Investment in Early Translational Cancer Research, 2005–2010

A special report from the Canadian Cancer Research Alliance's survey of government and voluntary sector investment in cancer research

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

CANADIAN PARTNERSHIP AGAINST CANCER
PARTENARIAT CANADIEN CONTRE LE CANCER

MARCH 2014

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Suggested Citation:
Canadian Cancer Research Alliance (2014). *Investment in Early Translational Cancer Research, 2005–2010: A Special Report from the Canadian Cancer Research Alliance's Survey of Government and Voluntary Sector Investment in Cancer Research.* Toronto: CCRA.

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ISBN 978-1-927650-18-9 (print) / ISBN 978-1-927650-19-6 (PDF)

Aussi offert en français sous le titre : Investissement dans la recherche les étapes initiales de la recherche translationnelle sur le cancer, de 2005 à 2010 : un rapport spécial de l'Alliance canadienne pour la recherche sur le cancer sur les investissements effectués dans la recherche sur le cancer par les organismes gouvernementaux et non gouvernementaux.

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ACKNOWLEDGEMENTS

Production of this report has been made possible through a financial contribution from Health Canada, through the Canadian Partnership Against Cancer. The views expressed herein represent the views of the Canadian Cancer Research Alliance.

The Canadian Cancer Research Survey relies on the participation of many organizations. In alphabetical order, we would like to thank Alberta Cancer Foundation, Alberta Innovates – Health Solutions, Brain Tumour Foundation of Canada, C[17] Research Network, Canada Foundation for Innovation, Canada Research Chairs Program, Canadian Association of Radiation Oncology, Canadian Breast Cancer Foundation, Canadian Cancer Society, Canadian Institutes of Health Research, Canadian Partnership Against Cancer, Canary Foundation of Canada, CancerCare Manitoba, Cancer Care Nova Scotia, Cancer Care Ontario, Cancer Research Society, Fonds de recherche du Québec – Santé, Genome Canada, Manitoba Health Research Council, Michael Smith Foundation for Health Research, National Research Council of Canada, Natural Sciences and Engineering Research Council, New Brunswick Health Research Foundation, Newfoundland and Labrador Centre for Applied Health Research, Networks of Centres of Excellence, Nova Scotia Health Research Foundation, Ontario Institute for Cancer Research, Ontario Ministry of Research and Innovation, Ovarian Cancer Canada, Pediatric Oncology Group of Ontario, PROCURE, Prostate Cancer Canada, Public Health Agency of Canada, Quebec Breast Cancer Foundation/Fondation du cancer du sein du Québec, Saskatchewan Cancer Agency, Saskatchewan Health Research Foundation, Social Sciences and Humanities Research Council, The Kidney Foundation of Canada, The Leukemia & Lymphoma Society of Canada, and The Terry Fox Foundation. The survey also includes information from the federal government's Indirect Costs Program, the Canadian Cancer Society-funded NCIC Clinical Trials Group, and the Atlantic Canada Opportunities Agency.

Instrumental to the inaugural version of this report were: Dr. Janet Dancey (Ontario Institute for Cancer Research), Dr. Jim Davie (Manitoba Health Research Council), Dr. Thomas Hudson (Ontario Institute for Cancer Research), Dr. Victor Ling and Mr. Stephen Herst (Terry Fox Research Institute), Dr. Anne-Marie Mes-Masson (Université de Montréal), Dr. Maureen O'Connor-McCourt (National Research Council of Canada), and Dr. Matthew Parliament (University of Alberta). A special note of thanks to Mr. Edward Kyle (National Institutes of Health, Research Analysis & Evaluation Division) and Ms. Jennifer Kwok (National Cancer Institute, Coordinating Center for Clinical Trials) for their help in the very early stages of this project. They provided access to key resources and helped in the interpretation of the Translational Research Working Group framework.

Kim Badovinac, who managed this project, prepared this updated report with the invaluable advice and expertise provided by Dr. Stuart Edmonds (Prostate Cancer Canada), Dr. Robin Harkness (Canadian Cancer Research Alliance/ Canadian Partnership Against Cancer), Dr. Thomas Hudson (Ontario Institute for Cancer Research), Mr. Stephen Herst (Terry Fox Research Institute), Dr. Jacques Magnan (Canadian Partnership Against Cancer), Dr. Anne-Marie Mes-Masson (Université de Montréal), Dr. Stephen Robbins (Canadian Institutes of Health Research), and Dr. Christine Williams (Canadian Cancer Society). We would also like to acknowledge Dr. James Hudson for providing critical advice on project coding in this report as well as the inaugural report. This report was designed by Unified Marketing Communications of Toronto.

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1. Introduction

1.1 REPORT PURPOSE & PLAN

This report updates an earlier analysis on the investment in early translational cancer research[1]. It utilizes a comprehensive framework of translational cancer research developed by the U.S. National Cancer Institute (NCI), described in the following section. The impetus for the original report was a question from Dr. Victor Ling, founding scientific director of the Terry Fox Research Institute: was it possible to quantify the investment in translational research from data gathered as part of the Canadian Cancer Research Survey (CCRS)? Other research funders and, more formally, the Canadian Cancer Research Alliance (CCRA) in its strategic plan,[2] echoed this need for information on how much and what kinds of translational research was being undertaken in Canada. The information in this report is intended to help research funders identify gaps and potential bottlenecks to translational research as well as prospective solutions that will improve the implementation of innovative findings from "benchtop to bedside."

1.2 CLASSIFYING TRANSLATIONAL RESEARCH

Between 2005 and 2007, the U.S. National Cancer Advisory Board, under the auspices of its Translational Research Working Group (TRWG), sought to evaluate the U.S. National Cancer Institute's investment in translational research and enhance the productivity of the translational research enterprise in the U.S. Very early in its evolution, the TRWG recognized the importance of a shared vocabulary to facilitate its work—although translational research is a significant part of the cancer research effort, "translational research" has no single standard definition and viewpoints on its nature and bounds vary.

The TRWG supported the broad and inclusive perspective on translational research proposed in the 2004–2005 Annual Report of the President's Cancer Panel report[3] (see Figure 1.1.1). In this conceptualization, translational research is conceived of in four main stages that follow basic science discovery and end in adoption/diffusion. The TRWG decided to focus its work on the "early translation" portion of the research translation continuum: "the translational process that follows fundamental discovery and precedes definitive, late-stage trials."[4] This phase is marked on the diagram below.

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1. Canadian Cancer Research Alliance (2011). *Investment in Early Translational Research, 2005–2007.* Toronto: CCRA.
2. The CCRA *Pan-Canadian Cancer Research Strategy* (CCRA, 2010) devotes four of its 24 action items for the 2010–2014 period to research translation.
3. The President's Cancer Panel, established by the 1971 National Cancer Act, is charged with monitoring and evaluating the National Cancer Program and reports at least annually to the president of the United States.
4. From E.T. Hawk et al., "The Translational Research Working Group development pathways: Introduction and overview," *Clinical Cancer Research* 14(18), 2008: 5666.

FIGURE 1.1.1

THE RESEARCH TRANSLATION CONTINUUM [1]

Basic Science Discovery	Early Translation	Late Translation	Dissemination	Adoption
• Promising molecule or gene target • Candidate protein biomarker • Basic epidemiologic finding	• Partnerships and collaboration (academic, government, industry) • Intervention development • Phase I/II trials	• Phase III trials • Regulatory approval • Partnerships • Production/ commercialization • Phase IV trials – approval for additional uses • Payment mechanism(s) established to support adoption • Health services research to support dissemination and adoption	*(of new drug, assay, device, behavioral intervention, education materials, training)* • To community health providers • To patients and public	• Adoption of advance by providers, patients, public • Payment mechanism(s) in place to enable adoption • Data collection to support outcomes research, intervention refinement, health services, and other research, and to inform provider practices

[1] The continuum is not unidirectional. In addition to transforming discoveries arising from fundamental laboratory, clinical, or population-based research into new drugs, devices, or population interventions, findings from the clinic and population may loop back and inform new early translational research projects designed to refine or expand the application of an innovation.

From Suzanne H. Reuben, *Translating Research into Cancer Care: Delivering on the Promise*. Bethesda, MD. President's Cancer Panel, 2004–2005 Annual Report, U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, June 2005, Figure 1, ii.

The TRWG group developed process diagrams for six pathways to clinical goals, outlining the steps required to advance discoveries (e.g., laboratory research, basic epidemiological and behavioural research, etc.) to early-phase clinical trials. This typology of early translational cancer research is the most comprehensive paradigm produced to date and is well described in the TRWG report *Transforming Translation: Harnessing Discovery for Patient and Public Benefit*, published in June 2007, and a series of seven articles published in the 2008 (Vol. 14, No. 18) issue of *Clinical Cancer Research*.

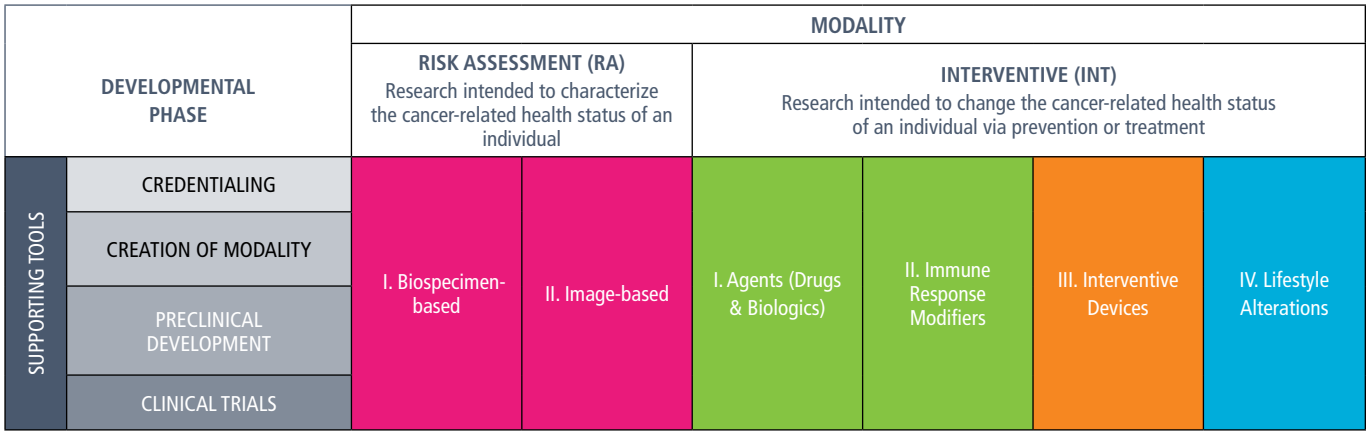
An overview of the typology is provided in Figure 1.1.2. The typology is described more fully in the following chapter. It consists of six modalities—two under the heading of risk assessment (diagnostics) and four under the heading of interventions (treatments) intended to characterize or change an individual's cancer-related status. Each modality has four developmental phases, with an overarching phase of supporting tools, so named because it supports the research in the other phases[5]. The TRWG framework was retained for this report because it is still the most

5. Early in the NCI's foundational work on this paradigm, a pilot project was conducted to apply the framework and identify the institute's overall effort in translational research. (For details, please consult the summary of this analysis available at http://www.cancer.gov/researchandfunding/trwg/portfolio-analysis.pdf.) The authors found that translational projects were distributed in varying degrees across NCI award-sponsoring offices, centers, and divisions and, likewise, across many different funding mechanisms. On the downside, they concluded that the inclusion criteria used for the pilot project likely overestimated the degree of translational research relevance.

comprehensive one published to date and allows for comparative benchmarking. Note that the colour coding used in Figure 1.1.2 is maintained through the entire report for the purposes of distinguishing the modalities.

FIGURE 1.1.2

OVERVIEW OF THE TRANSLATIONAL RESEARCH WORKING GROUP (TRWG) DEVELOPMENTAL PATHWAYS TO CLINICAL GOALS



Adopted from E.T. Hawk et al. (2009). The Translational Research Working Group Developmental Pathways: Introduction and Overview. *Clinical Cancer Research*, 14(18), 5664–5671.

1.3 TAILORING THE TYPOLOGY TO THE CANADIAN CONTEXT

As with the original report, the TRWG typology and inclusion criteria were tailored to the Canadian cancer research environment. In Canada, funding for direct support (operating grants), salary support, and equipment/infrastructure support often comes from different funding organizations in contrast to the all-inclusive support provided by many funding mechanisms offered through the NCI. Furthermore, the level of detail on equipment/infrastructure projects within the CCRS is, in most cases, limited and does not permit classification in terms of the TRWG phases. To account for the investment in equipment/infrastructure, an additional category was constructed. (Details are provided in the next chapter.)

1.4 REPORT COVERAGE

This report represents the portion of early translational research conducted in academic environments in the form of cancer research projects funded by major peer-reviewed programs offered by governments and charitable organizations in Canada. The pharmaceutical and medical devices industries, academic/health care institutions with monies raised by local hospital foundations, and government agencies through intramural research programs also conduct early

translational cancer research. Canadian researchers also receive funding from out-of-country sources to support early translational cancer research projects.

An estimate of the total investment in early translational research was calculated to give some context to the figures reported herein. The dearth of publicly available information from which to derive estimates complicated this exercise. The estimations suggest that this report represents approximately 34% to 37% of the total annual early translational cancer research investment in Canada during the 2005 to 2010 period (see Table 1.4.1).

TABLE 1.4.1

ESTIMATED ANNUAL INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH FROM MAJOR SOURCES, 2005 TO 2010

Source	Investment ($M)	%	Estimate Quality
This report/Canadian Cancer Research Survey	576.7	34–37	Good
Pharmaceutical industry [1]	690–725	43–44	Fair
Medical devices industry [2]	120–170	8–10	Poor
Hospital foundations [3]	165–185	10–11	Fair
Other intramural government funding [4]	3–7	less than 1	Poor
Funders outside Canada [5]	24–36	2	Good
Total	1,578.7–1,699.7		

[1] Annual figures (2005–2010) for R&D by research type (i.e., preclinical trial I, preclinical trial II, clinical trial phase I and clinical trial phase II) for pharmaceutical companies in Canada are available from the Patented Medicine Prices Review Board (PMPRB) (see http://www.pmprb-cepmb.gc.ca). Using U.S. National Institutes of Health's ClinicalTrials.gov, the largest database of government and privately supported clinical trials conducted in more than 170 countries, various searches were conducted to obtain estimates of the proportion of phase I and II industry-funded trials that are relevant to cancer. These estimates were then applied to the R&D figures reported by PMPRB.

[2] The Medical Device Industry Survey 2000, a one-time survey conducted by Statistics Canada, found the total R&D expenditures in 2000 of $126M by the Canadian medical devices industry. This included the following sector-specific expenditures: $26.7M medical imaging/radio-therapy, $9.1M medical surgical, $15.2M other hospital equipment/medical electronic, $8.5M assistive devices, $3.3M diagnostics, and $5.4 implants. The level of investment for the 2005 to 2010 period is not known. More significantly, there are no sources of data from which to estimate the cancer relevance of this investment.

[3] This estimate was based on annual reports of the Princess Margaret Cancer Foundation, the single largest hospital foundation in Canada and a hospital with an exclusive focus on cancer. Data were adjusted by the proportion of translational research for Princess Margaret Cancer Centre as captured in the CCRS and then increased by 30% to reflect other hospital foundation funding.

[4] Specific intramural research activities conducted by organizations such as the National Research Council of Canada are likely relevant, although no publicly available data sources exist to estimate the extent to which they are translational and specific to cancer.

[5] Publicly available data from the NCI and the Congressionally Directed Medical Research Programs (CDMRP - U.S. Department of Defense) were used to identify early translational research project funding and clinical trials infrastructure support provided to researchers in Canada for years 2005 to 2010. These are the top two cancer research funding organizations. An additional $12M was added to account for potential investment by other funding sources outside of Canada.

2. Methodology

Unless otherwise noted, subsequent references to translational research refer to the early translation phase of the research translation continuum. For a detailed description of the methodology, the reader should consult *Cancer Research Investment in Canada, 2005–2009: The Canadian Cancer Research Alliance's Survey of Government and Voluntary Sector Investment in Cancer Research* (available at http://www.ccra-acrc.ca/index.php/publications-en/investment-reports-annual). Key abbreviations used in this document are provided in the sidebar.

ABBREVIATIONS

CCRA	Canadian Cancer Research Alliance
CCRS	Canadian Cancer Research Survey
CSO	Common Scientific Outline
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practice
IND	Investigational New Drug
INT	Interventive
NCI	National Cancer Institute (U.S.)
PK/PD	Pharmacokinetics/Pharmacodynamics
PMPRB	Patented Medicine Prices Review Board
RA	Risk Assessment
TRWG	Translational Research Working Group

2.1 PROJECT IDENTIFICATION

The data source for this study was the CCRS, an annual survey that involves the collection of information on research projects funded by 40 organizations/programs from the government and voluntary sectors. The database is currently populated with 12,629 research projects that were active at some point during the January 1, 2005 to December 31, 2010 period.

All projects in the CCRS database are coded in terms of the CSO, cancer site (using the International Statistical Classification of Diseases and Related Health Problems, ICD-10), and type of funding mechanism. The CSO is an international standard for classifying cancer research. It is grouped into seven categories (1-Biology, 2-Etiology, 3-Prevention, 4-Early Detection, Diagnosis, and Prognosis, 5-Treatment, 6-Cancer Control, Survivorship, and Outcomes Research, and 7-Scientific Model Systems), which are rolled up from 38 codes. (Details about the CSO can be obtained at http://www.icrpartnership.org/CSO.cfm.)

