building, upgrading, and equipping of new research facilities) as they are needs-driven and ensure that leading-edge research can be conducted. As these investments involve large sums of money, they drive the overall investment trend.

The investments through the federal government's Networks of Centres of Excellence (NCE) program (dark blue line in Figure 8) included significant support for centres supporting/enabling cancer research and played an important role over this fifteen-year period. Although the NCE program has concluded, the decision to extend support to key networks for the next few years, specifically, BioCanRx, Canada's immunotherapy network, two of the Centres of Excellence for Commercialization and Research—the Centre for Probe Development and Commercialization (CPDC) and the Institute for Research in Immunology and Cancer (IRIC)/CECR in Therapeutics Discovery (IRICoR)— and Exactis, one of the business-led networks, will continue to yield important gains for cancer research and Canada's commercialization efforts in terms of new cancer therapies and imaging technologies.

Likewise, the "Other" category (gray line in Figure 8) shows a 'ramp up' or building of research platforms supported through other funding mechanisms (identified in greater detail in Figure 9), which also transitioned

to a maintenance phase over the fifteen-year span. This chart calls out several specific investments that involved multiple CCRA member organizations and other supporters:

- CanPath (Canadian Partnership for Tomorrow's Health), is a federated population cohort involving more than 330,000 Canadians. It was initiated as part of the research investment made at the inception of the Canadian Partnership Against Cancer in conjunction with regional partners. It has and will continue to serve as an important resource for etiological-based research in the coming decades. Recently, the cohort was leveraged to support national COVID-19 research.
- 3CTN (Canadian Cancer Clinical Trials Network) initiated under the auspices of a call to action from the CCRA, is funded by the Partnership, regional partners, and through industry partnerships, and works to improve recruitment and the efficiency and quality of maintained portfolio of academic cancer clinical trials in Canada. 3CTN spearheaded the development and launch of CRAFT (Canadian Remote Access Framework for Clinical Trials) and is supporting adoption by member cancer centres with a shared goal of providing equitable access to clinical trials for all people in Canada, regardless of their location. The CRAFT framework proposes a remote/rural trial delivery model where site investigators for a given trial delegate responsibilities to satellite health centres and the centres operate as a hub-and-spoke "trial cluster" (Sundquist et al., 2021).
- CTRNet (Canadian Tissue Repository Network), currently supported by the Canadian Institutes of Health Research (CIHR), The Terry Fox Research Institute (TFRI), and Fonds de recherche du Québec - Santé (FRQS), has developed important and international recognized standard operating procedures for biobanks and provides quality assurance through its certification and education program as well as through ATiM (www.atim-software.ca), a custom biobanking software solution.
- ICGC (International Cancer Genome Consortium), launched in 2008, has provided a forum for collaboration among cancer and genomic researchers across the globe and enabled coordination of large-scale cancer genome studies in tumours from several cancer types and subtypes. In 2014, the Cancer Genome Collaboratory, an academic cloud computing resource operating from OICR, was initiated to facilitate analysis of the ICGC data sets.

FIGURE 8

INFRASTRUCTURE INVESTMENT BY FUNDING SECTOR, 2005–2019 ($M)

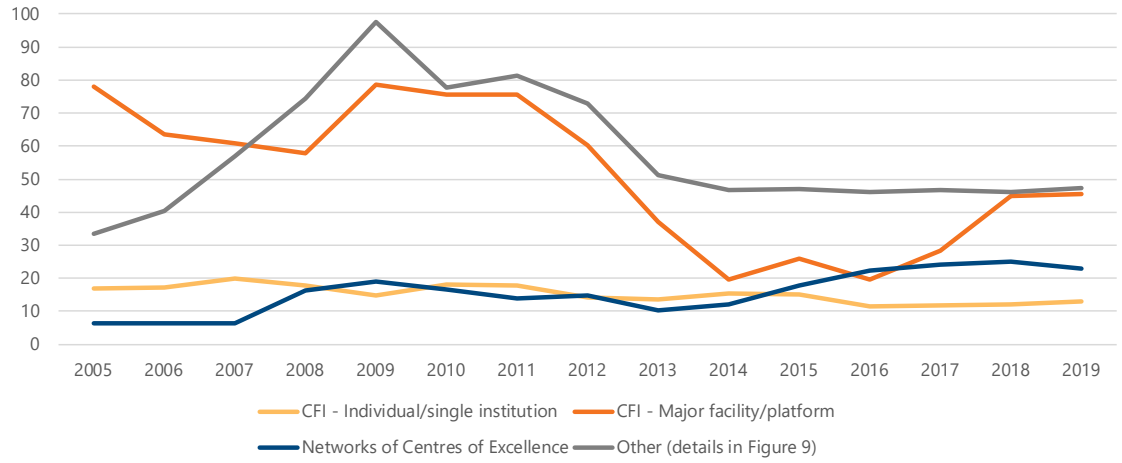
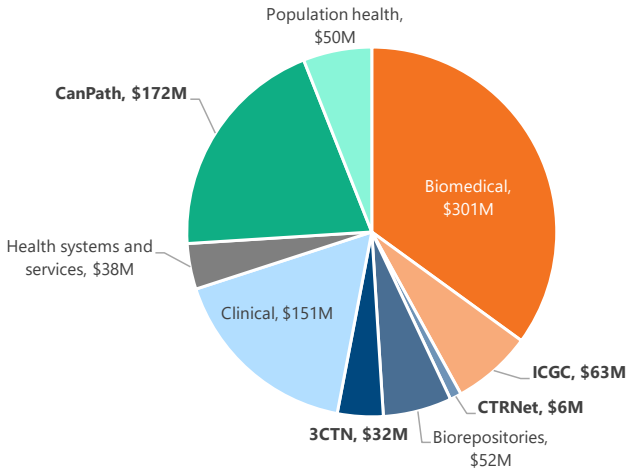


FIGURE 9

DISTRIBUTION OF FIFTEEN-YEAR INVESTMENT IN OTHER [1] INFRASTRUCTURE ($866M)

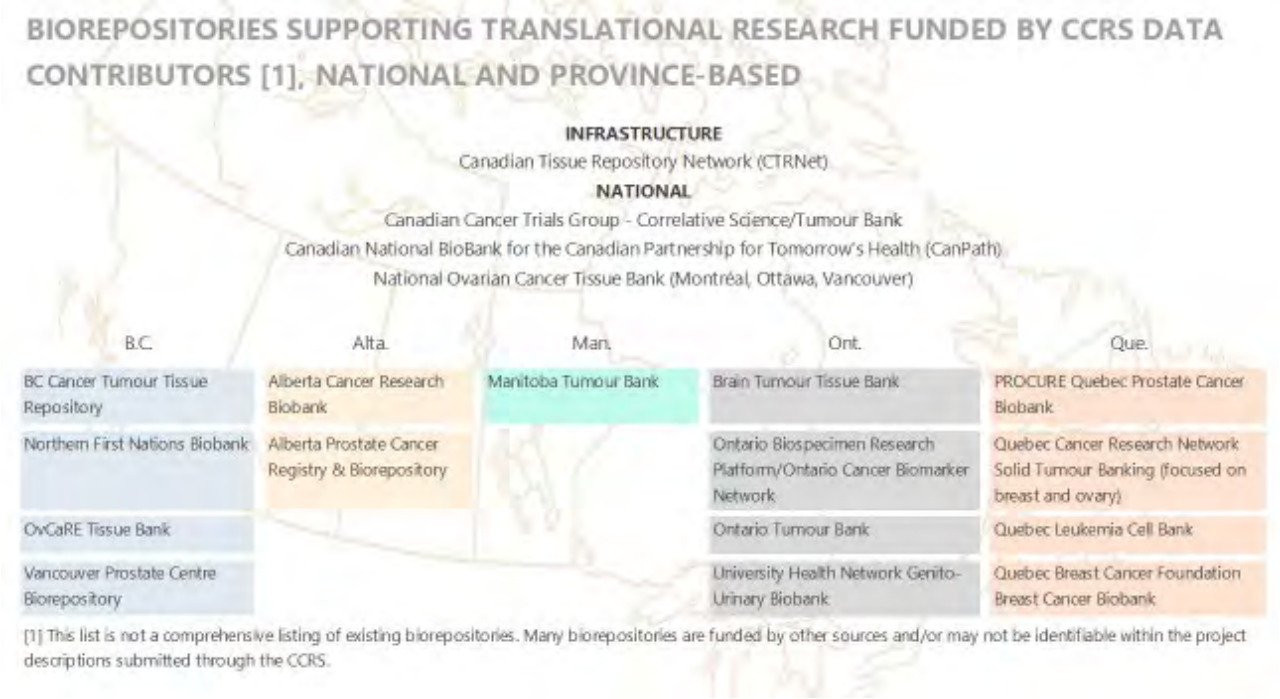


[1] Includes infrastructure not funded through CFI or the NCE programs. Specific infrastructure investments are bolded. Other equipment/infrastructure grants are grouped by major pillar of research supported.

Biorepositories

Biorepositories are essential for cancer research: "…the provision to investigators of high-quality human tissues by biobanks/bioresources has been critical to advancing biomedical research and science as well as improving medical care, especially of patients with cancer" (Al Diffalha et al., 2019). Although support for biorepositories is not often in the form of peer-reviewed grants, there is some data in the CCRS on biobanks supported in this way (Figure 10). In Canada, however, there has not been robust, coordinated core support for biorepositories or for the mechanisms needed to facilitate quality assurance and researcher access. Since 2004, the Canadian Tissue Repository Network (CTRNet) has created critically needed biobanking process standards and biobanking data standards and yet has struggled to garner broad, sustained financial support from those in the research funding community.

FIGURE 10



There is increasing attention in the literature on how output metrics may be developed and used to help convince stakeholders of the value of biobanks and, in turn, ensure their sustainability (see Rush et al., 2020; van der Stijl, Manders & Eijdems, 2021). It cannot be denied that biorepositories are critical components of the cancer research infrastructure and warrant sustained and increased investment to best meet the needs of precision medicine and precision population health.

Infrastructure Support for Individual Researchers

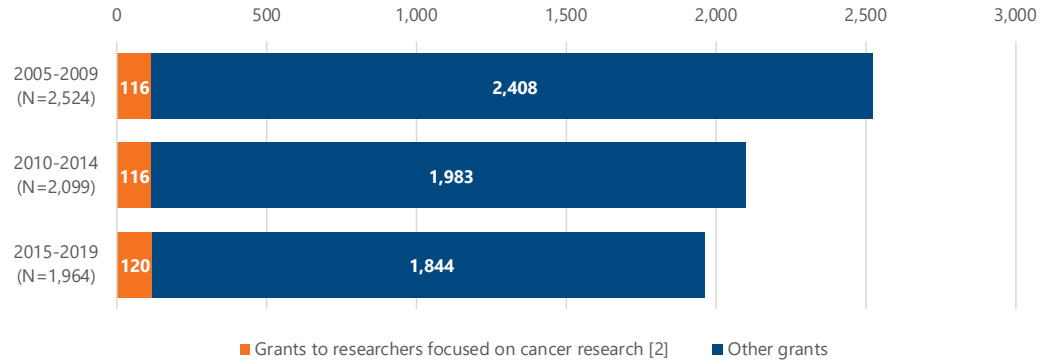
Beyond the major platform investments, CFI also supports individual investigators/laboratories. Figure 11 looks at how many of these individual-level CFI grants went to cancer researchers. Unlike the previous graphs, this figure shows counts and uses time periods based on the years that CFI decisions were made. While there was a significant drop in the number of individual-level CFI grants in each successive period, the number of grants going to cancer researchers held steady. The Federal government has made new commitments to both the CFI[3] and CRC[4] programs that will hopefully yield even greater positive change for cancer researchers.

[3]In its 2018 budget, the Federal government responded to the recommendations of the Fundamental Science Review with an investment of $763M to CFI and a commitment to establish permanent funding at an ongoing level of $462M per year by 2023-24. See https://www.innovation.ca/sites/default/files/2021-09/CFI-Annual-report-2017-2018.pdf.

[4]In 2021, the Federal government announced 156 new or renewed CRCs. See https://www.canada.ca/en/innovation-science-economic-development/news/2021/06/government-of-canada-makes-major-investment-in-canadian-science-research-and-engineering.html.

FIGURE 11

INDIVIDUAL/SINGLE INSTITUTION CFI GRANTS BY PERIOD [1], NUMBER



[1] Year of CFI final grant decision dates were grouped into five-year periods.
[2] Includes grants to researchers focused on cancer research.

4 DIRECT SUPPORT TO CANCER RESEARCHERS IN CANADA

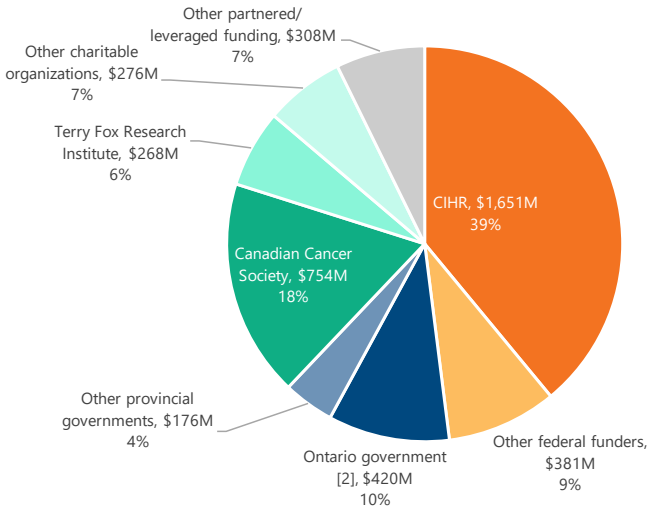
The CCRA needs to continue to monitor the investment trend in operating grants in cancer biology to ensure that the cancer research ecosystem is not jeopardized.

Operating grants support all the direct costs involved in conducting research projects including salaries for laboratory staff and research assistants, costs of supplies, samples, and other needed items. They are the lifeblood of academic research.

From 2005 to 2019, $4.2B was invested in operating grants, with about $300M invested annually since 2011. The distribution of this fifteen-year investment (Figure 12) shows that CIHR represented 39% of all the operating grants for cancer research over the fifteen-year span—a total of nearly $1.7B. Of note, the CIHR investment rose to 46% of the total cancer-related operating grant investment in 2019.

FIGURE 12

DISTRIBUTION OF OPERATING GRANTS BY SELECTED FUNDERS [1], FIFTEEN-YEAR TOTAL (%)



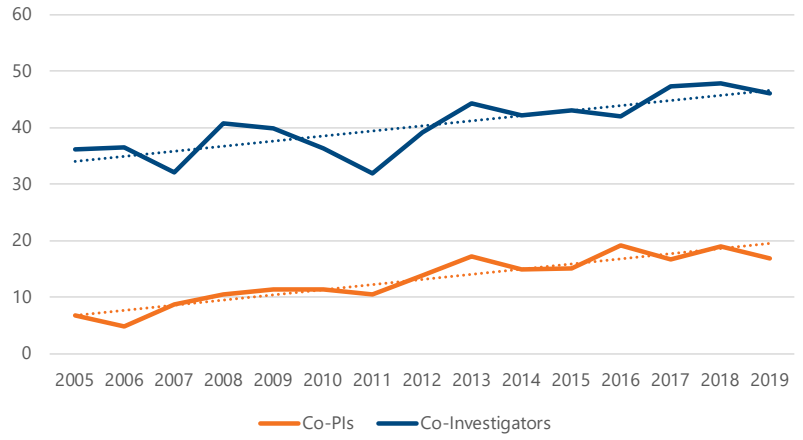
[1] Only organizations that represented 5% or more of the 15-year investment are listed by name. A full list of the investments made by organizations tracked in the CCRS is available on the CCRA website in a supplementary Excel file found at: https://www.ccra-acrc.ca/reports/

[2] Ontario government investment includes investments made by the Ontario Institute for Cancer Research, Ontario Ministry of Economic Development, Job Creation and Trade, Ontario Health (including Cancer Care Ontario), and Ontario Genomics.

In addition, there was an increasing proportion of operating grants with co-principal investigators (co-PIs) and co-investigators on their research teams over the fifteen-year period (Figure 13). The TFRI has been a leader in Canada in facilitating multi-investigator team grants.

FIGURE 13

CANCER-RELEVANT OPERATING GRANTS WITH CO-PRINCIPAL INVESTIGATORS AND CO-INVESTIGATORS BY START YEAR (%)



Areas of Science

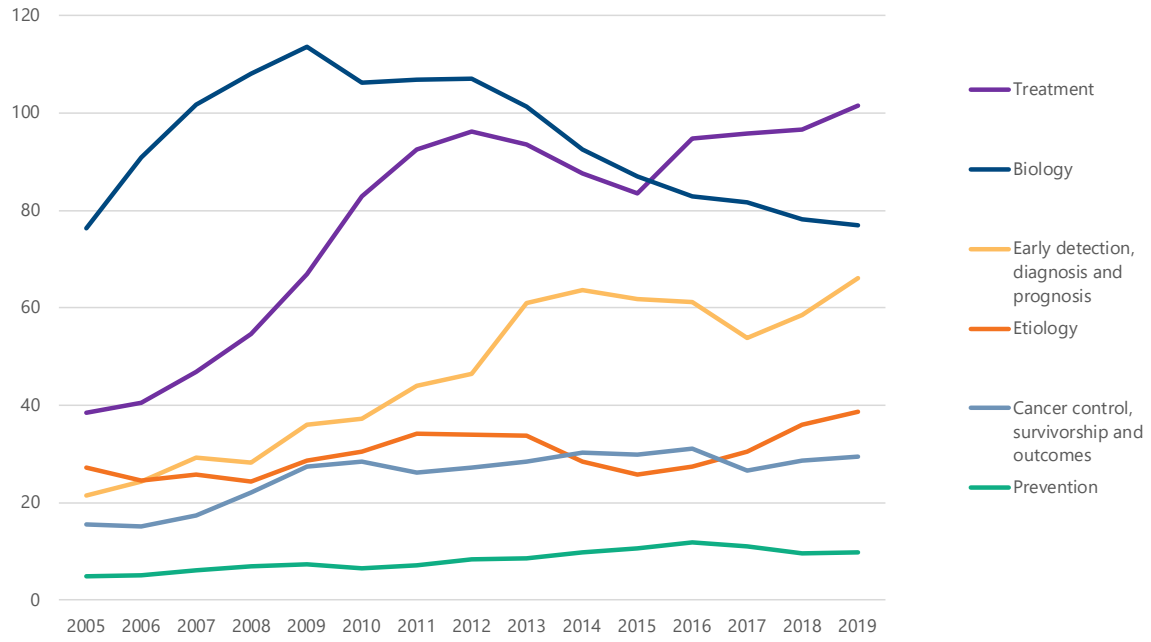
Understanding how the investment has changed in terms of areas of cancer science is a valued component of the CCRS. The Common Scientific Outline (CSO), an international framework used to classify cancer research, is a useful shorthand for understanding how the investment in cancer research has changed over time. The CSO is comprised of 34 codes included under six categories: 1) Biology, 2) Etiology, 3) Prevention,[5] 4) Early detection, diagnosis and prognosis, 5) Treatment, and 6) Cancer control, survivorship and outcomes (see sidebar, next page).