For the purposes of this study, projects coded entirely to the CSO category 1-Biology (n=3,834) were not considered because it was assumed that they were basic discovery projects and out of scope. The remaining 8,795 projects were reviewed and either excluded or included as part of the study sample[6]. Excluded projects focused on:

- basic discovery (biomolecular or epidemiological)
- model systems in which the research did not have immediate translational research goals
- surveillance, survivorship, and outcomes research
- treatment of cancer-causing infectious diseases

6. Projects coded to 1-Biology and another CSO code were included in the reviewed group of projects.

- late translation (e.g., phase III clinical trials,[7] research on dissemination and/or adoption of a modality)
- provision of general/multi-faceted infrastructure
- training/capacity building, creation/maintenance of tumour banks/tissue repositories, and large research platforms not directly linked to specific translational research activities/modalities. These projects are listed in Table 3.1.1 in the next chapter to recognize that these funded resources are essential for the conduct of translational research, although they are not translational research projects themselves.

The final sample consisted of 3,690 projects.

2.2 PROJECT CLASSIFICATION

This report incorporates the TRWG development pathways as its primary classification framework (as per Figure 1.1.2). The pathways typology distinguishes two classes of clinical modalities: risk assessment and interventive. **Risk assessment** modalities (RA) characterize the cancer-related health status of an individual and consist of biospecimens (biological molecules found in blood, other body fluids, or tissues) and image-based devices (e.g., computed tomography, contrast agents, and imaging enhancers). **Interventive** modalities (INT) change the cancer-related health status of an individual by either prevention or treatment and consist of agents (drugs or biological compounds), immune response modifiers (agents that mimic, augment, or require participation of a person's immune cells for optimal effectiveness), interventive devices (e.g., radiation therapy, cryoablation, high-intensity focused ultrasound), and lifestyle alterations (behavioural changes to reduce cancer risk). The developmental process underlying all six pathways consists of four phases:

- **Credentialing:** research that validates the modality
- **Creation of Modality:** research that creates and/or refines a tangible modality
- **Preclinical Development:** research that refines the modality for safety, quality, etc.
- **Clinical Trials:** early stage testing in people

The overarching **Supporting Tools** phase represents research on tools, techniques, or processes that support the research conducted in the four phases.

The Credentialing phase is distinct from basic discovery—it requires that the research project confirm a discovery and validate its potential clinical utility. Some specific research projects **included** as translational were:

7. Phase III cancer clinical trials within the CCRS represented an investment of $23.7M over the 2005 to 2010 period.

- establishing mitochondrial markers as valid predictors of treatment outcomes in human cervical cancer patients with known outcomes
- testing the inhibition of specific protein precursors on the prevention and treatment of hepatic micrometastases
- using non-invasive methods to determine if genetic signatures can be reliably identified in glioma cells

Examples of discovery projects **excluded** from the study were:

- identifying the role of a specific protein kinase in signalling pathways that control cell death
- exploring DNA profiles of lung cancer cells to identify a list of genes that may contribute to the aggressiveness of lung cancer
- determining the early genetic events in retinoblastoma

Details about the kinds of research coded to each modality-phase combination are provided on the following pages. The colour coding used in these tables is carried throughout the results section.

RISK ASSESSMENT MODALITIES

Table 2.2.1 outlines the coding criteria for research within each phase of the RA-I. Biospecimen-based and RA-II Image-based risk assessment modalities.

TABLE 2.2.1

RISK ASSESSMENT MODALITIES: CODING CRITERIA

Developmental Phase	BIOMARKERS	
	RA-I. BIOSPECIMEN-BASED [1]	RA-II. IMAGE-BASED [2]
DESCRIPTION	Protocols, reagents, or devices/instruments that reveal cancer risk from analysis of blood and/or tissues, the presence of a specific cancer or recurrent cancer, the stage or severity of a specific cancer, and how well the body responds to therapeutic intervention(s).	Includes devices like magnetic resonance imaging, computed tomography, and positron emission tomography scanners that identify the presence of a specific cancer, the stage or severity of a specific cancer, how well the body responds to treatment(s), and how to plan the most efficacious treatment on the basis of anatomical, functional, or molecular parameters. Also includes research on imaging agents, contrast agents, imaging enhancers, and therapeutic agents with secondary imaging attributes. Often characterized by applied research in contrast to the other modalities where laboratory research is often the point of entry. In addition, approvals tend to be more generic (on the basis of overall patient safety/efficacy) and are usually not related to specific clinical utility.
CREDENTIALING	• Discover molecular biomarker with clinical potential • Validate biomarker (confirm sensitivity/specificity expected for clinical utility) • Assess feasibility of development of protocol/reagent/device	• Discover imaging biomarker with clinical potential • Validate biomarker (confirm sensitivity/specificity expected for clinical utility) • Assess feasibility of developing agent or technique
CREATION OF MODALITY	• Define patient subset with biomarker using small number of specimens in a single laboratory • Validate assay and correlation of biomarker with outcomes retrospectively across large number of specimens in different labs	• Develop new imaging platform • Develop new technique/imaging agent • If technique, optimize acquisition of analytic parameters in preclinical or phase I setting • If imaging agent, perform radiolabeling dosimetry
PRECLINICAL DEVELOPMENT	• Develop/refine clinical grade biomarker assay protocol/reagent/device • Validate in prospective human study of biomarker correlation with outcome	• Test/refine imaging performance, pharmacokinetics/pharmacodynamics (PK/PD), toxicology, etc., in preclinical setting • Establish Good Manufacturing Practice (GMP) production for agent as necessary • Test/refine imaging performance, PK/PD, toxicology, etc., in phase I/II setting • Establish Good Manufacturing Practice (GMP) for platform as necessary • Optimize platform available for clinical testing
CLINICAL TRIALS	• Study in humans of utility of biomarker to direct therapy or chemoprevention or predict outcome/risk	• Conduct phase II+ trials for specific clinical utilities
SUPPORTING TOOLS	• Develop biospecimen repositories linked with outcomes data for relevant disease • Develop research-grade reproducible assay and standard reagent(s) for biomarker or profile	• Develop new assays or other supporting tools

[1] For more information, see S. Srivastava et al., "Translational Research Working Group developmental pathway for biospecimen-based assessment modalities," *Clinical Cancer Research* 14(18) 2008:5672–5677.

[2] For more information, see G.S. Dorfman et al., "Translational Research Working Group developmental pathway for image-based assessment modalities," *Clinical Cancer Research* 14(18) 2008:5678–5684.

INTERVENTIVE MODALITIES

Table 2.2.2 outlines the inclusion criteria for research within each phase of the four interventive modalities.

TABLE 2.2.2

INTERVENTIVE MODALITIES: CODING CRITERIA

Developmental Phase	DRUGS		INT-III. INTERVENTIVE DEVICES [3]	INT-IV. LIFESTYLE ALTERATIONS [4]
	INT-I. AGENTS (DRUGS & BIOLOGICS) [1]	INT-II. IMMUNE RESPONSE MODIFIERS [2]		
DESCRIPTION	Includes small molecules and biological compounds.	Immune-based therapies that either stimulate an individual's immune system so that it will recognize and destroy cancerous cells (also known as "active" immunotherapy, which includes vaccines and cytokine therapy), or provide the immune response to the patient (also known as "passive" immunotherapy like monoclonal antibody drugs or adoptive T-cell therapy).	May target local-regional sites of cancers or precancerous lesions or be delivered in systemic ways (i.e., for treatment of hematological malignancies or metastases). Examples include radiation therapy, cryoablation, radiofrequency or microwave ablation, interstitial laser thermal therapy, photodynamic therapy, high-intensity focused ultrasound, and minimally invasive surgery tools. May be delivered noninvasively, percutaneously, endoscopically, laparoscopically, transvascularly, or by open surgery. Research focused on the mechanism for guiding/monitoring the device and its effects is also included under this modality, as is research focused on radiobiological modelling and dosimetry.	Although the TRWG includes survivorship research within the Lifestyle Alterations, for the purposes of this report, this modality has been limited to behavioural change interventions used to prevent and/or treat a person's cancer disease status, thus making it more comparable with the other INT modalities. Includes stopping tobacco use, increasing physical activity, reducing alcohol intake, modifying diet, limiting sun exposure, and avoiding hazardous occupational exposures. Interventions that involve an assistive agent (e.g., nutritional supplements, nicotine replacement) or a device (e.g., acupuncture) are also included in this pathway.
CREDENTIALING	• Discover target with clinical potential • Validate target (convincing empirical basis for attributing clinical potential) • Assess feasibility of developing agent against the target	• Discover antigen or other immune modifier with clinical potential in specific cancer(s) • Validate immune modifier (convincing empirical basis for attributing clinical potential) • Assess feasibility of identifying/developing the immune response modifier	• Identify technology innovation or innovative application of existing technology • Validate technology (convincing empirical basis for attributing clinical potential) • Assess feasibility of developing the technology	• Validate correlation between behaviour or exposure and disease (empirical basis for attributing causal effect consistent across diverse populations/study designs) • Identify specific lifestyle alteration that would mitigate the risk factor
CREATION OF MODALITY	• Assess impact of perturbing target using experimental system • Identify candidate agents and screen for binding and influence on activity • Select lead candidate	• Characterize and/or modify antigens • Identify or develop delivery vehicle (vector, cell, etc.) • Identify or develop immune modulator (adjuvant, cytokine, chemokine, etc.) • Develop immune response modifier • Measure response to immune response modifier and refine antigen(s), delivery vehicle, immune modulator, as necessary • Refine immune response modifier and/or immunization strategy • Identify lead immune response modifier candidate	• Analyze utility of technology in laboratory • Build/refine prototype device • Test prototype on phantoms and/or animals • Define usage protocol for humans	• Specify lifestyle alteration

Developmental Phase	DRUGS		INT-III. INTERVENTIVE DEVICES [3]	INT-IV. LIFESTYLE ALTERATIONS [4]
	INT-I. AGENTS (DRUGS & BIOLOGICS) [1]	INT-II. IMMUNE RESPONSE MODIFIERS [2]		
PRECLINICAL DEVELOPMENT	• Conduct preliminary toxicology screening • Conduct process development/pilot manufacturing • Verify activity/PK in pilot product • Implement Good Laboratory Practice (GLP)/GMP • Verify activity/pharmacokinetics (PK)/ stability/quality control in GLP/GMP product • Perform definitive toxicology screening • Complete Investigational New Drug (IND) submission	• Conduct process development/pilot manufacturing • Verify activity in pilot product • Implement GLP/GMP • Verify activity in GMP/GMP product • Conduct toxicology screening • Complete IND submission	• Build/refine clinical-grade device • Test clinical-grade device on phantoms and/or animals • Conduct phase 0 tests on humans • Prepare regulatory submission	• Evaluate effect in relevant animal model
CLINICAL TRIALS	• Conduct phase I clinical trial(s) • Conduct phase II clinical trial(s)	• Conduct phase I clinical trial(s) • Conduct phase II clinical trial(s)	• Conduct phase I trials (proof of principle)	• Conduct pilot study to assess efficacy of lifestyle alteration • Refine specification of lifestyle alteration • Conduct study of efficacy in larger, more diverse population
SUPPORTING TOOLS	• Identify/develop research-grade reproducible assay for effect of agent on oncogenic activity • Identify/develop clinically or target-relevant cell culture system(s) and/or target-relevant animal model(s) • Develop and validate assay and standard reagents or imaging methods to measure biomarkers of biological response • Develop and validate assay and standard reagents or imaging methods to measure biomarkers of endpoint in humans • Identify or develop biospecimen/image repositories linked with outcomes data for relevant disease • Identify/develop research-grade reproducible assay and standard reagents or imaging methods to measure target • Validate assay or imaging biomarker(s) that define(s) patient cohort likely to respond to agent	• Identify/develop clinically or target-relevant cell culture system(s) and/or animal model(s) • Develop/validate assay and standard reagents or imaging biomarkers to measure response to immune response modifier • Develop/validate assay and standard reagents or imaging biomarkers to measure molecular endpoint in humans • Identify/develop research-grade reproducible assay and standard reagents or imaging biomarkers for immune target • Identify/develop biospecimen/image repositories linked with outcomes data • Identify patient subset with immune target • Characterize statistical correlation of target with outcome • Validate assay or imaging biomarkers for identifying patient cohort	• Identify/develop reproducible assay and standard reagents or imaging biomarkers for target • Identify/develop biospecimen/image repositories linked with outcomes data • Identify marker(s) that define patient subset with target • Develop/validate assay and standard reagents or imaging biomarkers to measure biological response or molecular endpoint in humans • Characterize statistical correlation of markers with outcomes, select optimal marker or profile • Validate assay or imaging biomarker for identifying patient cohort	• Identify target population via existing databases or new studies • Develop and validate biochemical, behavioural, and/or imaging assays to measure effect of lifestyle alteration

[1] For more information, see R.L. Schilsky et al., "Translational Research Working Group developmental pathway for anticancer agents (drugs or biologics)." *Clinical Cancer Research* 14(18) 2008:5685–5691.

[2] For more information, see M.A. Cheever et al., "Translational Research Working Group developmental pathway for immune response modifiers," *Clinical Cancer Research* 14(18) 2008:5692–5699.

[3] For more information, see G.S. Dorfman, T.S. Lawrence, and L.M. Matrisian, "Translational Research Working Group developmental pathway for interventive devices," *Clinical Cancer Research* 14(18) 2008:5700–5706.

[4] For more information, see E.T. Hawk et al., "Translational Research Working Group developmental pathway for lifestyle alterations," *Clinical Cancer Research* 14(18) 2008:5707–5713.

Additional Coding Conventions

For the purposes of this report, investment in equipment and other related infrastructure that is **directly** used in translational research projects was also identified. This category included support for:

- specific equipment
- laboratory set-up/multi-user equipment and other infrastructure, when the principal investigators were actively involved in translational research
- related workshops/conferences
- letters of intent and other research planning/development activities, such as network set-up
- support for clinical trials infrastructure

Funding for clinical trials infrastructure was weighted at 30% and coded to Agents. The weighting was derived from the finding that early-stage clinical trials represented about 30% of the investment of all clinical trials in the CCRS and that the vast majority was drug trials.

Other conventions, designed to clarify issues related to modality coding, were as follows:

- Research on image-guided treatment (e.g., adaptive radiotherapy) was coded to Interventive Devices.
- Research involving radionuclides was coded to Image-based risk assessment when imaging biomarkers were the focus of the research and to Agents when treatment was the focus.
- Research on devices for biopsy and lymphadenectomy was coded under Biospecimen-based RA.
- Research on drug-delivery vehicles (e.g., lipid-based nanoparticles) was coded as Agents and/or Immune Response Modifiers. Where the translational effort was concentrated on a mechanical device for drug delivery, however, the research was coded to Interventive Devices.
- Research on optimizing stem cell and bone marrow transplants was coded to Agents.
- Research on the prevention of cancer-causing infectious agents was coded to Agents and/or Immune Response Modifiers. (As previously mentioned, projects dealing with the treatment of cancer-causing infectious agents were excluded.)

2.3 REPORTING CONVENTIONS

The calendar year defines the time frame within the CCRS to standardize the disparate funding cycles of participating organizations to consistent 12-month periods. In this study the investment for each project was based on a prorated calculation that assumed that project dollars were paid in equal monthly instalments in accordance with project start and end dates. Project funding was calculated for the six years within the period January 1, 2005 to December 31, 2010 and analyzed by three two-year periods or biennia (that is, 2005–2006, 2007–2008, and 2009–2010).

Project budgets are weighted/allocated in a variety of ways, as summarized in Table 2.3.1. Overall, project budgets were weighted from 10% to 100%. Most project budgets (67.6%) were included in full. Figures shown in the tables and charts are rounded and may not always equal the totals shown.

TABLE 2.3.1

EXAMPLES OF WAYS IN WHICH PROJECT BUDGETS WERE WEIGHTED

Issue	EXAMPLE	APPROACH
Project is not entirely focused on cancer	*Microwave-acoustic breast tumour detection and design and analysis of wireless implants for neurophysiological research*	Budget was weighted at 50% because the cancer component was assumed to compose half the research activities.
Project does not entirely qualify as early translational research	*Establish the most effective combination chemotherapy with anti-angiogenic factors on osteosarcoma and elucidate the hereditary mechanism of embryonal rhabdomyosarcoma*	Budget was weighted at 50% because the project had an early translational component focusing on novel anti-angiogenic agents, as well as a discovery component focusing on the genetic etiology of rhabdomyosarcoma.
Project involves more than one modality of the TRWG framework	*Combined oncolytic virotherapy and targeted radiotherapy of peritoneal carcinomatosis*	Budget was split between Agents and Interventive Devices.
Project spans more than one phase of the TRWG framework	*Regional delivery of antineoplastic and chemosensitizing agents by polymeric microspheres*	Budget was assigned to both Creation of Modality and Preclinical Development.
Project involves more than one cancer site	*Molecular structure for the optimization of single domain antibodies developed against brain and breast cancer biomarkers*	Budget was allocated to two cancer sites (i.e., brain, breast). Note that predetermined site allocations based on expert input are used for projects dealing with specific risk factors (e.g., tobacco) when cancer sites were not identified.

For the analyses of research personnel, nominated principal investigators were included in the head count when they had at least one operating grant, equipment award or career award weighted at 50% or higher for early translational research. All trainees awarded grants were counted when at least some of their research project involved early translational research.