The investment in cancer-related operating grants by CSO category varied across the fifteen years (Figure 14). Most notably, the investment in cancer biology grew from 2005 to 2009, then had a sharp decline (dark blue), while the investment in the other CSO categories increased in recent years when compared with the initial years surveyed, especially in the Treatment (purple) and Early detection, diagnosis and prognosis categories (light orange).

[5]Of note, the Prevention CSO is focused on prevention interventions. For a fuller perspective, please refer to our report and interactive visualization on the investment in cancer risk and prevention research for the 2005 to 2019 period, which is available on the CCRA website at https://www.ccra-acrc.ca/wp-content/uploads/2021/11/Prev_2019_EN.pdf and https://www.ccra-acrc.ca/tools/cancer-risk-and-prevention-visualization/, respectively. This broader analysis includes etiological research and research on behavioural determinants.

FIGURE 14

INVESTMENT IN OPERATING GRANTS BY CSO CATEGORY, 2005-2019 ($M)



SIX CATEGORIES OF THE COMMON SCIENTIFIC OUTLINE (CSO)

■ **BIOLOGY**: How cancer starts and progresses as well as normal biology relevant to these processes

■ **ETIOLOGY**: Causes or origins of cancer - genetic, environmental, and lifestyle, and the interactions between these factors

■ **PREVENTION**: Individual and population-based primary prevention interventions, which reduce cancer risk by reducing exposure to cancer risks and increasing protective factors

■ **EARLY DETECTION, DIAGNOSIS, AND PROGNOSIS**: Identifying and testing cancer markers, imaging and other methods that are helpful in detecting and/or diagnosing cancer as well as predicting the outcome or chance of recurrence or to support treatment decision-making in stratified/personalized medicine

■ **TREATMENT**: Identifying and testing treatments administered locally (such as radiotherapy and surgery) and systemically (treatments like chemotherapy which are administered throughout the body) as well as non-traditional (complementary/alternative) treatments (such as supplements, herbs). Research into the prevention of recurrence and treatment of metastases is also included here.

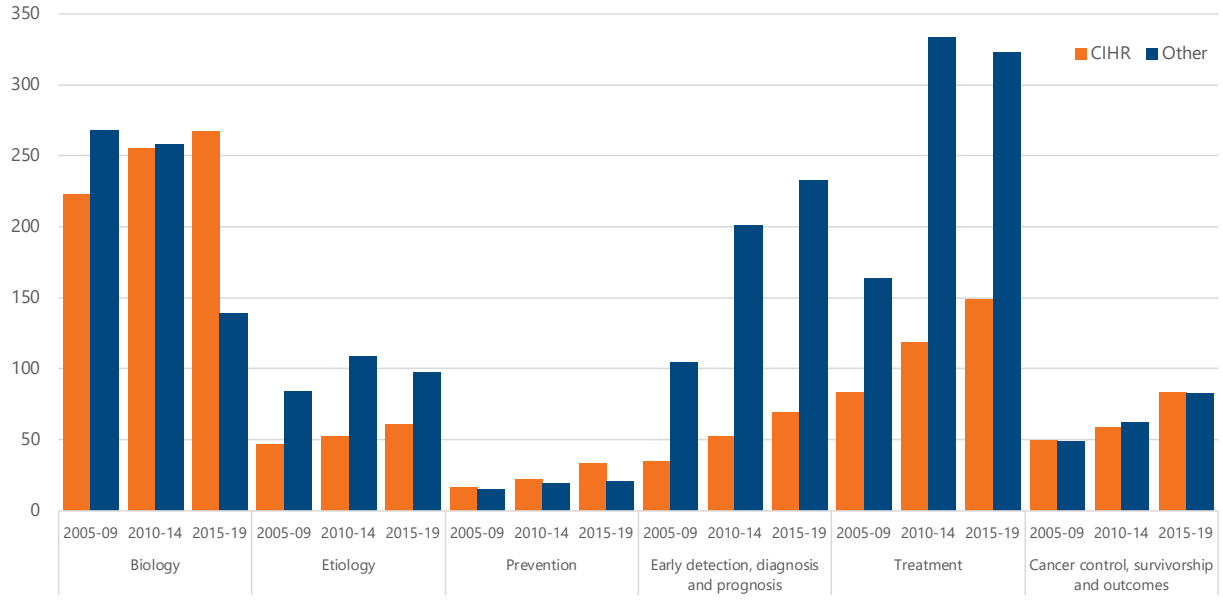
■ **CANCER CONTROL, SURVIVORSHIP, AND OUTCOMES RESEARCH**: Includes a broad range of areas: patient care and pain management; tracking cancer cases in the population; beliefs and attitudes that affect behavior regarding cancer control; ethics; education and communication approaches for people with cancer, family/caregivers, and health care professionals; supportive and end-of-life care; and health care delivery in terms of quality and cost effectiveness.

See https://www.icrpartnership.org/cso.

To get more insights into this data, CIHR was isolated from the other funders and the investments made in each of the three five-year periods for each CSO category were examined (Figure 15).

FIGURE 15

INVESTMENT IN OPERATING GRANTS, CIHR AND OTHER FUNDERS, THREE PERIODS ($M)



Percent change from 2005-09 to 2015-19	Biology	Etiology	Prevention	Early detection, diagnosis and prognosis	Treatment	Cancer control, survivorship and outcomes
CIHR	20%	32%	103%	99%	79%	26%
Other funders	-48%	16%	41%	122%	97%	71%
Overall	-17%	21%	74%	117%	91%	49%

The CIHR's annual operating grant investment in cancer biology continued to rise from 2007 on. In 2019, CIHR's investment represented 71% of the overall investment in cancer biology. The vital role of fundamental research has been well documented.[6] It is noteworthy that 64% of CIHR investments in operating grants in cancer biology in 2015-2019 were from national investigator-initiated funding programs (open grant competitions), suggesting perhaps that fundamental cancer research in Canada continues to be a competitive force in the basic science sphere. The declining investment in cancer biology by other funders was largely the result of decreased investments by the CCS.[7]

Investments from the first to the third five-year period across the CSO categories for the CIHR increased, although this growth was outpaced by other funders for the Early detection, diagnosis and prognosis, Treatment, and Cancer control, survivorship and outcomes categories. The increased investment in Early detection, diagnosis and prognosis reflected the focused investments in early translational research by the

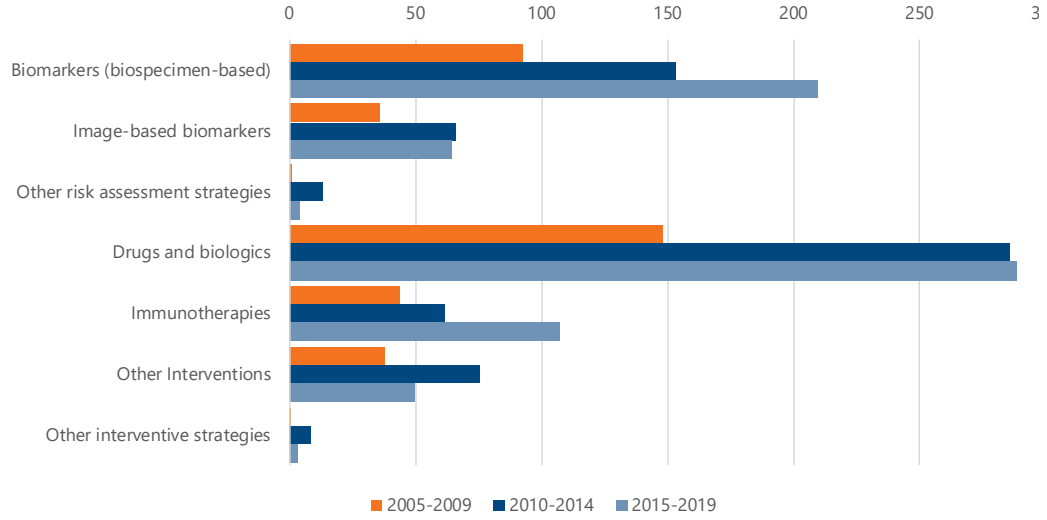
[6]Canada's Fundamental Science Review – see http://www.sciencereview.ca/eic/site/059.nsf/vwapj/ScienceReview_April2017.pdf/$file/ScienceReview_April2017.pdf.
[7]Specific funder profiles for all organizations covered in the CCRS can be retrieved from interactive reports on the CCRA website (see https://www.ccra-acrc.ca/tools/funder-profile/).

OICR, CCS, and TFRI. Even greater investments in early translational Treatment research were made by the CCS, OICR, TFRI, and Genome Canada.