The institutional affiliation of the nominated principal investigator was used for analyses based on geography/province. There is only one nominated principal investigator per project. Components of multi-component projects were considered individual projects if the funding organization provided details (i.e., description, researchers, budget, etc.) on the component parts. The Canadian Cancer Society, National Research Council of Canada, Ontario Institute for Cancer Research (for some projects), The Terry Fox Foundation, and the now defunct Canadian Breast Cancer Research Alliance provided this level of detail. For clinical trials supported by the Canadian Cancer Society, each site involved in the trial was treated as a separate project with its own principal investigator and budget (based on per case and site administration funding). There are, however, many large projects, which may involve multiple researchers that straddle provincial boundaries, for which details are not available.

All projects are coded to cancer sites using the ICD-10 in accordance with the level of detail provided in the project description. ICD-10 codes are rolled up to 24 cancer sites. Collectively, these cancer sites represent ~90% of all new cancer cases and deaths per year. Individually, each represents a weighted average of at least 0.3% of all new cancer cases and deaths in a given year.

To streamline presentation of the findings, the TRWG development pathways were grouped as follows: Drugs (INT-I. Agents plus INT-II. Immune Response Modifiers), Biomarkers (RA-I. Biospecimen-based plus RA-II. Image-based), Interventive Devices (INT-III), and Lifestyle Alterations (INT-IV). In order to simplify the graphic presentations of the phase-specific investments for each modality, averaged annual investments from 2005 to 2010 were computed for funders, cancer sites, and provinces and those with the highest averages were selected.

The reader is advised that the scales used for the investment axis varies from graph to graph even when the same graphing conventions are used to portray modality-specific trends.

2.4 LIMITATIONS

This study shares the same limitations as the CCRS. The CCRS captures data on projects funded on the basis of peer review and often in response to publicly announced research granting competitions. It is not designed to include all intramural translational cancer research supported by federal and provincial governments/agencies or by universities, hospitals, or cancer centres. Although there has been an attempt to include research funding by hospital foundations, to date, no data has been obtained. In addition, the BC Cancer Agency did not contribute data to the CCRS during the reporting period so the figures shown for British Columbia may underrepresent the level of early translational cancer investment for the province.

Research undertaken by industry is also not part of the CCRS database. As noted in chapter 1, industry investment in the preclinical and early trials phases of translational research is likely substantial.

Beyond issues related to the scope of the survey, it is also worth mentioning that project classification is highly dependent on the quality of the research descriptions provided by the funding organizations. Coding to phase was most susceptible to poor project descriptions.

And finally, it is recognized that there may be issues related to the study's methodology. The inclusion of validated discovery within the definition of the Credentialing phase in the TRWG framework is somewhat controversial. In NCI's own pilot work involving the framework, there was concern that the translational relevance of its research investment may have been overstated. There are also concerns that the inclusion of Lifestyle Alterations was a forced fit and did not readily belong in what was traditionally construed as biomedical/clinical translational research. The separation of Immune Response Modifiers from other Agents, while justified by the TRWG because of their primary mode of action and the inherent methodological challenges of immune response research, is a fairly arbitrary distinction. Furthermore, the exclusion of investment in training/capacity building and stand-alone biospecimen banks/repositories and platforms, which are important foundations for translational research, may have understated the extent of the investment.

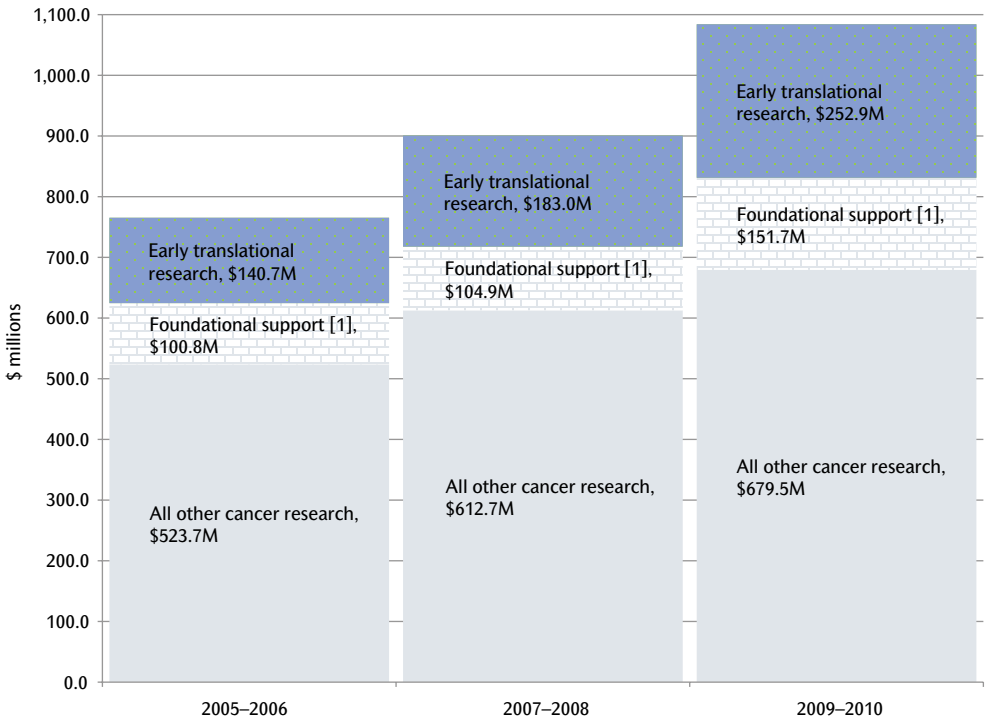
3. RESULTS

3.1 OVERALL INVESTMENT

Investment in early translational research as defined by the TRWG framework grew from $140.7M in 2005–2006 to $252.8M in 2009–2010, a 79.3% percent increase (67.0%, when corrected for inflation), which surpassed the 41.7% increase found for the investment in cancer research overall. Correspondingly, the investment in early translational research represented 23.3% of the overall cancer research investment in 2009–2010, up from 18.4% in 2005–2006.

FIGURE 3.1.1

CANCER RESEARCH INVESTMENT CAPTURED IN THE CCRS BY FUNDING PERIOD



[1] Includes investment in platforms/instrastructure, capacity-building/training, and biorepositories that support translational and discovery research. See Table 3.1.1 for details.

Translational research would not be possible without investment in foundational support—that is, investment in projects that provide training/capacity building, research platforms/infrastructure, and biorepositories to support translational as well as discovery-based research. The investment in foundational support critical to translational research that is captured in the CCRS is shown in Figure 3.1.1 and is detailed in Table 3.1.1. Of note, the investment in foundational support is not included in the early translational modality-phase specific analyses that form the remainder of this chapter.

TABLE 3.1.1

FOUNDATIONAL PROJECTS EXCLUDED FROM THE EARLY TRANSLATIONAL RESEARCH INVESTMENT CALCULATION

TYPE OF PROJECT	ADMINISTERING ORGANIZATION		PROJECT TITLE
PLATFORMS/INFRASTRUCTURE	Canada Foundation for Innovation	B.C.	• Centre for integrated genomics: The new BC Cancer Research Centre
		Alta.	• High-field MR for Biological Image-Guided Tomotherapy at the University of Alberta • Positron Emission Tomography for Basic Research, Radiopharmaceutical Development and Translational Research in Patients with Cancer – An Alberta Cancer Board/University of Alberta Joint Project at the University of Alberta • Creation of an Institute for Biomolecular Design (IBD) at University of Alberta
		Sask.	• BioMedical Imaging and Therapy (BMIT) Beamline at the Canadian Light Source at the University of Saskatchewan
		Ont.	• Advanced Medical Discovery Institute: Drug Discovery and Clinical Impact in Cancer at the University Health Network • Building the (University Health Network) UHN Advanced Therapeutics Research Platform • Centre for Functional Genomics and Chemical Genetics at McMaster University • Centre for Research in Image-Guided Therapeutics at Sunnybrook Health Sciences Centre • NanoMed Fab: A nanofabrication centre for personalized medicine at University Health Network • Ontario Initiative in Personalized Stem Cell Medicine at the University of Toronto • Ontario Regional Centre for Cell and Vector Production at the University Health Network • Robotic Positioning for Image-guided Surgery and Radiation Therapy at the University Health Network • Spatio-Temporal Targeting and Amplification of Radiation Response (STTARR) Innovation Centre at the University Health Network • Sunnybrook and Women's College Comprehensive, Multidisciplinary Breast Cancer Research Centre • Toronto Angiogenesis Research Centre at Sunnybrook Health Sciences Centre • Translation of Innovation into Medical Excellence (TIMEx) at the Ottawa Hospital Research Institute
		Que.	• Brain Tumour Initiative at the Montreal Neurological Institute • Creation of the Institute of Research in Immunovirology and Cancer (Institut de Recherche en Immunovirologie et Cancérologie) (IRIC) at the Université de Montréal • Integration of advanced technologies into a multidisciplinary biomedical research complex at the Université de Sherbrooke • IRIC Phase II: From Target Discovery to Clinical Application at the Université de Montréal • Montreal Centre for Experimental Therapeutics in Cancer (MCETC) at McGill University • National Core Facility to Monitor Immune Responses in Humans to Vaccines Against Infectious Diseases and Cancer at the Université de Montréal • Translational Research and Intervention Across the Lifespan at McGill University Health Centre
	Canadian Cancer Society	Can.	• Support for NCIC Clinical Trials Group [trial-specific funding for Phase I and II trials, however, is included in the analysis]
	Michael Smith Foundation for Health Research	B.C.	• BC Clinical Genomics at The University of British Columbia
	Networks of Centres of Excellence - Centres of Excellence for Commercialization	B.C.	• Advanced Applied Physics Solutions, Inc. (AAPS) in Vancouver • Centre for Drug Research and Development (CDRD) in Vancouver (has also been supported through the Canada Foundation for Innovation programs) • Prostate Centre's Translational Research Initiative for Accelerated Discovery and Development (PC-TRIADD) at the Vancouver Prostate Centre at Vancouver General Hospital (has also been supported through the Canada Foundation for Innovation programs)
		Ont.	• Centre for Probe Development and Commercialization (CPDC) at McMaster University (in partnership with Cancer Care Ontario)

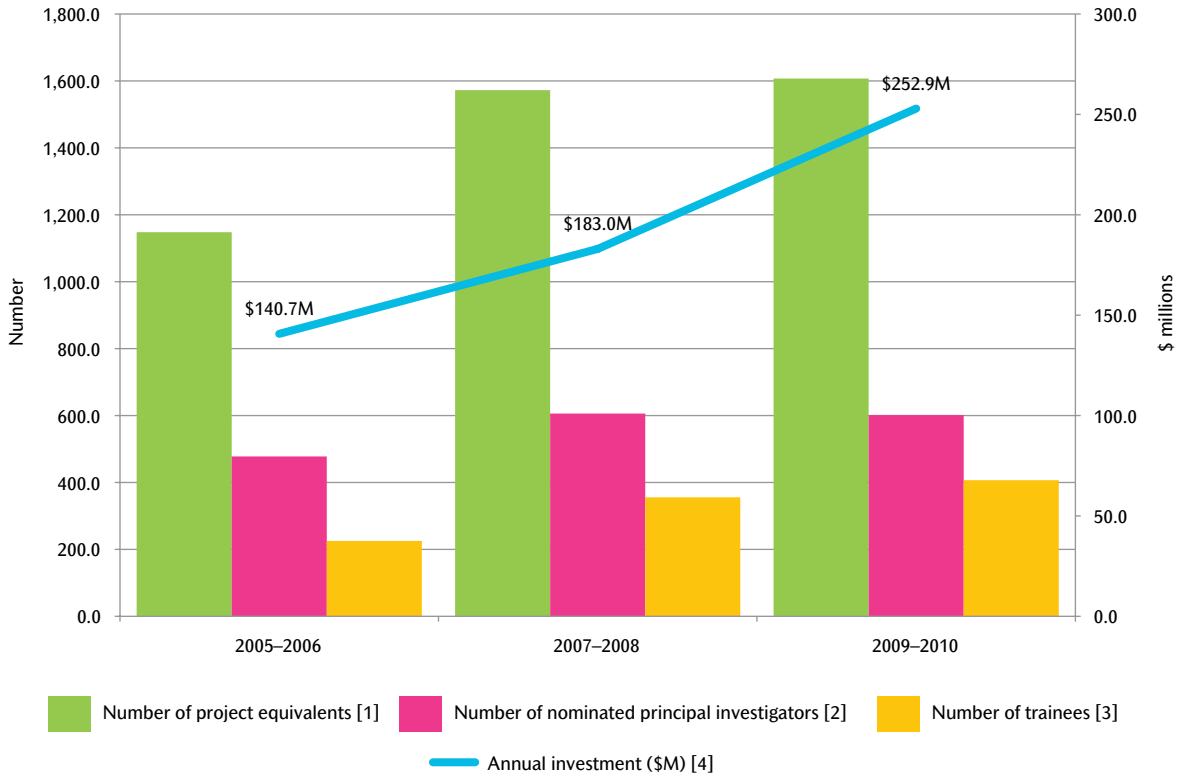
TYPE OF PROJECT	ADMINISTERING ORGANIZATION		PROJECT TITLE
		Que.	• Institute for Research in Immunology and Cancer (IRIC)/CECR in Therapeutics Discovery (IRICoR) at the Institut de recherche en immunologie et en cancérologie • Quebec Drug Discovery Consortium (CQDM)/Consortium québecois sur la découverte du médicament (CQDM) (funded through the Business-led Networks of Centres of Excellence – Group)
	Ontario Institute for Cancer Research	Ont.	• High Impact Clinical Trials Program (HICT) - Translational Research Teams at Lawson Health Research Institute, McMaster University, Ottawa Hospital Research Institute, Princess Margaret Cancer Centre, Thunder Bay Regional Health Sciences Centre
	Ontario Ministry of Research and Innovation	Ont.	• Integrated Molecular Pathology of Targeted Cancer Therapy in Lung Cancer at the University Health Network
CAPACITY-BUILDING/TRAINING	Canadian Institutes of Health Research	B.C.	• Bioinformatics training for health research at the BC Cancer Agency - Canada's Michael Smith Genome Sciences Centre • CIHR Multidisciplinary Training in Drug Development (M-TraDD) Program at The University of British Columbia
		Alta.	• Alberta Cancer Board Training Program in Translational Cancer Research in a partnership with the University of Alberta and the University of Calgary
		Sask.	• CIHR Training Grant in Health Research Using Synchrotron Techniques (CIHR - THRUST) at the University of Saskatchewan
		Ont.	• CIHR Strategic Training Grant in the Development of Biological Therapeutics at the University of Toronto • CIHR Training Grant in Cancer Research and Technology Transfer (CaRTT) at The University of Western Ontario • Clinician scientists in molecular oncologic pathology, a Strategic Training Initiative in Health Research at the University of Toronto • London Strategic Training Initiative in Cancer Research and Technology Transfer at the London Regional Cancer Program at the London Health Sciences Centre (in partnership with Cancer Care Ontario) • Queen's University Transdisciplinary Training Program in Cancer Research at Queen's University (in partnership with the Cancer Research Society) • Research excellence in radiation medicine for the 21st century, a Strategic Training Initiative in Health Research at the Princess Margaret Cancer Centre (in partnership with Cancer Care Ontario) • Tobacco use in special populations research training program at The Centre for Addiction and Mental Health (CAMH)
		Que.	• CIHR-FRQS Drug Development Training Program (DDTP) at McGill University (in partnership with the Fonds de recherche du Québec - Santé) • CIHR-FRSQ Training Grant – Applied Genetic Medicine at the Centre hospitalier universitaire Sainte-Justine (in partnership with the Fonds de recherche du Québec - Santé) • CIHR Strategic Training Program in Chemical Biology at McGill University • CIHR/FRQS Training Program in Cancer Research at McGill University (in partnership with the Fonds de recherche du Québec - Santé) • IRCM training program in cancer research: From genomics to molecular therapy, a Strategic Training Program Grant at Institut de recherches cliniques de Montréal (in partnership with the Cancer Research Society) • McGill University Cancer Consortium training grant in cancer research (in partnership with the Fonds de recherche du Québec - Santé) • Montreal Centre for Experimental Therapeutics in Cancer (MCETC) at Sir Mortimer B. Davis Jewish General Hospital (in partnership with the Fonds de recherche du Québec - Santé)
	The Terry Fox Foundation	Ont.	• Terry Fox Foundation Strategic Health Research Training Program in Molecular Pathology of Cancer at CIHR at the University Health Network • Terry Fox Foundation Strategic Training Initiative for Excellence in Radiation Research for the 21st Century (EIRR21) at CIHR at the Princess Margaret Cancer Centre • Terry Fox Foundation Training Program in Transdiciplinary Cancer Research at CIHR at Queen's University (in partnership with Canadian Institutes of Health Research)
	Canadian Cancer Society	B.C.	• Prostate Centre at the Vancouver General Hospital, a large centre training grant
		Ont.	• Prostate Cancer Group at the Princess Margaret Cancer Centre, a large centre training grant

TYPE OF PROJECT	ADMINISTERING ORGANIZATION		PROJECT TITLE
	Natural Sciences and Engineering Research Council	Ont.	• CREATE Molecular Imaging Probes Program at McMaster University • NSERC CREATE Training Program in Computer-assisted Medical Intervention (CAMI) at The University of Western Ontario
BIOREPOSITORIES	Alberta Cancer	Alta.	• ACRI Biorepository • PolyomX Initiative
	Brain Tumour Foundation of Canada	Ont.	• Brain Tumour Tissue Bank at London Health Sciences Centre
	Canada Foundation for Innovation	Ont.	• Canadian Centre for Applied Cancer Genetics at The Hospital for Sick Children (in partnership with the Ontario Ministry of Research & Innovation)
		Que.	• Network of tissue banks and data for breast and ovarian cancers at the Université de Montréal (in partnership with the Fonds de recherche du Québec - Santé)
	Canadian Breast Cancer Foundation	Alta.	• Canadian Breast Cancer Foundation Alberta Research Tumour Bank
	Canadian Institutes of Health Research	Can.	• Canadian Tumour Repository Network (CTRNet)
		Man.	• Manitoba Tumour and Breast Tumour Banks at the University of Manitoba
	Canadian Partnership Against Cancer	Can.	• National Bio-Bank to support the Canadian Partnership for Tomorrow Project (CPTP)
	Fonds de recherche du Québec - Santé	Que.	• Réseau de recherche en cancer/Cancer Research Network, which includes the Leukemia Cell Bank, the Tissue and Data Bank, and the Experimental Therapies program
	Michael Smith Foundation for Health Research	B.C.	• BC BioLibrary at The University of British Columbia • Tumour Tissue Repository at the BC Cancer Agency
	Ontario Institute for Cancer Research	Ont.	• Ontario Tumour Bank
	Ovarian Cancer Canada	Can.	• National Ovarian Cancer Tissue Bank in Centre de recherche du CHUM - Pav. Notre-Dame, The University of British Columbia, and the University of Ottawa
	PROCURE	Que.	• PROCURE Québec Prostate Cancer Biobank
	Prostate Cancer Canada	Man.	• Manitoba Prostate Tumour Bank at the University of Manitoba

The early translational research investment is presented alongside the project equivalents, nominated principal investigators, and trainees in Figure 3.1.2. The number of trainees and number of projects rose from the first to the third biennia. The number of principal investigators, however, dropped slightly in 2009–2010, from a high of 606 in 2007–2008, suggesting that a smaller number of nominated principal investigators were receiving more of the early translational research dollars.