From the first to the most recent five-year period, operating grants supporting early translational research increased by $368M, representing 47% of the operating grant investment in 2015-2019.[8] Looking at the investment in early translational research in more detail reveals expansive growth for research on drugs/biologics, immunotherapies, and biomarkers (biospecimen-based) (Figure 16).

FIGURE 16

INVESTMENT IN OPERATING GRANTS FOCUSED ON EARLY TRANSLATIONAL RESEARCH BY MODALITY AND PERIOD ($M)



Directed and Targeted Research Investments

Within the CCRS, distinctions are made between directed funding programs and targeted ones. **Directed** funding programs are part of the inherent nature of an organizational or funding program mandate – for example, grants awarded by the Brain Tumour Foundation Canada focus on brain cancers, grants awarded by the Canadian Association of Radiation Oncology focus on radiation oncology, and grants awarded by the Saskatchewan Health Research Foundation go to researchers in Saskatchewan. **Targeted** funding programs support a very specific research area. For example, the CCS's "Interventions to Prevent Cancer" grant program or CIHR's "Catalyst Grant for HPV Screening & Vaccination in Underserved Populations" specifically support cancer prevention research.

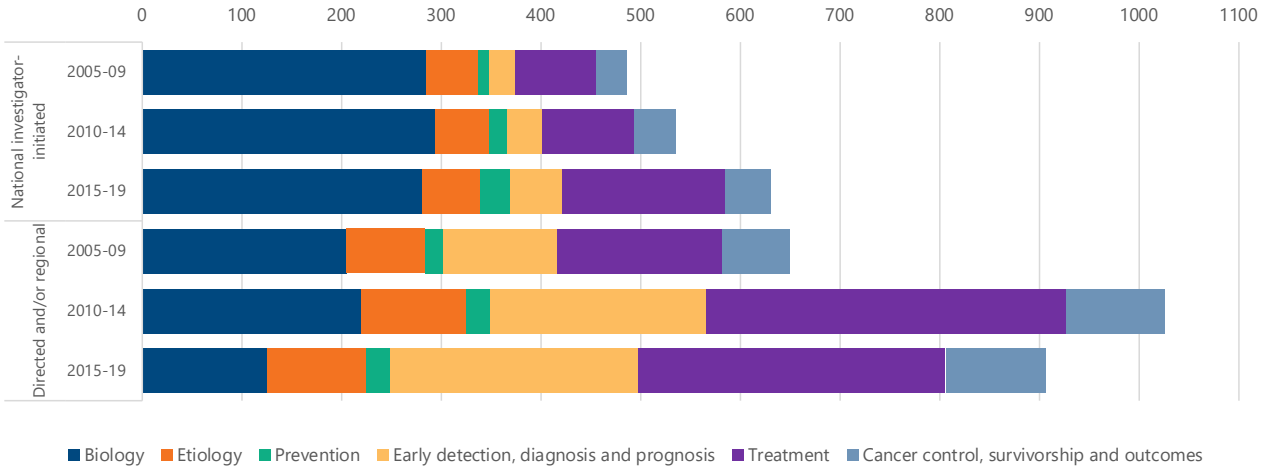
Funding programs that are entirely without restrictions—i.e., those that are open to any researcher living anywhere in Canada and conducting research on any area/topic—play a critical role in innovative discovery. Directed and targeted investments are also, however, crucial in advancing the science for under-researched cancer types and areas of science beyond cancer biology. Determining what the optimal balance should be remains an important topic of discussion among funders.

[8]Further details on the investment in early translational cancer research can be retrieved from this interactive report on the CCRA website (see https://www.ccra-acrc.ca/tools/translational-cancer-research-visualization/).

There were increased investments over the three five-year periods from operating grant funding programs classified as "National investigator-initiated" (i.e., investment in research by investigators from anywhere in Canada for any cancer-related research they propose), with over 70% of the investments coming from CIHR (Figure 17). There was also an increased investment in operating grants from programs that were directed and/or regional, although this investment contracted in the 2015-2019 period. The investments by the CCS, CIHR, OICR, and TFRI combined accounted for over half (52%) of the 15-year total through "Directed and/or regional" funding programs.

FIGURE 17

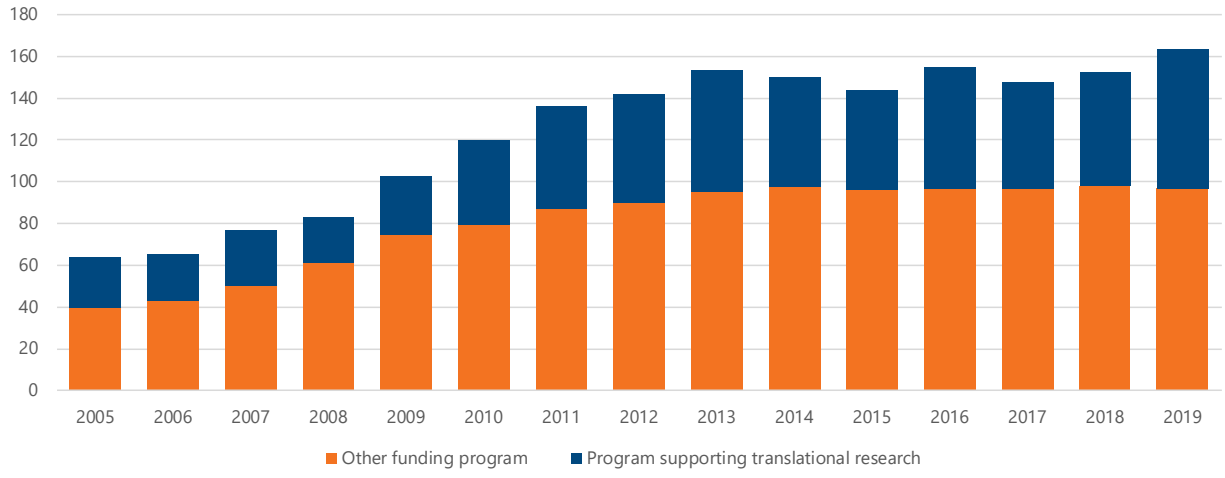
INVESTMENT IN OPERATING GRANTS BY PROGRAM AND CSO CATEGORY, THREE PERIODS ($M)



Patterns of investment by targeted operating grant programs varied by the specific research area. For example, funding programs designed to support translational research were important drivers of sustained investment in this area of research since 2011 (Figure 18).

FIGURE18

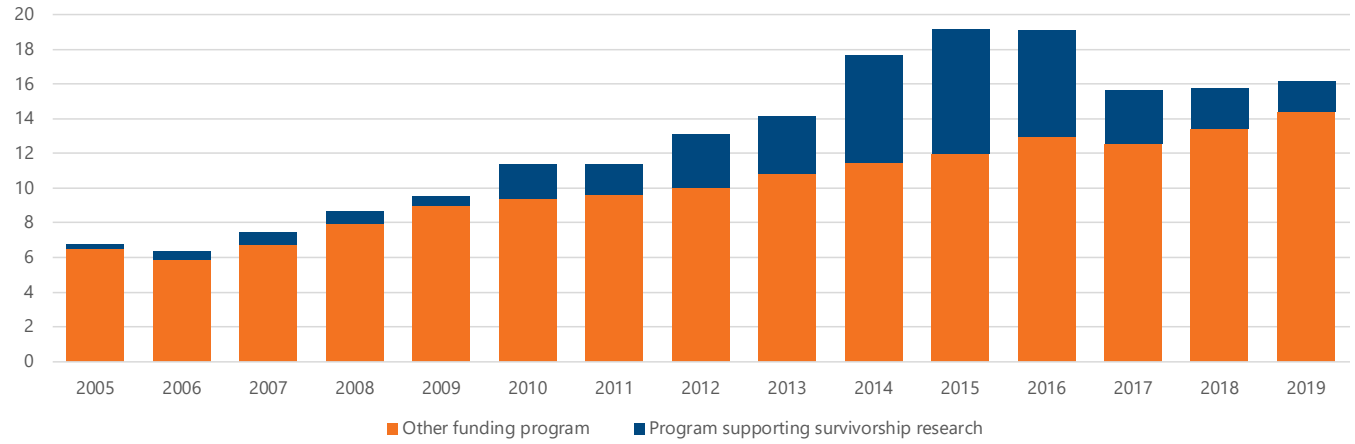
INVESTMENT IN OPERATING GRANTS FOR TRANSLATIONAL CANCER RESEARCH BY FUNDING PROGRAM, 2005–2019 ($M)



Similarly, targeted investments were also a critical component of cancer survivorship research, helping to build research capacity and support scale and spread of novel supportive care approaches (Figure 19).

FIGURE 19

INVESTMENT IN OPERATING GRANTS FOR CANCER SURVIVORSHIP RESEARCH BY FUNDING PROGRAM, 2005–2019 ($M)



Investment in Clinical Trials

The investment in clinical trials from 2005 to 2019 was estimated to be $310.9M,[9] with 150% growth from the first five-year period ($57.8M) to the latest five-year period ($144.6M). Combined, the CCS, CIHR and OICR accounted for 78% of the investment from 2005 to 2019, and all three organizations ramped up their investments over time (Figure 20).

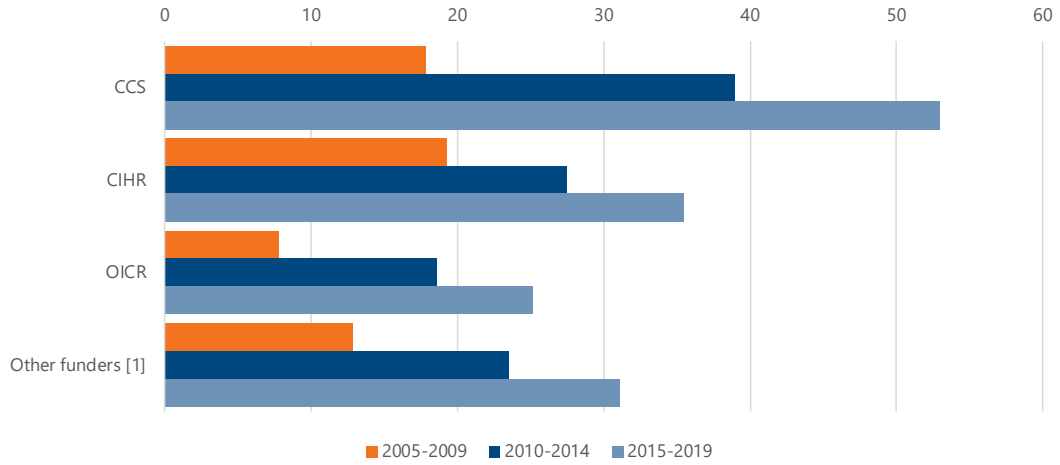
Trials varied in terms of their focus. Over half of CCS's trial investment was for symptom management/supportive care intervention (31%) and systemic treatments (24%) (Figure 21).[10] For OICR, 62% of its trial investment was for systemic treatment interventions. CIHR's investment was more distributed across the spectrum of trials.

[9]The investment in cancer clinical trials was estimated using several coded data elements within the CCRS (e.g., CSO subcodes, special topics coding). It is a proxy as not all operating grants can be mapped to registered trials.

[10]The Canadian Cancer Trials Group (CCTG) is a cooperative oncology group that designs and administers clinical trials in cancer therapy, supportive care, and prevention across Canada and has been supported by the CCS since 1980. Within CCRS, this funding is allocated to direct support and infrastructure.

FIGURE 20

INVESTMENT IN CLINICAL TRIALS BY PERIOD AND FUNDER ($M)



[1] Includes all other funders tracked in the CCRS. Industry-sponsored trials are not reported to the CCRS, but some industry support of trials sponsored by organizations tracked in the CCRS may be included in the "Other funders" category. We recognize that industry funding of clinical trials is a major omission.

FIGURE 21

15-YEAR INVESTMENT IN CLINICAL TRIALS BY FUNDER AND TRIAL FOCUS ($M)

	Prevention/ risk reduction	Biomarkers/ imaging for cancer detection, diagnosis, and prognosis	Treatments - localized	Treatments - systemic	Treatments - other [1]	Symptom management/ supportive care	Palliative/ end-of-life care
CCS	12.9	11.7	15.9	26.5	5.5	33.7	3.7
CIHR	16.8	19.5	18.7	5.4	3.5	16.1	2.1
OICR	0.3	15.4	3.3	32.0	0.2	0.3	
Other funders [1]	6.4	20.1	11.5	17.0	1.2	10.7	0.6

[1] Includes all other funders tracked in the CCRS. Industry-sponsored trials are not reported to the CCRS, but some industry support of trials sponsored by organizations tracked in the CCRS may be included in the "Other funders" category. We recognize that industry funding of clinical trials is a major omission.

Trials focused on breast and prostate cancers represented 26% and 16% of the total clinical trial investment, respectively. For most cancer types, the clinical trial investment grew over time. There was variability in the ways in which trial investment was distributed by cancer type and trial focus (Figure 22).

FIGURE 22

15-YEAR INVESTMENT IN CLINICAL TRIALS BY CANCER TYPE AND TRIAL FOCUS ($M)

	Blood cancer	Brain	Breast	Cervix	Colorectal	Lung	Oral	Ovary	Pancreas	Prostate	All other sites	Non-specific/all sites
Prevention/risk reduction			11.82	5.39	2.55	5.98	2.30	1.28		0.48	4.30	2.25
Biomarkers/imaging for cancer detection, diagnosis, and prognosis	3.38	0.29	13.98	10.78	3.07	2.54	1.72	3.31	1.27	16.25	2.79	7.30
Treatments - localized	0.26	1.67	19.87	3.23	0.43	4.23	6.29		0.10	8.86	3.22	1.27
Treatments - systemic	14.12	3.87	18.06	0.94	3.15	0.98	2.07	3.91	3.37	8.29	6.53	15.71
Treatments - other	0.01	0.12	0.08		2.85	0.74	0.07	0.02	0.08	3.10	3.07	0.10
Symptom management/supportive care interventions	1.78	1.22	17.37	0.39	3.49	0.72	4.10	0.34	0.20	13.60	3.82	13.76
Palliative/end-of-life care interventions		0.00	0.04		0.35	0.29				0.03	0.30	5.37

5 INVESTMENT IN RESEARCH TO INFORM CANADA'S CANCER SYSTEM

The CCRA needs to identify where strategic funding should be deployed to address the urgent needs of the cancer control system and ensure research is a key enabler to impactful system change.

Investment in Health Services and Policy Research

The operating grant investment in cancer-related health services and policy research (HSPR) was tracked for the 2015-2019 period using a coding system developed by the CIHR Institute of Health Services and Policy Research (ISPHR). The investment rose from $21.7M in 2015 to $26.8M in 2019 and was largely the result of increased investment by CIHR (Figure 23). CIHR represented 57% of the cancer relevant HSPR investments in 2019, up from 35% in 2015. Half of the HSPR investment was in three main areas of focus: 1) drugs and emerging technology, 2) methods, tools, and theories, and 3) primary and community-based healthcare (Figure 24).

The investment in cancer-related HSPR operating grants represented 8% of the overall operating grant investment in cancer research for 2015-2019. Figure 25 shows the distribution of HSPR investment relative to the overall operating grant investment for each province. Notably differences were found. For B.C., Saskatchewan, and Alberta, 14% of their operating grant investments going to PIs in their province were for HSPR (Figure 25). The inset graph shows the five-year cancer-related HSPR investment ($M) by province.

FIGURE 23

OPERATING GRANT INVESTMENT IN HEALTH SERVICES AND POLICY RESEARCH BY FUNDER, 2015–2019 ($M)