FIGURE 3.1.2

ANNUAL INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH BY FUNDING PERIOD



[1] Number of projects funded at some point in the calendar year and weighted by relevance to the early translational research schema. Projects may be weighted from 10% to 100%.

[2] Number of nominated principal investigators with one or more operating grant, career award, and equipment/infrastructure award funded at some point in the calendar year. Early translational research weighting was applied.

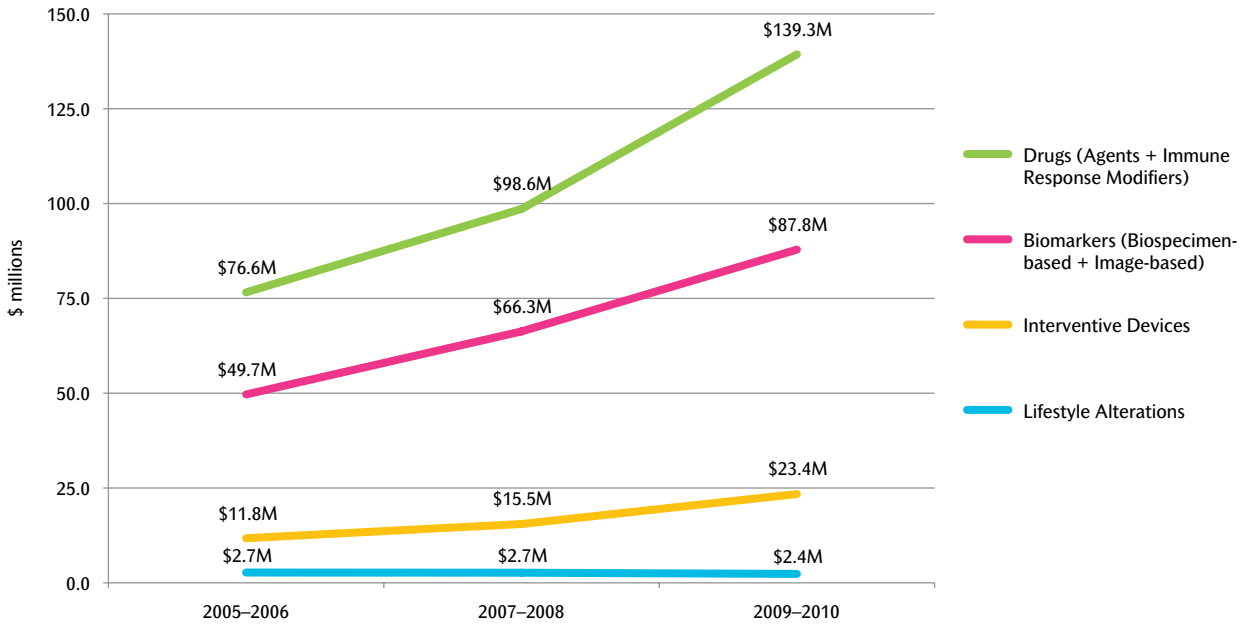
[3] Number of trainees who received training awards for undergraduate, graduate, and postgraduate studies. Early translational research weighted was applied.

[4] Investment as captured in the CCRS. An estimate of total investment is provided in Table 1.4.1.

In terms of the TRWG development pathways paradigm, investments in drugs (INT-I. Agents plus INT-II. Immune response modifiers), biomarkers (RA-I. Biospecimen-based plus RA-II. Image-based), and interventive devices (INT-III) nearly doubled from the first to the third biennia. Investment in lifestyle alterations (INT-IV), however, showed a slight drop in investment (Figure 3.1.3). There was no significant shift in the distribution of the investments during the three biennia – that is, drugs represented approximately 54% and biomarkers 35% of the overall early translational research investment for each of the three time periods.

FIGURE 3.1.3

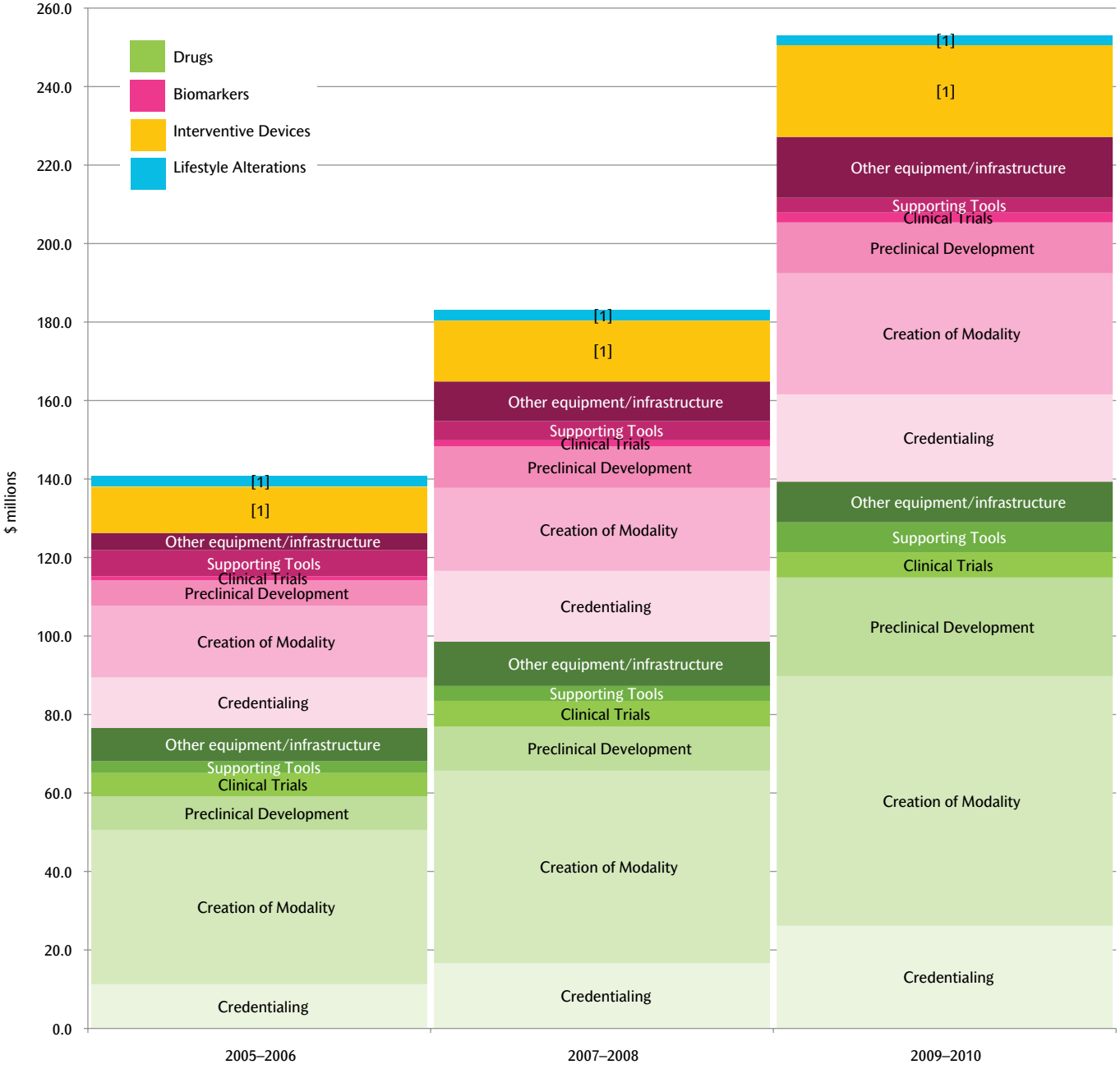
INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH BY MODALITY AND FUNDING PERIOD ($M)



An overview of the investment by modality and phase is presented in Figure 3.1.4. While a quarter of the investment was for "Drugs-Creation of Modality," the highest investment level for any modality-phase combination, there was a more than doubling of modality-phase investments from the first to the third biennia for (listed in descending order of percent change increases): Biomarkers-Other equipment/infrastructure, Drugs-Preclinical Development, Drugs-Supporting Tools, Biomarkers-Clinical Trials, Drugs-Credentialing, and Biomarkers-Preclinical Development. A more detailed look at the modalities is provided in the subsequent sections of this chapter.

FIGURE 3.1.4

INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH BY MODALITY, PHASE AND FUNDING PERIOD ($M)



[1] Includes all phases.

Investment in early translational research grew in all funding sectors. The greatest growth, however, was among provincial governments, where the investment nearly tripled from 2005–2006 ($33.6M) to 2009–2010 ($96.5M) (see Figures 3.1.5A and 3.1.5B) The $62.8M increased investment from the first to the third biennia was almost entirely the result of increased investments on the part of three organizations, most notably, the Ontario Institute for Cancer Research, and to a lesser extent, the Ontario Ministry of Research and Innovation and Alberta

Cancer, which included investments from the Alberta Cancer Board, Alberta Cancer Foundation, Alberta Health Services, and the Alberta Cancer Prevention Legacy Fund administered by Alberta Innovates – Health Solutions. Investment in early translational research represented one-third of the total cancer research investment by provincial organizations in 2009–2010.

FIGURE 3.1.5A

INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH FOR FUNDING SECTORS BY FUNDING PERIOD

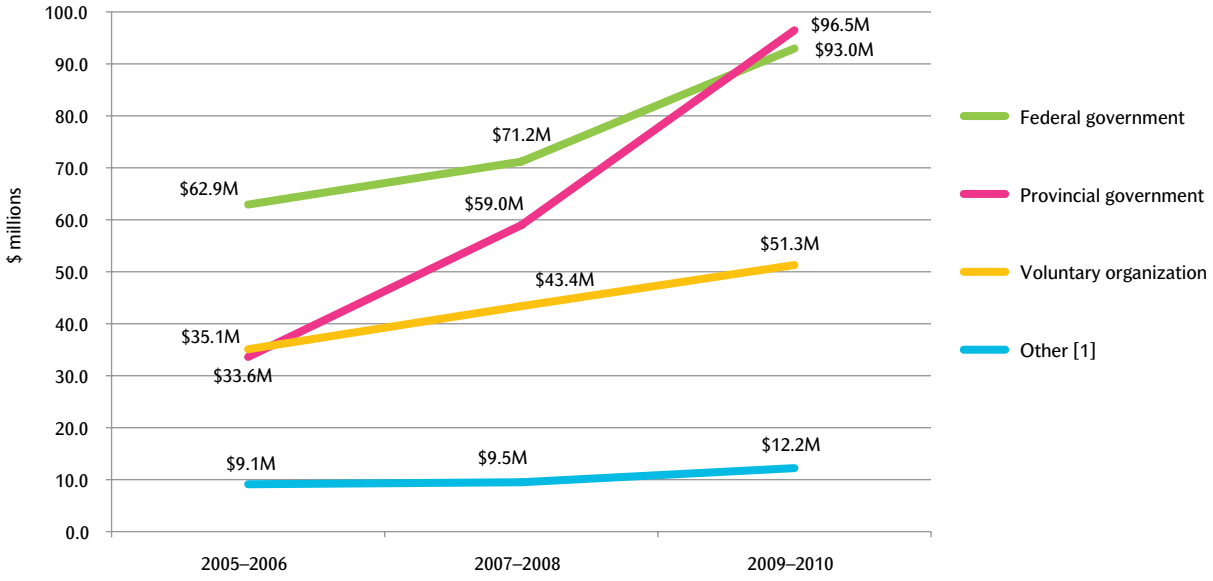
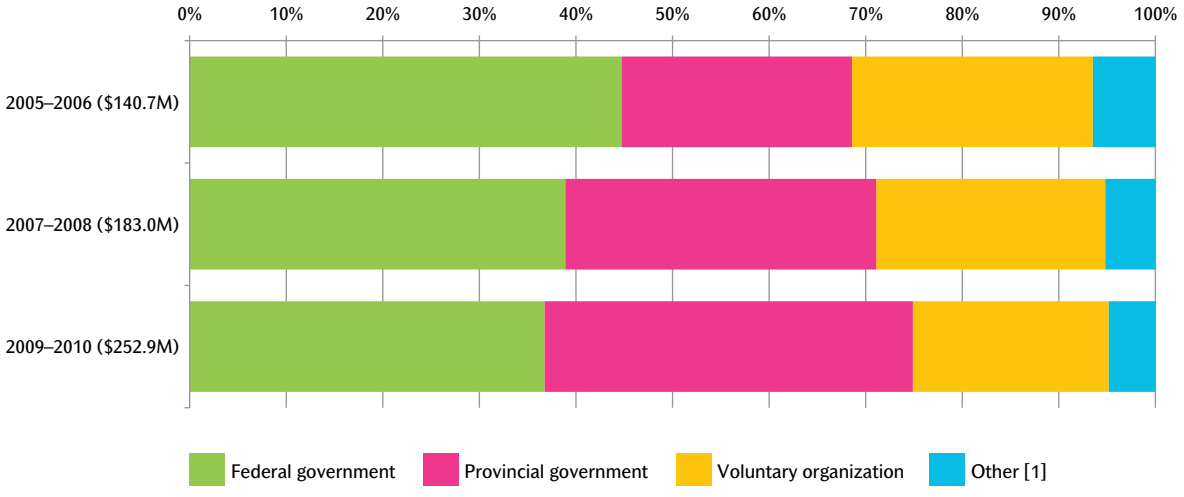


FIGURE 3.1.5B

DISTRIBUTION OF EARLY TRANSLATIONAL CANCER RESEARCH INVESTMENT BY FUNDING SECTORS FOR EACH FUNDING PERIOD



[1] Co-funding of projects supported by CCRS participant organizations by institutional, industry and foreign sources.

In terms of federal organizations, $30.0M more was invested in 2009–2010 than in 2005–2006. This increase was largely due to three organizations: Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council, and the National Research Council of Canada. Only 18% of the overall cancer research investment in 2009–2010 from the Federal government sector was in the early translational cancer research area, although this varied significantly from organization to organization.

Although a smaller piece of the overall early translational research investment, the investment by voluntary organizations in 2009–2010 was $51.3M, up from $35.1M in 2005–2006. This represented 27% of the overall cancer research investment in the third biennia for this sector. Much of the increased investment in 2009–2010 came from The Terry Fox Foundation, and to a lesser extent from the Canadian Breast Cancer Foundation and Prostate Cancer Canada. Details of the organization-level investments per biennia are provided in Appendix A.

Investment in operating grants in the area of early translational research grew from $107.6M in 2005–2006 to $173.7M in 2009–2010. The investment in operating grants was further analyzed in terms of whether or not the funding program was strategically-focused on translational research. The operating grant investment funded through programs that were focused on translational research increased only slightly from the first to third biennia (Figure 3.1.6A) and represented a shrinking proportion of operating grants for all sectors but the voluntary sector (Figure 3.1.6B). This finding may suggest that translational researchers were competing more successfully over time in open operating grants competitions. A bolder interpretation of this finding is that there has been a shift to translational research in cancer science overall.

FIGURE 3.1.6A

INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH OPERATING GRANTS BY FOCUS AND FUNDING PERIOD

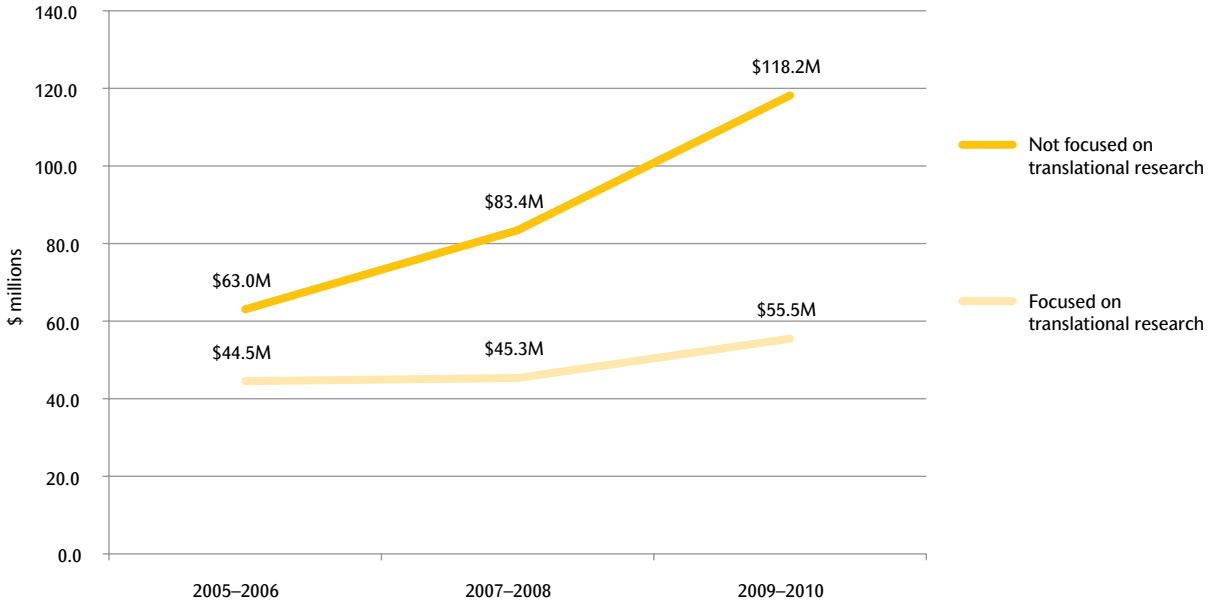
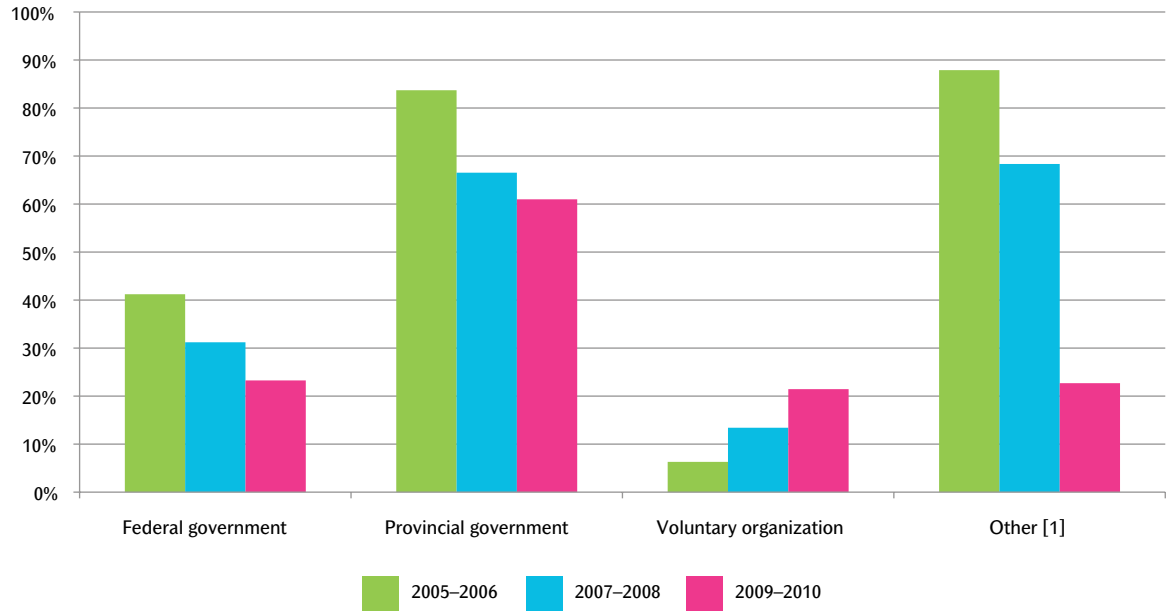


FIGURE 3.1.6B

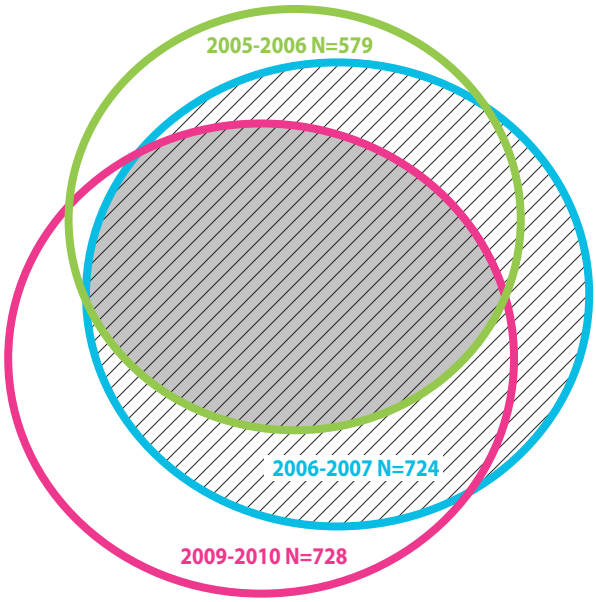
PROPORTION OF INVESTMENT IN CANCER RESEARCH OPERATING GRANTS FOCUSED ON EARLY TRANSLATIONAL RESEARCH BY FUNDING SECTOR AND FUNDING PERIOD



[1] Co-funding of projects supported by CCRS participant organizations by institutional, industry and foreign sources.

FIGURE 3.1.7A

NUMBER OF NOMINATED PRINCIPAL INVESTIGATORS [1] FUNDED FOR EARLY TRANSLATIONAL CANCER RESEARCH BY FUNDING PERIOD

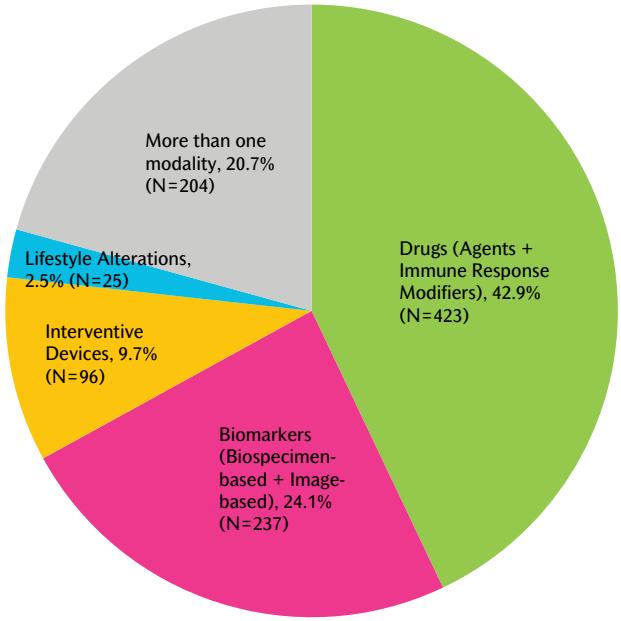


[1] There were 985 nominated principal investigators who had at least one operating grant, equipment award or career award in the 2005 to 2010 period in the area of early translational research weighted at 50% or higher. Investigators were grouped according to the years in which they received funding.

There were 985 nominated principal investigators who were funded for early translational research at some point in the six-year period, with a core of 358 researchers who were funded during all three biennia (Figure 3.1.7A). These data show a net increase of 149 researchers funded from 2005–2006 to 2009–2010, which may suggest some increased capacity. Of the 985 researchers, many were engaged in drug research exclusively, although 204 were funded for research focused on more than one modality (see Figure 3.1.7B).

FIGURE 3.1.7B

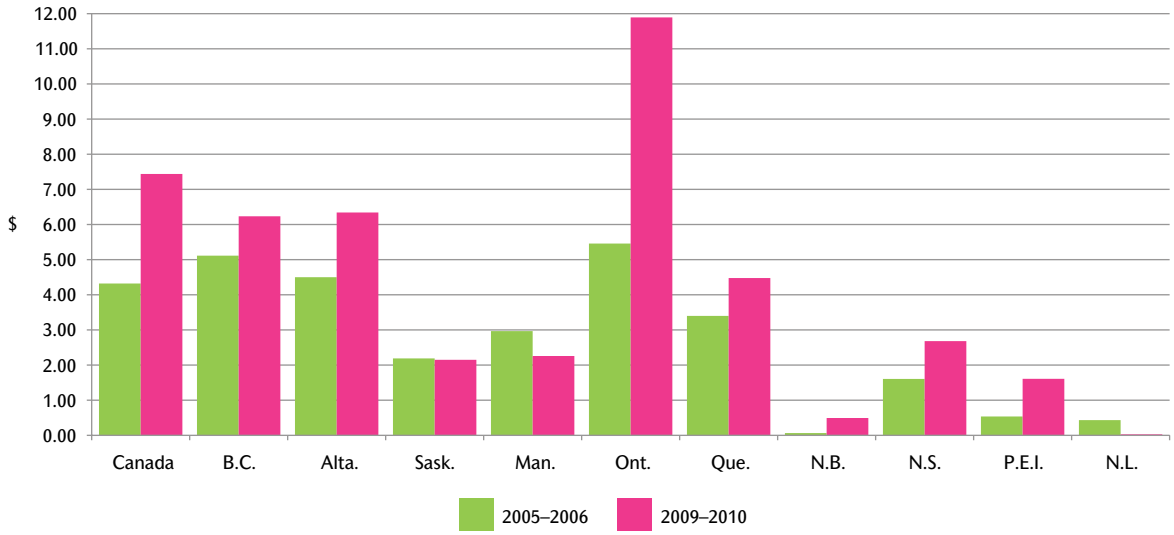
DISTRIBUTION OF NOMINATED PRINCIPAL INVESTIGATORS BY MODALITIES (N=985)



On a per capita basis, the investment in early translational cancer research was $7.44 in 2009–2010 compared to $4.32 in 2005–2006. There was significant growth in the investment in Ontario—at $11.89 in 2009–2010, this was more than double the amount in 2005–2006. The per capita investments in 2009–2010 for Alberta and British Columbia approached the national one at $6.34 and $6.23, respectively. There was a lower per capita investment in 2009–2010 than in 2005–2006 in Manitoba, Newfoundland and Labrador, and to a lesser extent, Saskatchewan despite the fact that per capita investment for Manitoba and Newfoundland and Labrador for all areas of cancer research actually increased. These data are summarized in Figure 3.1.8.

FIGURE 3.1.8

PER CAPITA INVESTMENT IN EARLY TRANSLATIONAL CANCER RESEARCH [1] BY PROVINCE OF NOMINATED PRINCIPAL INVESTIGATOR, 2005-2006 AND 2009-2010

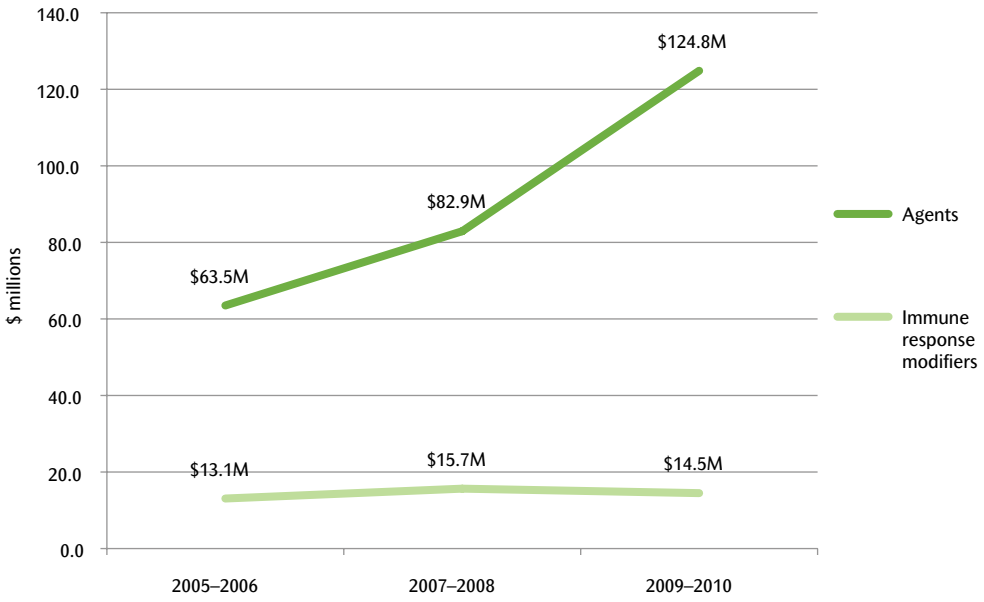


[1] Canada-wide and provincial population estimates from: Statistics Canada (2013). *Annual Demographic Estimates: Canada, Provinces and Territories, 2013.* Catalogue no. 91-915-X no. 2. Ottawa: Minister of Industry.

3.2 INVESTMENT IN DRUG RESEARCH

FIGURE 3.2.1A

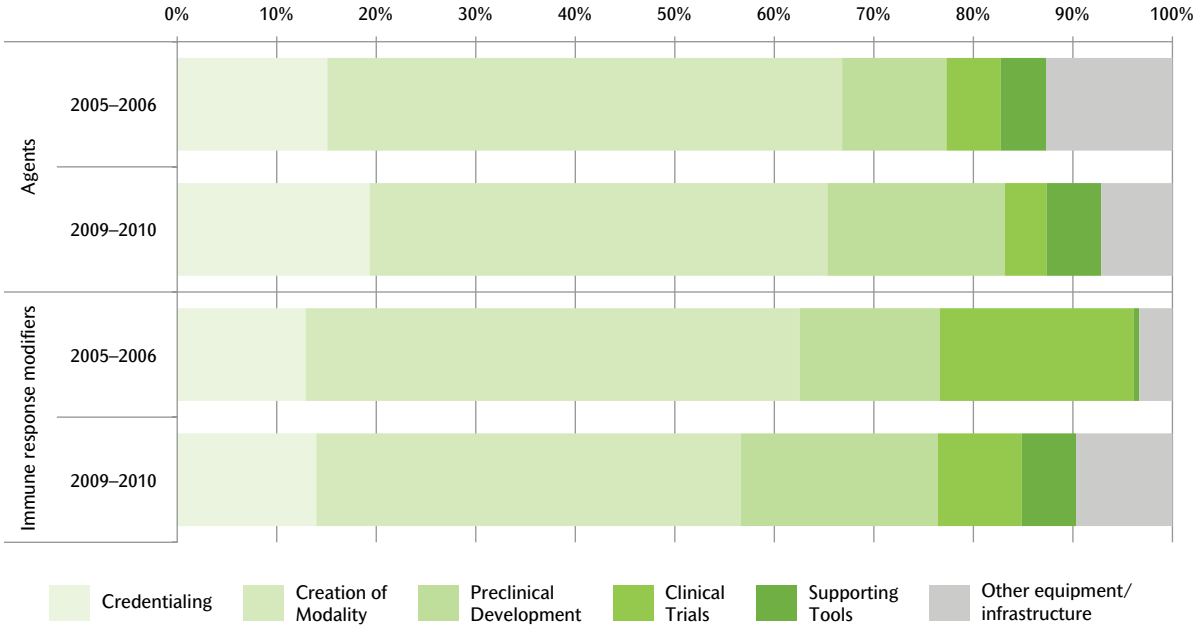
INVESTMENT IN EARLY TRANSLATIONAL DRUG RESEARCH BY FUNDING PERIOD



There was $62.7M more invested in early translational drug research in 2009–2010 than in 2005–2006. Immune response modifiers formed a small portion (10.4%) of the 2009–2010 investment (Figure 3.2.1A). There was proportionately more investment in the Preclinical Development, Credentialing and Supporting Tools in 2009–2010 than in 2005–2006 (Figure 3.2.1B). For the rest of the analyses presented in this section, agents and immune response modifiers are grouped.

FIGURE 3.2.1B

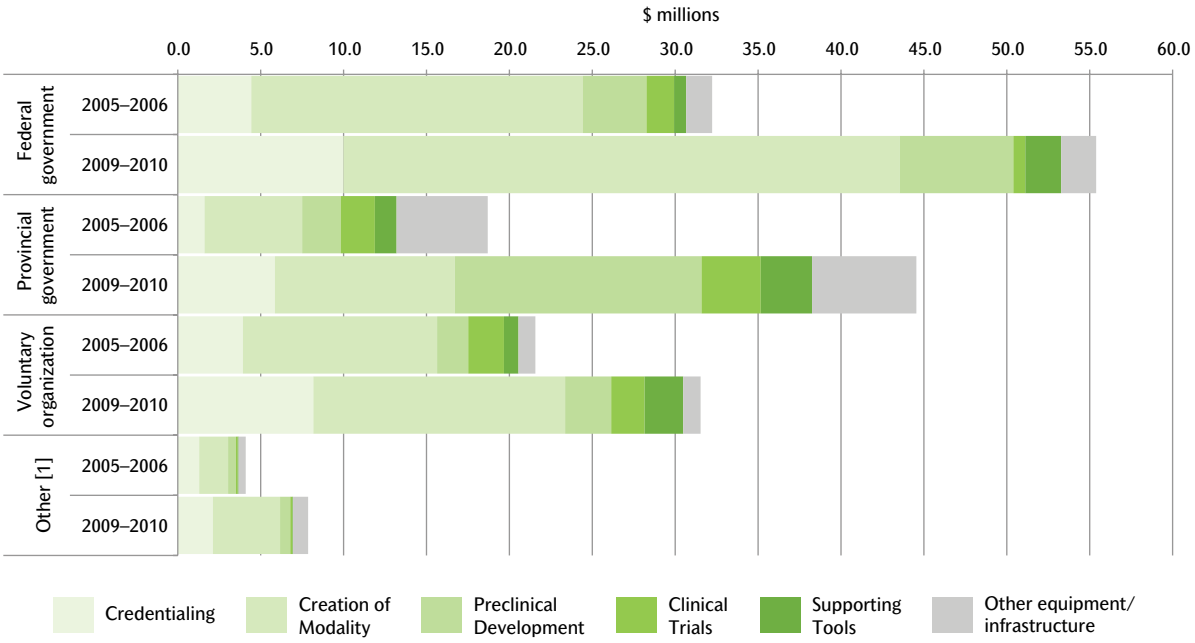
DISTRIBUTION OF INVESTMENT IN EARLY TRANSLATIONAL DRUG RESEARCH BY PHASE, 2005–2006 AND 2009–2010



Increases of $13.5M in investment in Creation of Modality by federal government organizations and $12.6M in Preclinical Development by provincial government agencies in 2009–2010 were two major changes from the first to third biennia in the funding sector analysis (see Figure 3.2.2). The investment in Credentialing from 2005–2006 to 2009–2010 also increased at the multimillion dollar level for the federal government, provincial government, and voluntary sectors.