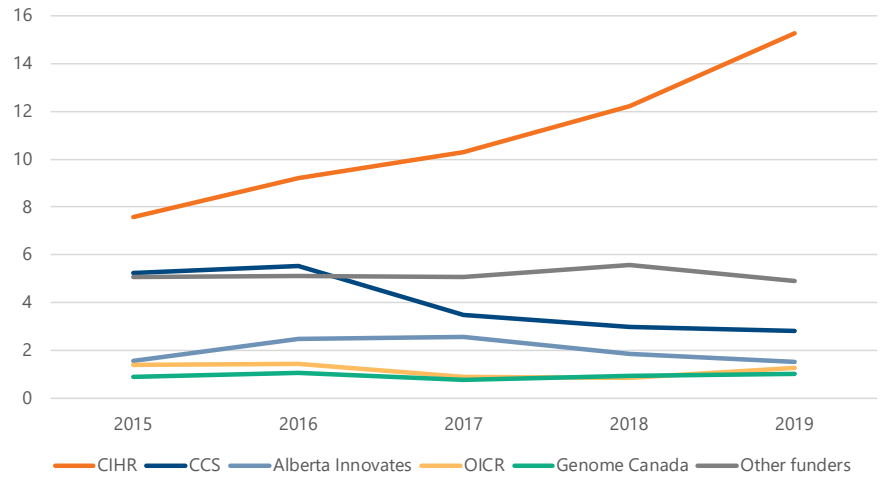


FIGURE 24

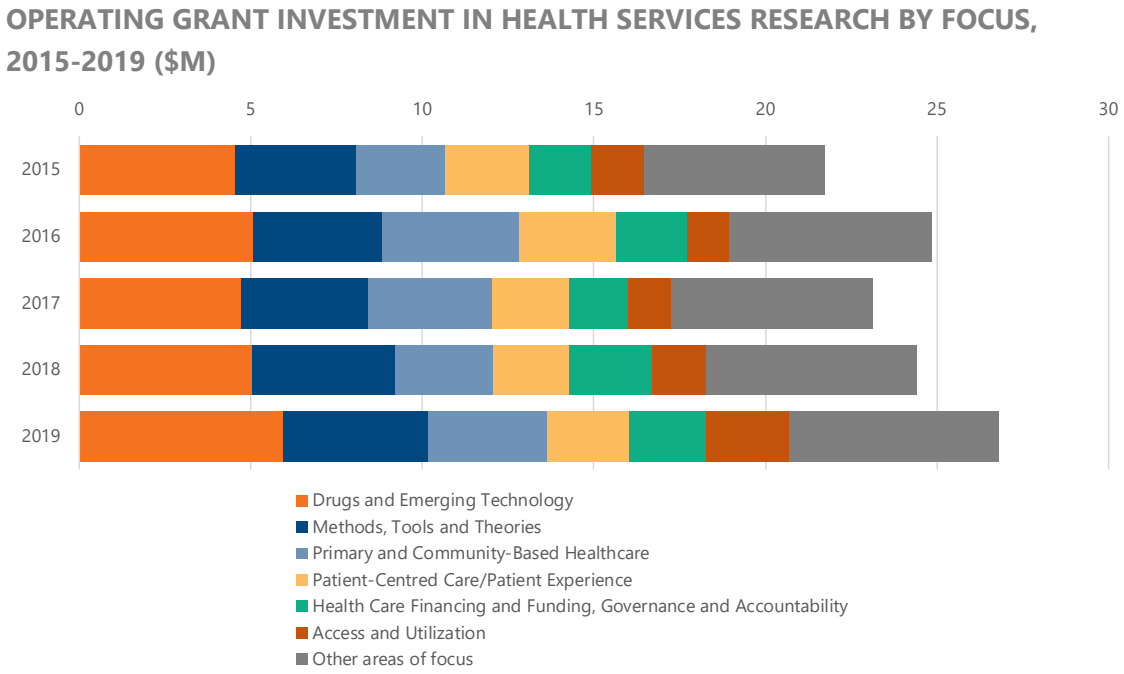
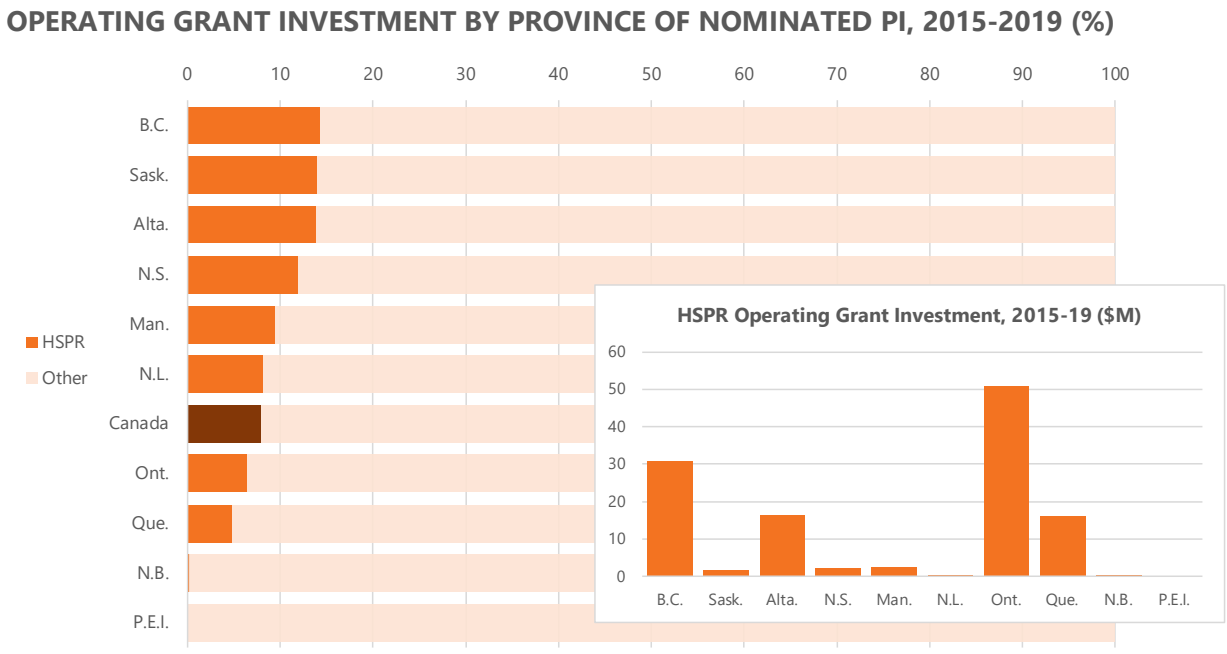


FIGURE 25



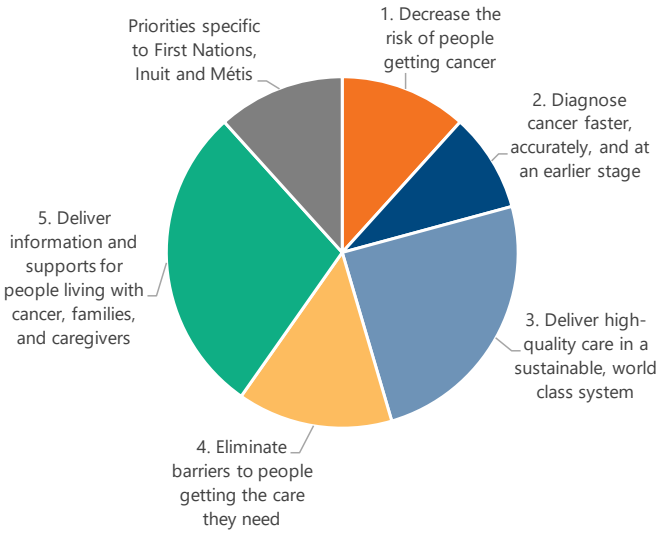
Research to Inform the Canadian Strategy for Cancer Control

All operating grants initiated in 2019 were reviewed and assigned to the major priorities identified in the Canadian Cancer Research Strategy or the CSCC (see sidebar for more information on the CSCC). There were 77 operating grants distributed across the priorities (Figure 26).

A reporting system to identify current and ongoing research aligned with the strategy will be developed in 2022/23 to help facilitate connections between researchers, providers, and system leaders, and accelerate research to action.

FIGURE 26

OPERATING GRANTS INITIATED IN 2019 MAPPED TO CSCC PRIORITIES (N=77) [1]



[1] Each grant is counted once and attributed to the most aligned priority even if the grant may have relevance to more than one priority.

The Canadian Strategy for Cancer Control is a 10-year action plan to improve equity in the cancer system and address the challenges and opportunities of the next decade— while ensuring a sustainable health-care system for the future.

The refreshed Strategy was shaped by the voices of 7,500 Canadians, including health-care leaders from across the country. First Nations, Inuit and Métis communities, governments and organizations across Canada were also engaged using a parallel process to identify Peoples-specific priorities and challenges.

The result is a forward-looking Strategy that identifies eight priorities with specific actions to strengthen cancer care for all people in Canada, families and caregivers affected by the disease:

- Priority 1 - Decrease the risk of people getting cancer.
- Priority 2 - Diagnose cancer faster, accurately and at an earlier stage.
- Priority 3 - Deliver high-quality care in a sustainable, world-class system.
- Priority 4 - Eliminate barriers to people getting the care they need.
- Priority 5 - Deliver information and supports for people living with cancer, families and caregivers.
- Priority 6 - Culturally appropriate care closer to home
- Priority 7 - Peoples-specific, self-determined cancer care
- Priority 8 - First Nations-, Inuit- or Métis-governed research and data systems

Source:
https://www.partnershipagainstcancer.ca/cancer-strategy/

6 INVESTMENT IN CANADA'S CANCER RESEARCHERS

The CCRA needs to develop initiatives to build a diverse cancer researcher workforce and look at ways to improve supports offered to trainees, particularly, postdoctoral fellows.

Early Career Investigators

Support for investigators at the outset of their research careers is widely recognized as a crucial component of sustaining the research enterprise and this is a key focus for the Canada Research Coordinating Committee.[11] Gibson et al. (2020) point out that the pandemic has provided an opportunity to rethink and reset the ways that scientists, especially early career researchers, have been supported.

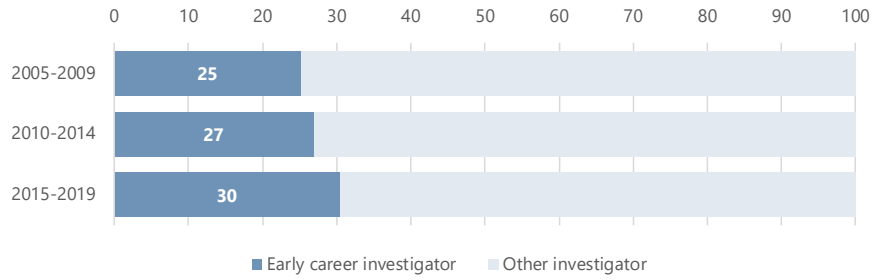
Although within the CCRS, we are unable to reliably confirm all early career investigators, we based our inclusion criteria on the funding program and, when this information was unavailable, we cross-referenced those in the CCRS with a trainee award, who then went on to receive an operating grant, equipment grant or career award in the CCRS, and included those individuals in our count.

The distribution of early career investigators over the three five-year periods increased but not substantively (Figure 27).

> "This pandemic has particularly impacted senior postdoctoral fellows seeking academic faculty positions and early career faculty seeking to establish themselves as independent investigators. Special consideration for these early career researchers is key to overcoming the crisis and strengthening the foundations of academic science" (Gibson et al., 2020).

FIGURE 27

INVESTIGATORS BY YEAR OF INITIAL OPERATING GRANT (%)



Canada Research Chairs

The Canada Research Chairs Program (CRCP), launched in 2000, is designed to strengthen Canada's research capacity and offset emigration of talent ("brain-drain") by helping Canadian universities and their research affiliates retain talented Canadian researchers and attract the best international researchers to Canada. The program is a tri-agency initiative of the CIHR, the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Social Sciences and Humanities Research Council of Canada (SSHRC). As previously noted, the CFI also provides accompanying funds to support infrastructure for some CRCs.