FIGURE 3.2.2

INVESTMENT IN EARLY TRANSLATIONAL DRUG RESEARCH BY PHASE FOR EACH FUNDING SECTOR, 2005–2006 AND 2009–2010

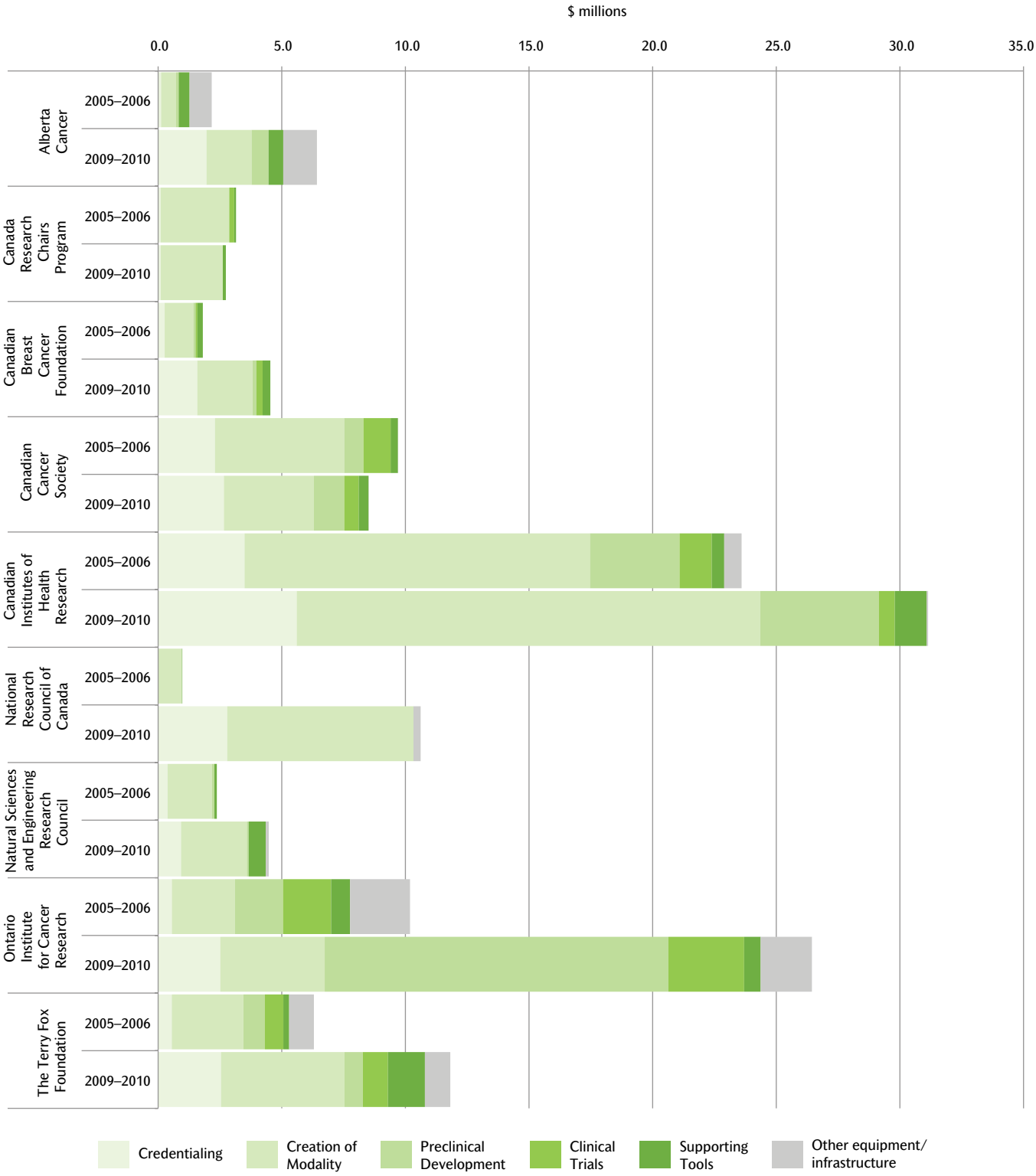


[1] Co-funding of projects supported by CCRS participant organizations by institutional, industry and foreign sources.

Over three-quarters of the early translational drug investment was accounted for by nine organizations (listed in Figure 3.2.3). The Canadian Institutes of Health Research had the highest investments for the first and last biennia, accounting for 30.8% of the 2005–2006 and 22.4% of the 2009–2010 investments. The Ontario Institute for Cancer Research invested $16.3M more in early translational drug research in 2009–2010 than 2005–2006, the largest increased investment among all funders. Much of this new investment was in the Preclinical Development phase. Investments per phase are detailed for the nine organizations in Figure 3.2.3. Early translational drug research represented a significant proportion of the total cancer research investment in 2009–2010 for the National Research Council of Canada (59.1%), Ontario Institute for Cancer Research (26.0%) and The Terry Fox Foundation (24.4%).

FIGURE 3.2.3

INVESTMENT IN EARLY TRANSLATIONAL DRUG RESEARCH BY PHASE FOR SELECTED FUNDERS [1], 2005–2006 AND 2009–2010

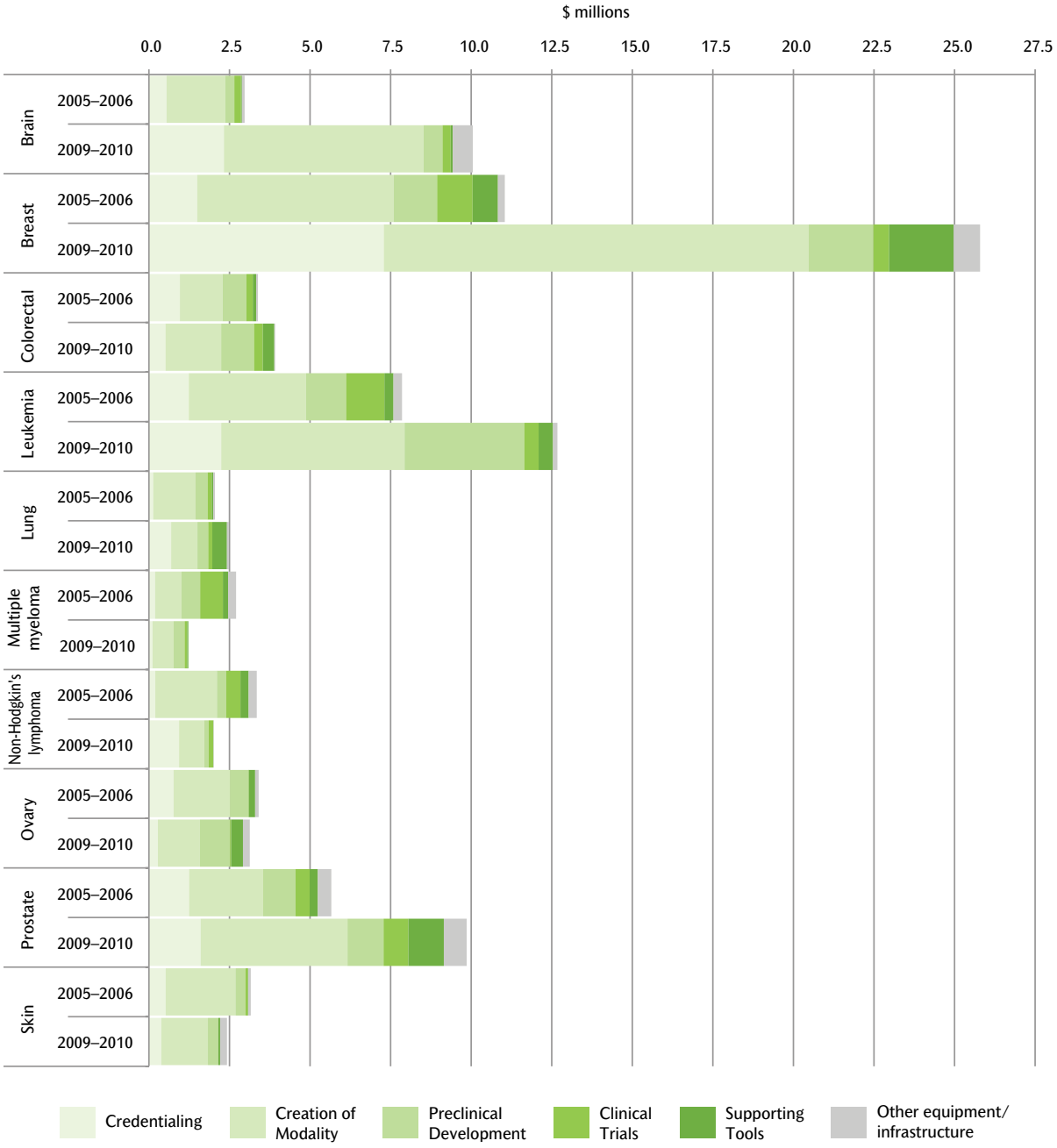


[1] Organizations shown have an average annual investment in early translational drug research of $1M or more.

Investments in ten cancer sites represented 55.2% of the total funding in early translational drug research from 2005 to 2010 (see Figure 3.2.4). The early translational drug investment in brain cancer rose more than three-fold from $3.0M in 2005–2006 to $10.1M in 2009–2010 and the investment in early translational drug focused on breast cancer more than doubled from $11.0M in 2005–2006 to $25.8M in 2009–2010. The investment in breast cancer research alone represented 18.5% of the total early translational drug investment in 2009–2010 and, within the breast cancer research investment, there was $7.1M and $5.8M more invested in 2009–2010 than in 2005–2006 in Creation of Modality and Credentialing, respectively. Leukemia research, which had the second highest investment in 2009–2010, had a more than doubling of investment in the Preclinical Development phase from the first to the third biennia. Although the 2009–2010 investments for multiple myeloma and skin cancer were less than the 2005–2006 investments, more than 25% of the total 2005–2010 cancer research investments in these sites/types of cancer were in early translational drug research.

FIGURE 3.2.4

INVESTMENT IN EARLY TRANSLATIONAL DRUG RESEARCH BY PHASE FOR SELECTED CANCER SITES [1], 2005–2006 AND 2009–2010

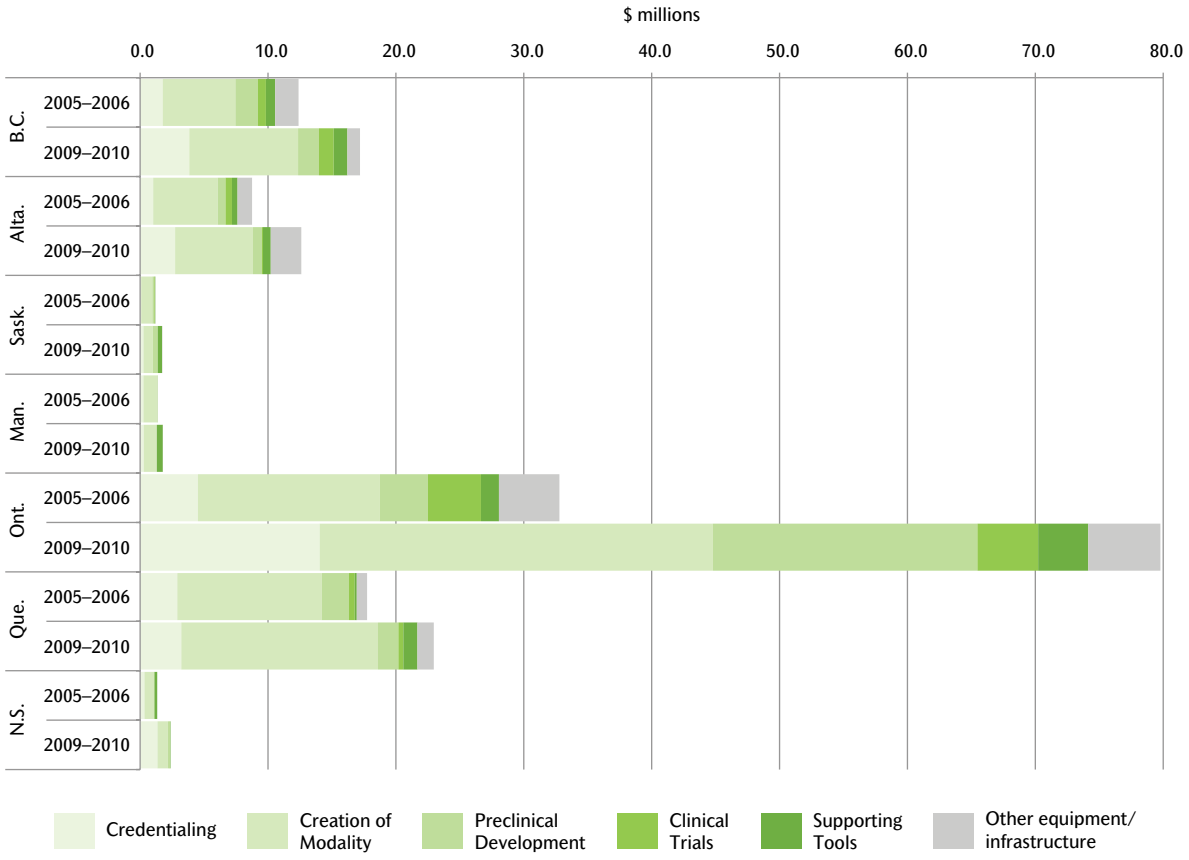


[1] Cancers shown have an average annual investment in early translational drug research of $1M or more.

The investment in early translational drug research by province of nominated principal investigator is provided in Figure 3.2.5. There was a 143% increase in investment from 2005–2006 to 2009–2010 in Ontario, representing an additional $47.0M. Over a third of this new investment (34.5%) came from the Ontario Institute for Cancer Research. The investment in the Creation of Modality phase grew across all regions from 2005–2006 to 2009–2010.

FIGURE 3.2.5

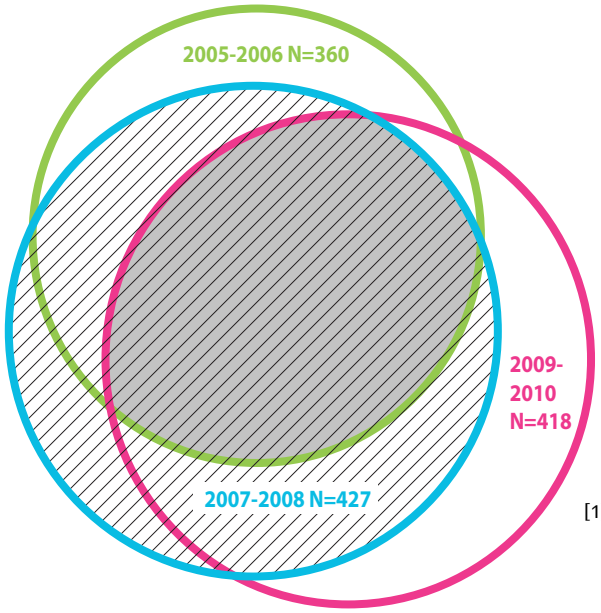
INVESTMENT IN EARLY TRANSLATIONAL DRUG RESEARCH BY PHASE AND PROVINCE OF NOMINATED PRINCIPAL INVESTIGATOR [1], 2005–2006 AND 2009–2010



[1] Provinces shown have an average annual investment in early translational drug research of $0.5M or more.

FIGURE 3.2.6

NUMBER OF NOMINATED PRINCIPAL INVESTIGATORS [1] FUNDED FOR EARLY TRANSLATIONAL DRUG RESEARCH BY FUNDING PERIOD



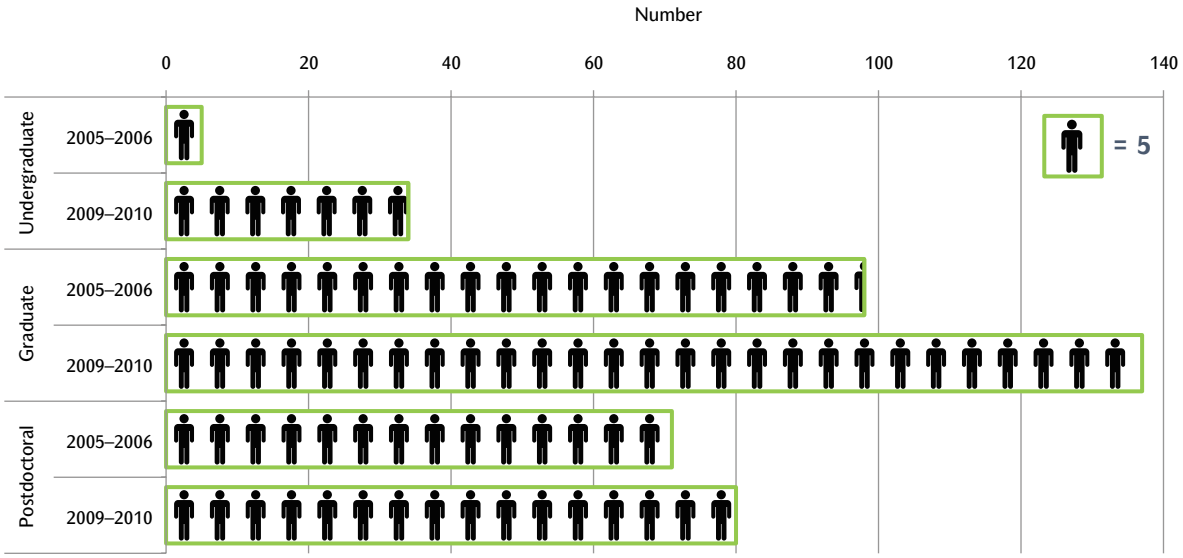
There were 585 nominated principal investigators who were funded for early translational drug research at some point over the six-year period, with a core of 219 researchers who were funded during all three biennia (Figure 3.2.6). The number of funded principal investigators increased from 2005–2006 to 2006–2007, but dropped slightly in 2009–2010.