[11] https://www.canada.ca/en/research-coordinating-committee/priorities/support-early-career-researchers.html

Across the board, there were 3,665 CRCs actively funded at some point in the fifteen-year time frame of this report. Of these, 188 (5%) had a focus on cancer research and 96 of the 188 (51%) had received CFI support in conjunction with their CRC. There were no differences in terms of the proportion of cancer-focused chairs progressing through the program when compared with all CRCs in this period. (Table 3).

TABLE 3

CANCER-FOCUSED CANADA RESEARCH CHAIRS BY INITIAL TIER, INITIAL START PERIOD [1] AND PROGRESSION [N=188]

	START PERIOD				
	Pre-2005	**2005-2009**	**2010-2014**	**2015-2019**	**TOTAL**
Tier 1	**37**	**13**	**6**	**18**	**74**
Tier 1 renewed	*30*	*10*	*3*		
Tier 2	**41**	**23**	**18**	**32**	**114**
Tier 2 renewed	*24*	*12*	*15*		
Advanced to Tier 1	*9*	*6*			

[1] Period when initial CRC was funded. Researchers are counted once in the bolded line.

The 105 cancer CRCs active in 2019 represented 6.5% of all cancer focused PIs actively funded in 2019. These CRCs worked in seven provinces (there were no cancer CRCs in Saskatchewan, Nova Scotia or P.E.I.), with most in Ontario (50), Quebec (29), B.C. (12), and Alberta (10).

Trainees

Although most trainees are supported from diverse sources like provincial or institutional programs, internships or operating grants, a small group of trainees receive awards through the grant peer-review process. This caveat is important to bear in mind when reviewing the data provided in this section.

CIHR alone accounted for 43% of the investment in trainee awards over the fifteen-year span. Notably, the Fonds de la recherche du Québec – Santé (FRQS), a provincial funding organization, ranked second and represented 10% of the overall trainee award investment. The extent of the Quebec government's support of trainees is unique in the country.

From 2005 to 2019, 7,203 awards focused on cancer were conferred to 5,648 recipients. Awards made through federal programs assumed a larger proportion of the awards over time (Figure 28). Most of these awards went to trainees pursuing graduate degrees, although undergraduate studentship programs became a larger part of the funding landscape over time and drove the slight increase in the total number of awards from the first to the second periods (Figure 29). The number of awards to postdoctoral trainees dropped 20% from the first to the third five-year period, the steepest decline being for fellowship awards from the charitable sector (Figure 30).

IN THEIR OWN WORDS

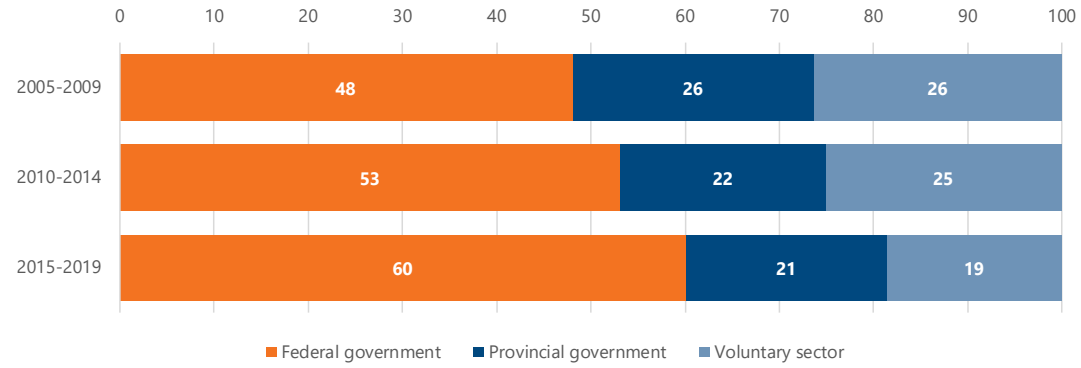
259 postdoctoral fellows working at Canadian institutions responded to a global survey of postdoctoral fellows (all disciplines) undertaken by *Nature* in the early summer of 2020. 31% reported that their postdoctoral experience was worse than they had imagined it would be. 64% felt that the COVID-19 pandemic had negatively affected their career prospects and felt extremely/somewhat negative about the future—the negativity was higher among female than male respondents. This dataset can be accessed at: https://figshare.com/s/a0a0f1c90843c12e6373.

Source: Woolsten C. Postdoc survey reveals disenchantment with working life. Nature. 2020 Nov;587(7834):505-8. https://doi.org/10.1038/d41586-020-03191-7

There has been much written in the past few years about the precarious position of postdocs, often considered to be the most valuable members of research laboratories (Herschberg, Benschop, van den Brink, 2018; OECD, 2021) and this has been exacerbated by the pandemic (Morin et al., 2021 and sidebar). CRS's two-pronged "Scholarships for the Next Generation of Scientists" is an innovative mechanism to address this issue. It supports a one-year postdoctoral fellowship followed by two years of operating grant funding to awardees in their initial faculty positions. Our analysis also showed additional evidence of the high calibre of postdoctoral cancer researchers in Canada. One-quarter of the 211 Banting fellowships[12] awarded by CIHR from 2010 to 2019 went to postdoctoral trainees focused on cancer research.[13]

FIGURE 28

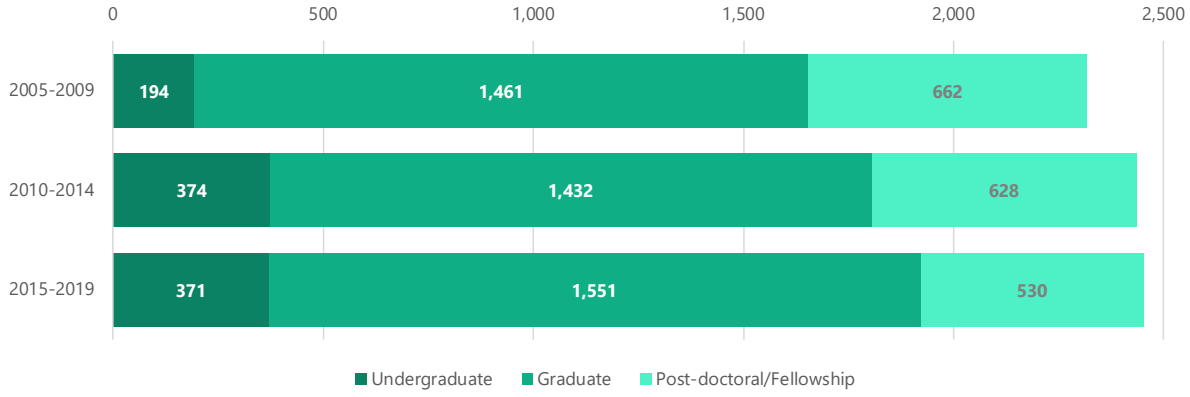
DISTRIBUTION OF NUMBER OF TRAINEE AWARDS [1] BY PERIOD OF START YEAR AND ADMINISTERING FUNDER SECTOR (%)



[1] Percentage of awards with a cancer weighting of 80% or more.

FIGURE 29

NUMBER OF TRAINEE AWARDS BY LEVEL AND PERIOD OF START YEAR [1]



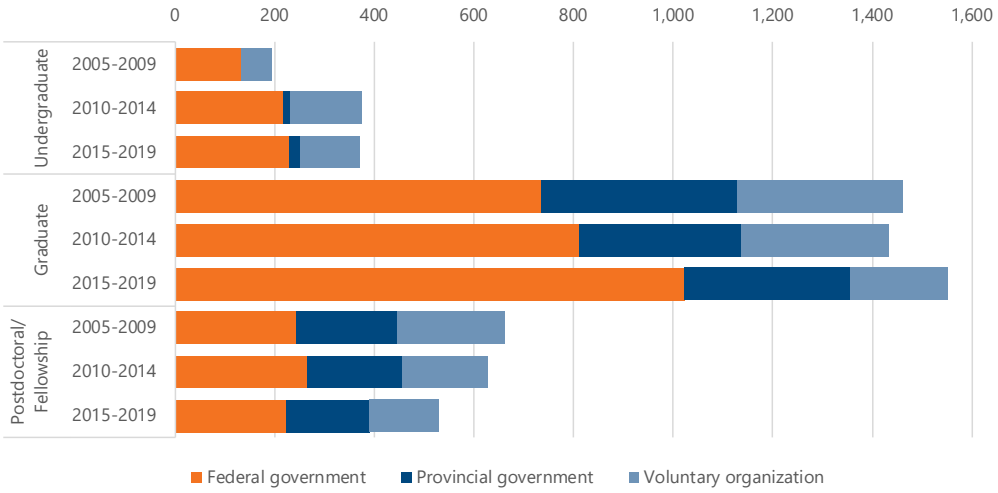
[1] Number of awards with a cancer weighting of 80% or more.

[12]The Banting Postdoctoral Fellowships program was launched by the Tri-Council agencies in 2010 as part of a broader federal government strategy to increase Canadian capacity for research excellence (CIHR, 2015).

[13]This calculation was based on data exported from the online CIHR funding database for FY2011/12 to FY2019/20.

FIGURE 30

NUMBER OF AWARDS BY LEVEL, [1] PERIOD OF START YEAR AND ADMINISTERING FUNDER SECTOR



Promoting a Diverse Cancer Researcher Workforce

Within the CCRS, data from individual researchers are not collected and thus it is not possible to report on the extent to which funded cancer researchers reflect the diversity of Canada's population. CCRA members acknowledge that diversity in cancer research and science more broadly is needed to:

- widen perspectives, methodologies, and theoretical frameworks
- generate research with improved generalizability and, conversely, more specificity
- increase our understanding of how populations vary
- develop interventions that yield more benefits and reduce harm

Prior to the pandemic, efforts to address systemic racism and bias in science and more generally in our society were underway but these efforts have been accelerated by the unequal burden of the pandemic and the broadcast of major injustices against racialized communities. The impacts of colonialism, patriarchy, and racism are being recognized and challenged in unprecedented ways and significant institutional and policy reforms are in process.

> "Diversity has many facets, including background, age, gender, sexual orientation, race, ethnicity, culture, religion, geography, disability, socioeconomic status, area of expertise, level of experience, thinking style, and skill set. The benefits of engaging individuals with a wide swath of perspectives have great potential to improve our capacity to innovate" (Swartz, Palermo, Masur & Aberg, 2019).

Diversity, equity, inclusion, and reconciliation are important across the research system, in terms of:

- the cultivation, training, recruitment, and ongoing support of researchers
- research priority setting
- the funding and adjudication processes
- governance of data and research
- support for Indigenous-led research

- the research methodology (how it is conducted, assumptions, model systems, subjects, variables, analyses, etc.)
- the academic/science publishing system (editorial boards, reviewers, special topics/supplements)
- dissemination of research findings beyond publication (outreach, knowledge translation approaches)
- merit and career advancement systems in academia and health care and availability of formalized mentorship opportunities
- other recognition systems (what is valued, who is recognized including authorship, etc.)
- patent applications and the commercialization pathway (e.g., IP approaches)

The call to action for this chapter is to support trainees and postdoctoral researchers, and more specifically to ensure a diverse cancer researcher workforce moving forward. It is recognized that science, technology, engineering, and mathematics (STEM) outreach programs for students at the earliest years, such as Let's Talk Science, are important foundational strategies.

"…an 'inclusivity mindset' demands a paradigm shift regarding how to think about and plan research, how to conduct training, and how to engage communities in a meaningful way. Such a goal must entail plans that are systematic, sincere, and sustained, with a lens toward recognizing institutional clinical trial features that hinder or promote effective inclusion. Engaging and incentivizing communities, families, and patients in research is paramount…" (Meade & Gwede, 2020).

7 2020 AND BEYOND

The CCRA is committed to continued monitoring of the investment in cancer research and to working innovatively to fund cancer research so that it meets the challenges outlined in this report. The timeframe for this report does not, however, capture recent and major events that will shape the cancer research landscape going forward.

New Investments

The timeline for this report does not reflect the many changes that have happened since 2019. Cancer research has been on the receiving end of major federal government investments over the past couple of years. Significant investments in cancer research were announced in the 2019 Federal Budget to support of the TFRI's Marathon of Hope Cancer Centres Network, the Digital Health and Discovery Platform (DHDP) (TFRI and Imagia) and Ovarian Cancer Canada's OvCan initiative. The work to secure those commitments took many years, and much groundwork and persistence on the part of many stakeholders— especially those affected by cancer (Baugh et al., 2022).

The federal government has also provided additional resources to support research chairs, trainees, and innovation (e.g., New Frontiers in Research Fund) and, in the 2021 Federal Budget, $30M was designated for strategic research on pediatric cancer, more specifically, the creation of a Pediatric Cancer Consortium. The "CIHR Team Grant: Pediatric Cancer Consortium" funding opportunity was launched in February 2022 and anticipated decision and start dates will be in the summer of 2022. The 2021 Budget also provided $250M to CIHR to implement a new Clinical Trials Fund, which will include support for a pan-Canadian Clinical Trials Consortium.

Impacts of the Pandemic

The COVID-19 pandemic has had a significant impact on the cancer funding landscape as well as cancer care delivery. The research enterprise writ large made a major pivot to address the urgencies of COVID-19 and, for some cancer researchers, this has meant repurposing their cancer research programs to respond to emerging needs on a temporary or full-time basis. In many respects, 2020 was a watershed year. Change was necessitated by the pandemic and by growing awareness of the immediacy to address structural and societal inequities, biases, and racism.

The immediate impacts—lab closures, disruptions in professional interactions, and reductions in fund raising by the charitable sector—although not sustained in many cases may adversely impact cancer research for years to come (Colbert et al., 2020). Furthermore, women, who largely continue to assume a prominent role in child and elder care, racialized and minority researchers, and those in the early phases of their careers have all been identified as among the groups most affected by the disruptions created by the pandemic (Krukowski, Jagsi & Cardel, 2021; Levine & Rathmell, 2020). The pandemic also fundamentally affected the practice of oncology and, in some cases, redefined care delivery and what treatments people with cancer should and can receive (Broom et al., 2020). Delays and postponements of cancer screening, surgeries, and clinical trials may erode gains made over the decades in terms of improved outcomes, and reduced mortality (Hanna et al., 2020, Maringe et al., 2020, Sud et al., 2020). These challenges are being experienced at the global level.

While it is recognized that cancer research fares better than other disease-focused research in terms of its share of the research grants (Ralaidovy, Adam & Philippe Boucher, 2020), with the pandemic, there have been

recent calls for a rebalancing of funding from cancer to global health priorities (Swaminathan et al., 2022) and this may have a bearing on future research prioritization.

Moving Evidence to Practice

The Partnership along with the Canadian Association of Provincial Cancer Agencies (CAPCA) and some key HSPR research funders of the CCRA are currently developing a cancer health services and policy research implementation plan for the 2022-27 period with an equity focus, which will identify the actions required to: ensure evidence needed by the cancer system is generated and translated, build on existing priorities and investments, leverage current commitments, tap jurisdictional and research strengths and structures, help drive the quality agenda, and advance the evolution of learning health systems within cancer programs and services. This implementation plan builds from a series of recommendations generated from consultations with experts from across the country. The implementation plan will align with Canada's Vision for Cancer Research and the CSCC.

In Conclusion

This report has focused on several key trends within the cancer research investments for years 2005 to 2019 as tracked by the CCRA and called out specific actions for members in the coming years. While cancer researchers have remained a competitive force, Canada's lagging investment in cancer research is concerning. Fortifying and diversifying the cancer research workforce is an important need and will be a sustained focus for CCRA members. Ongoing reporting will continue to be a pillar of CCRA's work as we monitor the impacts of the pandemic on investments in cancer research and continue to track Canada's investment on the global stage.

Ongoing reporting will continue to be a pillar of CCRA's work as we monitor the impacts of the pandemic on investments in cancer research and continue to track Canada's investment on the global stage. Facilitating the translation of research to policy and practice to support equitable access to quality cancer care for all people in Canada is an ongoing focus for the Partnership in its role as stewards of the CSCC. Opportunities to showcase progress will be an important component of future reports.

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ABBREVIATIONS

3CTN	Canadian Cancer Clinical Trials Network
CanPath	Canadian Partnership for Tomorrow's Health (formerly CPTP – Canadian Partnership for Tomorrow Project)
CAPCA	Canadian Association of Provincial Cancer Agencies
CCRA	Canadian Cancer Research Alliance
CCRS	Canadian Cancer Research Survey
CCS	Canadian Cancer Society
CCSC	Canadian Strategy for Cancer Control
CCTG	Canadian Cancer Trials Group
CFI	Canada Foundation for Innovation
CIHR	Canadian Institutes of Health Research
CPDC	Centre for Probe Development and Commercialization
CRAFT	Canadian Remote Access Framework for Clinical Trials
CRCP	Canada Research Chairs Program
CRS	Cancer Research Society
CSO	Common Scientific Outline
CTRNet	Canadian Tissue Repository Network
DEI	Diversity, Equity and Inclusion
FRQS	Fonds de recherche du Québec - Santé
HSPR	Health services and policy research
ICGC	International Cancer Genome Consortium
IHSPR	Institute of Health Services and Policy Research
NCE	Networks of Centres of Excellence
OECD	Organization for Economic Co-operation and Development
OICR	Ontario Institute for Cancer Research
Partnership	Canadian Partnership Against Cancer
PI	Principal investigator
TFRI	The Terry Fox Research Institute

ACKNOWLEDGEMENTS

We would like to thank the many organizations that participate in the CCRS by contributing their data on an annual basis. Without them, this report would not have been possible.

We would also like to acknowledge the experts who advised us on this report. An iterative review process was used. Reviewers for the first round were: Dr. Anne-Marie Mes-Masson (Centre de recherche CHUM and Institut du cancer de Montréal), Dr. Stephen Robbins (CIHR Institute for Cancer Research), and Dr. Christine Williams (OICR). Reviewers for the second round were: Drs. Judy Bray and Rachel Reeve (CCS), Dr. Dajan O'Donnell (CRS), Dr. Paula Robson (Cancer Care Alberta, Alberta Health Services), and Dr. Jim Woodgett (TFRI). The final review was completed by the full CCRA membership.

The quality of the CCRS is enabled by a dual coding process and we are grateful to Dr. Jim Hudson for his ongoing role in this effort.

Production of this report has been made possible through collaboration and financial support from the Canadian Partnership Against Cancer and Health Canada. The views expressed herein do not necessarily represent the views of Health Canada or the Canadian Partnership Against Cancer.

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