Regardless of training level, the number of trainees receiving grant funding for early translational drug research increased from 2005–2006 to 2009–2010 by 77 trainees (see Figure 3.2.7). Over half of the trainees (54.6%) in 2009–2010 were graduate students.

[1] There were a total of 585 nominated principal investigators who had at least one operating grant, equipment award or career award weighted at 50% or higher. Investigators were grouped according to the years in which they received funding.

FIGURE 3.2.7

NUMBER OF TRAINEES [1] IN EARLY TRANSLATIONAL DRUG RESEARCH BY TRAINING LEVEL, 2005–2006 AND 2009–2010



[1] Includes all trainees awarded grants where at least some of the research project involved early translational drug research. Trainees awarded grants for more than one training level are included for each time period-training level combination. There were 172 trainees in 2005–2006 and 249 trainees in 2009–2010.

3.3 INVESTMENT IN BIOMARKER RESEARCH

For the analyses in this section, Biospecimen-based and Image-based biomarker research investments are presented separately. The investment in Image-based biomarker research more than doubled from 2005–2006 to 2009–2010. Whereas Image-based biomarker research was less than half the investment in Biospecimen-based biomarker research in 2005–2006, it was only $5.9M lower than the 2009–2010 (Figure 3.3.1A). For Image-based biomarker research, there was $7.8M more in the Creation of Modality and $6.7M more in the Preclinical Development phases in the third compared to the first biennia. In terms of the Biospecimen-based biomarker research investment, most of the growth was in Other equipment/infrastructure and Clinical Trials. See Figure 3.3.1B.

FIGURE 3.3.1A

INVESTMENT IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY FUNDING PERIOD

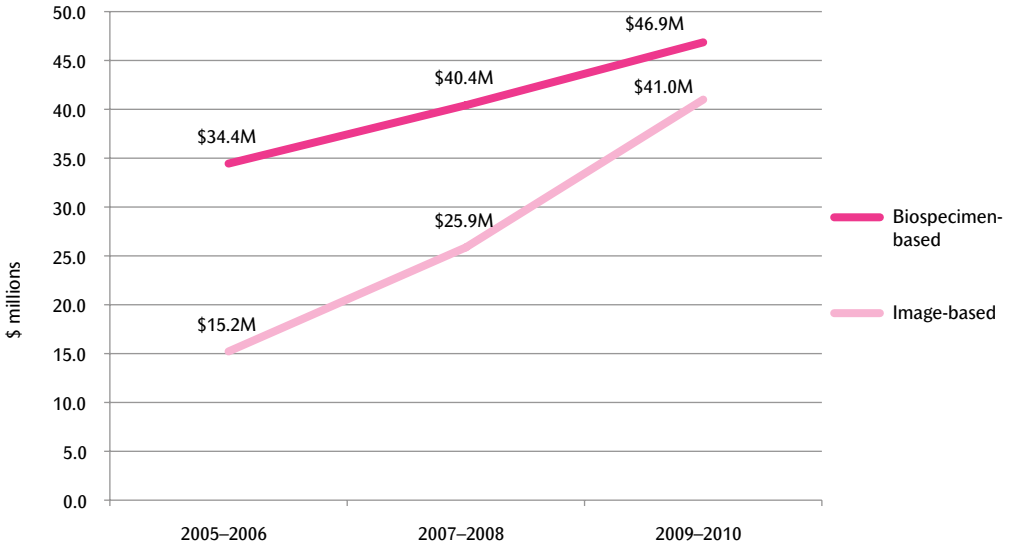
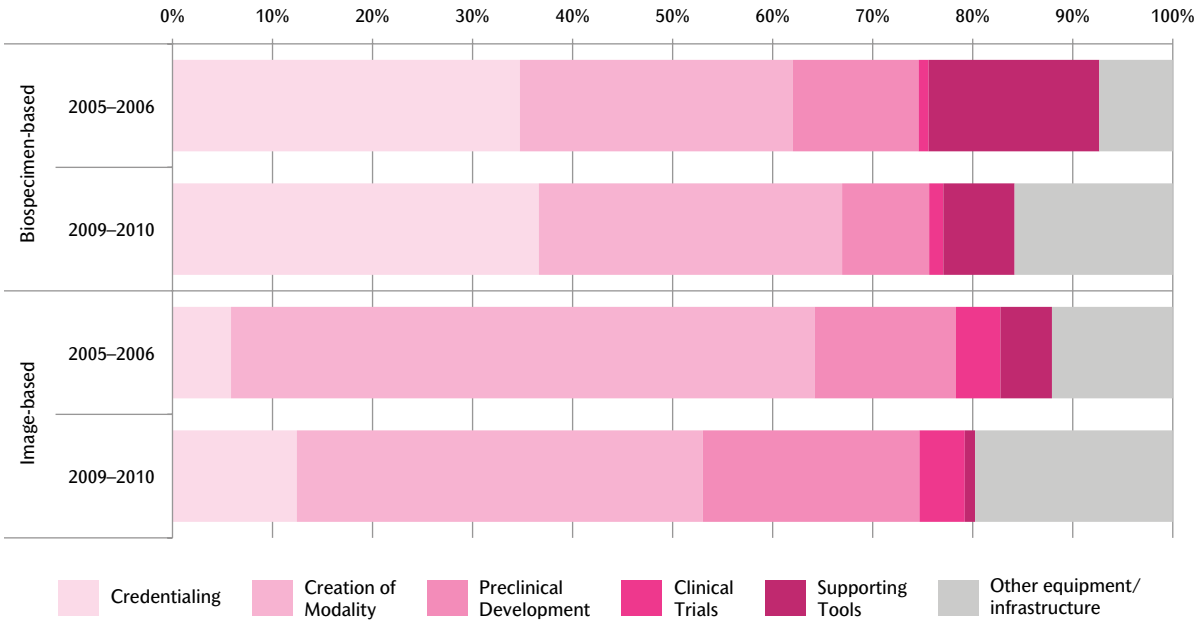


FIGURE 3.3.1B

DISTRIBUTION OF INVESTMENT IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY PHASE, 2005–2006 AND 2009–2010

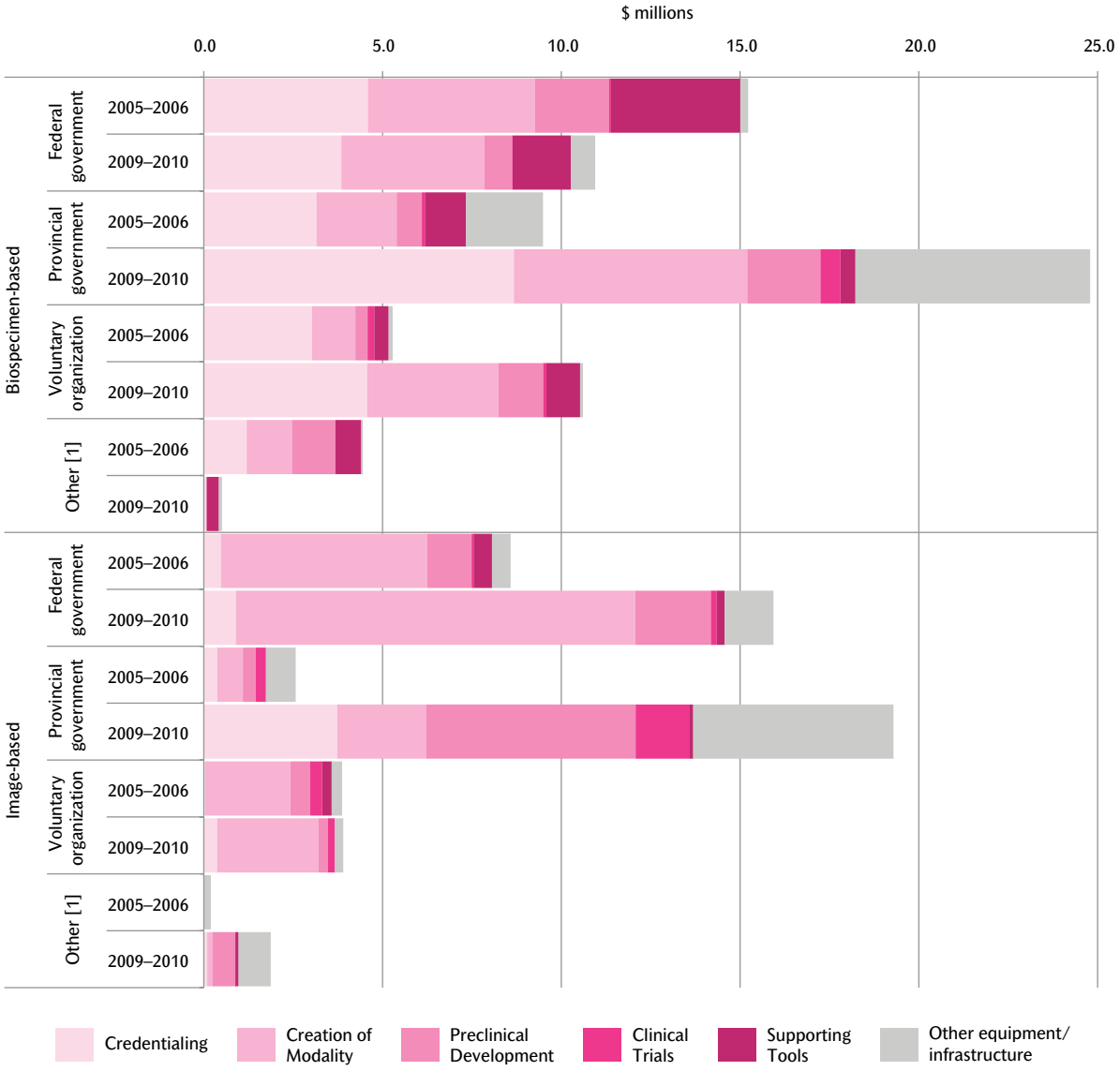


Increased investment in 2009–2010 by the provincial government sector accounted for most of the rise in investment in Biospecimen-based biomarker research from the first to third biennia. Investment in all phases of research, except for Supporting Tools, more than doubled. There was also a doubling of the investment by the voluntary sector in Biospecimen-based biomarker research from the first to third biennia, accounted for largely by increased investment in the Creation of Modality and Credentialing phases. Federal government investment, however, contracted from the first to the third biennia.

The pattern of increased provincial investment was also the case for Image-based biomarker research where investment in all phases of research rose, most strikingly for the Preclinical Development phase and Other equipment/infrastructure. Federal government investment in Image-based biomarker research also increased, largely as a result of increased investment in the Creation of Modality phase (see Figure 3.3.2).

FIGURE 3.3.2

INVESTMENT IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY PHASE FOR EACH FUNDING SECTOR, 2005–2006 AND 2009–2010



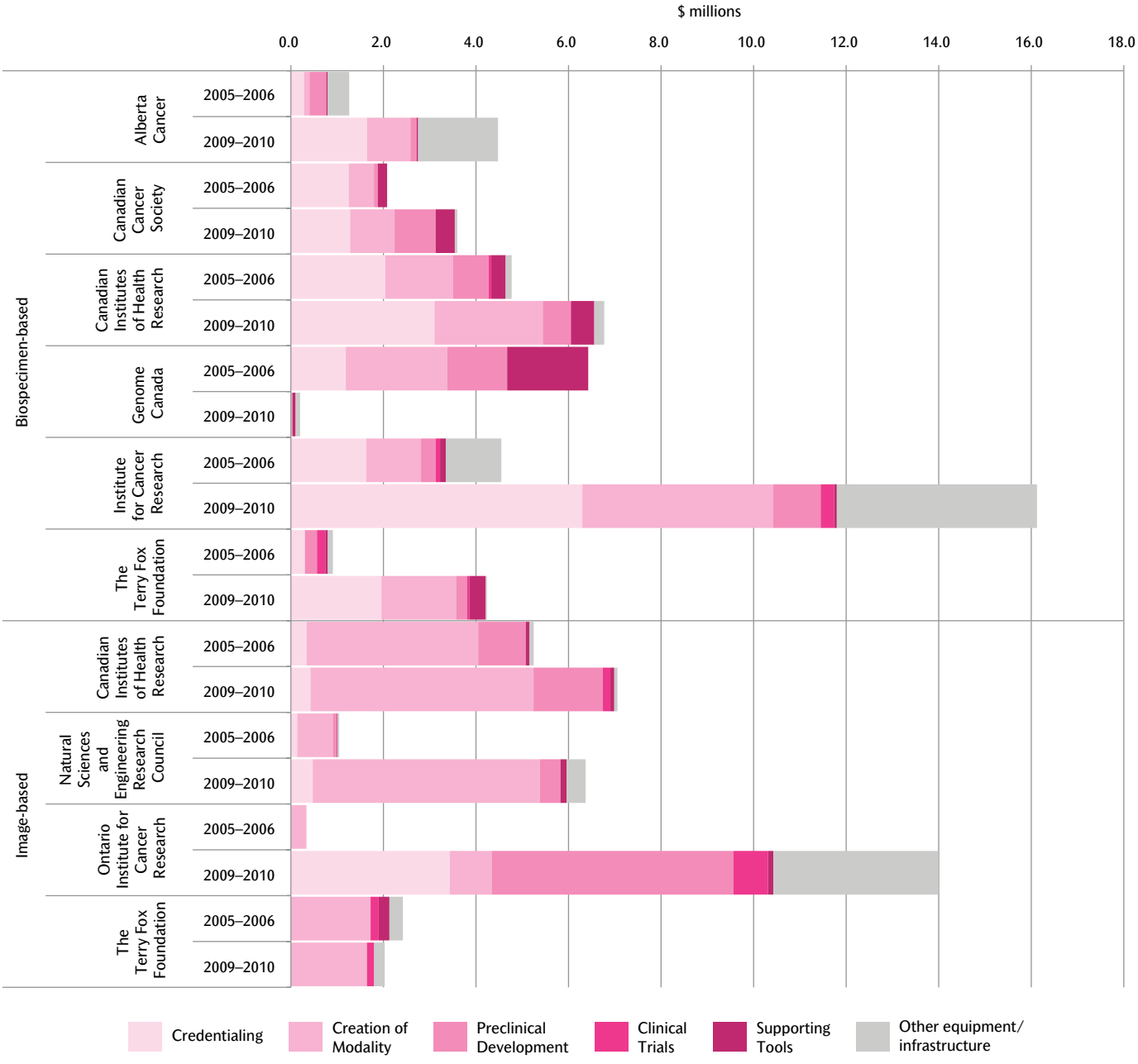
[1] Co-funding of projects supported by CCRS participant organizations by institutional, industry and foreign sources.

Two-thirds of the early translational Biospecimen-based biomarker investment was accounted for by six organizations. While Genome Canada was the largest funder in the early translational Biospecimen-based biomarker in 2005–2006, it was surpassed by the Ontario Institute of Cancer Research in 2009–2010 with an increased investment of $11.6M, much of which was in Credentialing, Other equipment/infrastructure, and Creation of Modality. Like the Ontario Institute of Cancer Research, investment in Biospecimen-based biomarker research also more than doubled for Alberta Cancer from the first to third biennia. In fact, all organizations, with the exception of Genome Canada, invested more in Biospecimen-based biomarker research in 2009–2010 than in 2005–2006.

Two-thirds of the funding of Image-based biomarker research was accounted for by four organizations. Here again, the increased investment from the first to third biennia was largely the result of the Ontario Institute of Cancer Research, which represented $13.7M of the $20.4M new funding. Most of the increased investment by the Ontario Institute of Cancer Research was in Preclinical Development, Other equipment/infrastructure, and Credentialing. There was also a six-fold increase in the Image-based biomarker research investment from 2005–2006 to 2009–2010 by the Natural Sciences and Engineering Research Council. Of the additional $5.3M invested in the third biennia by the Natural Sciences and Engineering Research Council, $4.1M was in the Creation of Modality phase. The investment by the Canadian Institutes of Health Research increased modestly and contracted slightly for The Terry Fox Foundation from 2005–2006 to 2009–2010. Investments per phase by these selected organizations are detailed in Figure 3.3.3.

FIGURE 3.3.3

INVESTMENT IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY PHASE FOR SELECTED FUNDERS [1], 2005–2006 AND 2009–2010



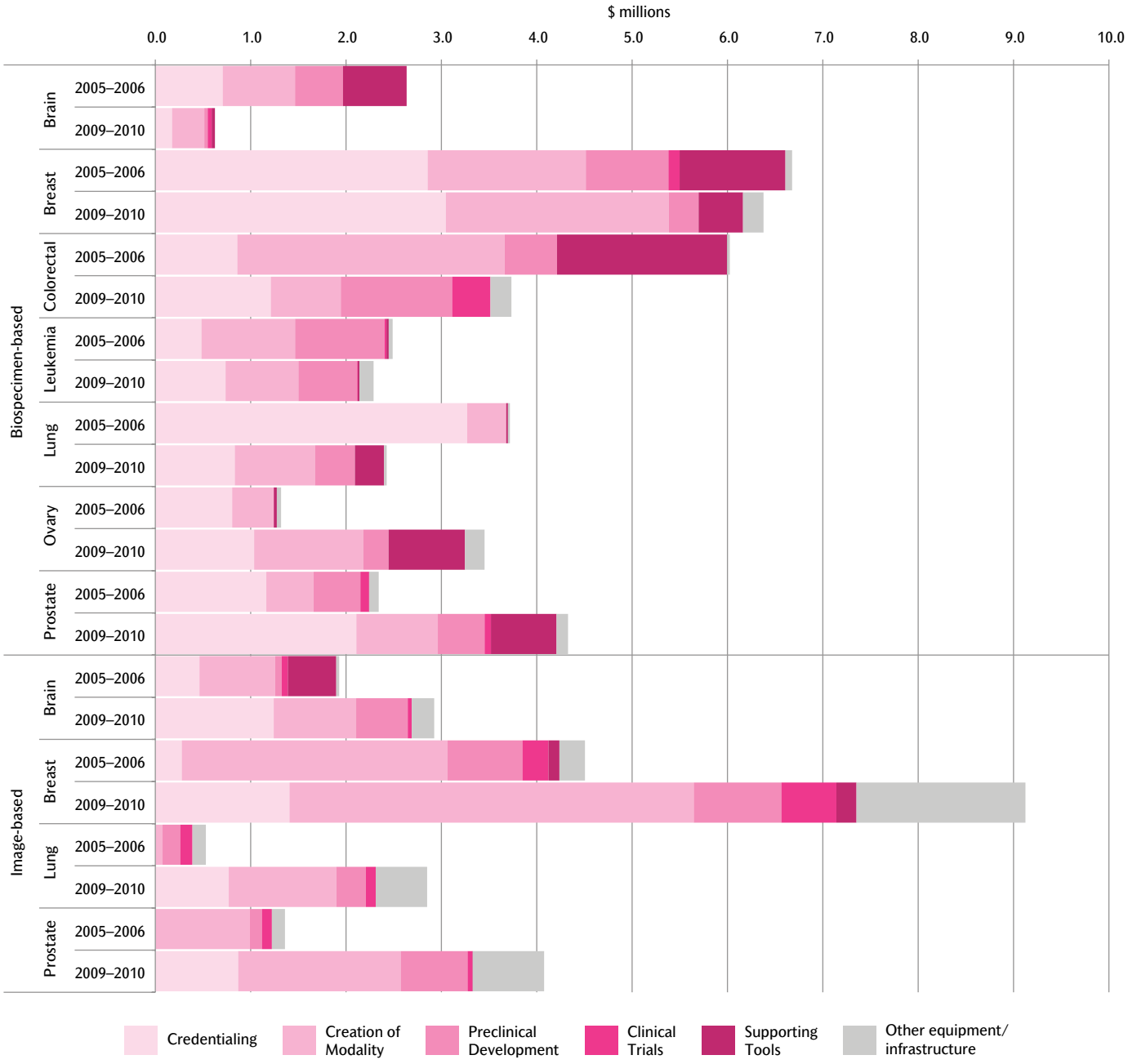
[1] Organizations shown have an average annual investment of $1M or more in biospecimen-based and/or image-based biomarker research.

Of the Biospecimen-based biomarker investment over the full six-year period, 60.3% was in seven cancer sites. For all sites but ovarian and prostate cancers, there was less investment in the third than the first biennia—the contracted investments in colorectal and brain cancers were more than $2M each. Investment in breast cancer represented 17.5% of the total 2009–2010 Biospecimen-based biomarker investment, although the investment was slightly lower than in 2005–2006.

In terms of Image-based biomarker research, nearly half (47.8%) of the six-year investment was accounted for by four cancer sites. Investments for all four cancer sites increased from 2005–2006 to 2009–2010. Breast cancer, however, was far and away the highest investment representing 22.3% of 2009–2010 investment in Image-based biomarker research, with an increased investment of $4.6M from the first to the third biennia. Much of the increased investment in breast cancer was in Other equipment/infrastructure and the phases of Creation of Modality and Credentialing. See Figure 3.3.4 for a summary.

FIGURE 3.3.4

INVESTMENT IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY PHASE FOR SELECTED CANCER SITES [1], 2005–2006 AND 2009–2010



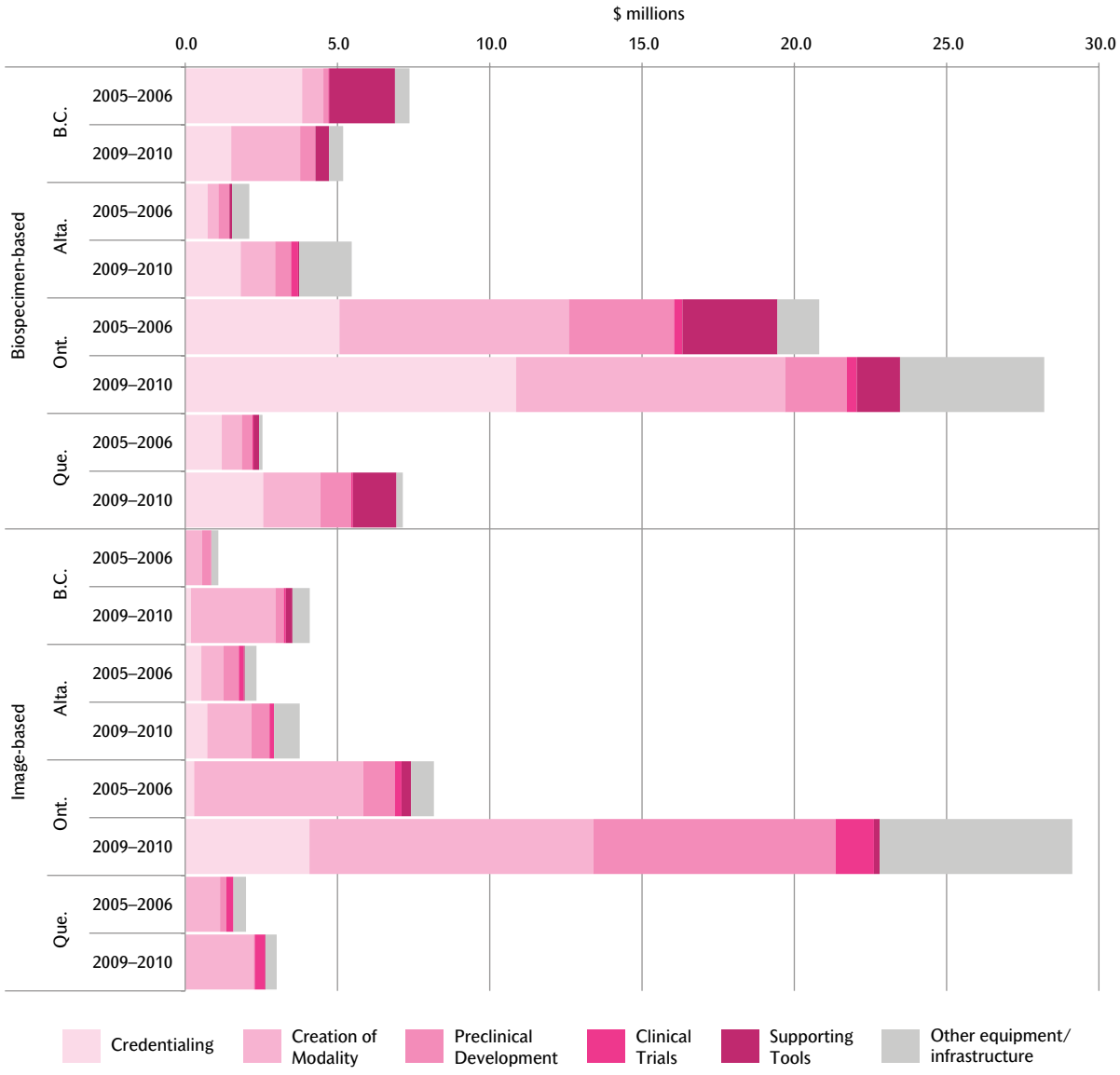
[1] Cancers shown have an average annual investment of $0.5M or more in biospecimen-based and/or image-based biomarker research.

Four provinces accounted for over 95% of the investment in biomarker research for the 2005 to 2010 period. The investments for these four provinces are provided in Figure 3.3.5. For Biospecimen-based biomarker research, the investment from the first to the third biennia more than doubled for Quebec and Alberta. While the relative investment in Ontario remained the same (that is, it represented 60.2% of the 2009–2010 investment and 60.4% in 2005–2006), there was $5.8M more in Credentialing and $3.4M more in Other equipment/infrastructure in 2009–2010.

In terms of Image-based biomarker research, the investments for all four provinces increased from the first to the third biennia. There was $21.0M more invested in Ontario in 2009–2010 than 2005–2006. This growth was in Preclinical Development and Other equipment/infrastructure. In British Columbia, the investment in the third biennia was more than three-fold higher than the investment in the first biennia and much of this increase was in the Creation of Modality phase.

FIGURE 3.3.5

INVESTMENT IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY PHASE AND PROVINCE OF NOMINATED PRINCIPAL INVESTIGATOR [1], 2005–2006 AND 2009–2010

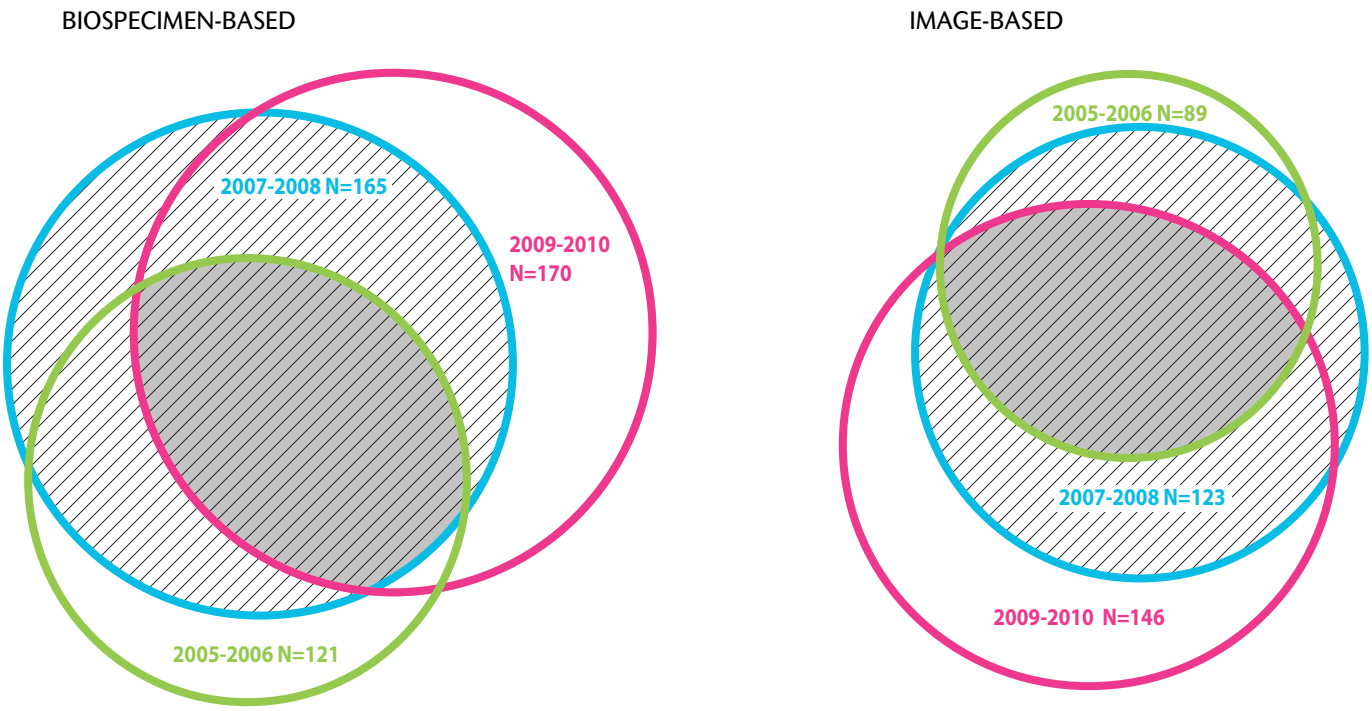


[1] Provinces shown have an average annual investment of $1M or more in biospecimen-based and/or image-based biomarker research.

There were 238 nominated principal investigators who were funded for early translational Biospecimen-based biomarker research at some point over the six-year period, with a core of 56 researchers who were funded during all three biennia. There was an increase of 49 principal investigators from the first to the third biennia. For Image-based biomarker research, the numbers were: 185 nominated principal investigators; 53 core researchers; and an increase of 57 principal investigators. See Figure 3.3.6 for a summary.

FIGURE 3.3.6

NUMBER OF NOMINATED PRINCIPAL INVESTIGATORS [1] FUNDED FOR EARLY TRANSLATIONAL BIOMARKER RESEARCH BY FUNDING PERIOD

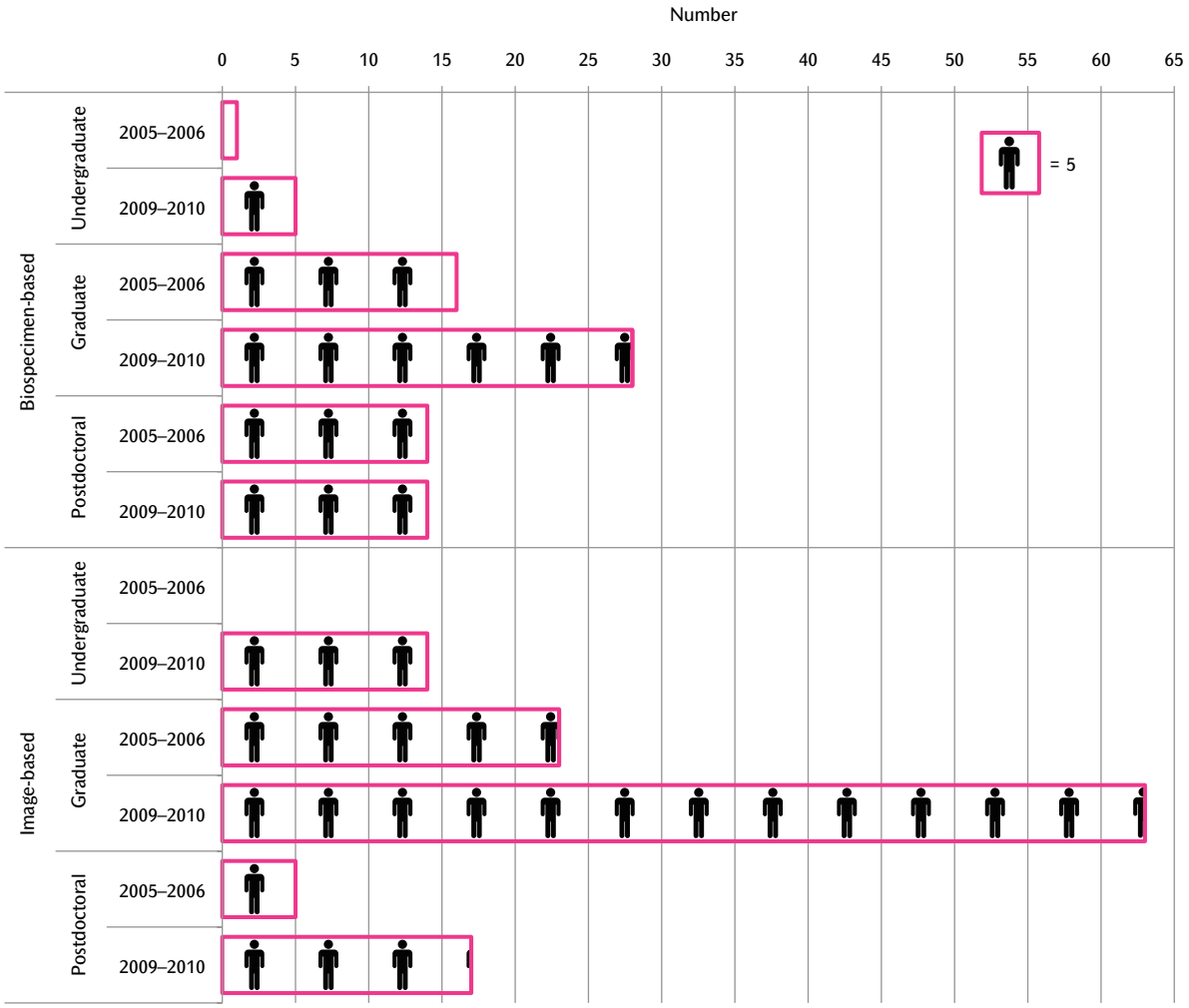


[1] There were 238 nominated principal investigators (biospecimen-based) and 185 (image-based) who had at least one operating grant, equipment award or career award weighted 50% or higher. Investigators were grouped according to the years in which they received funding.

The number of trainees receiving grant funding for early translational biomarker research increased from 2005–2006 to 2009–2010, more notably for Image-based biomarker research (by 66 trainees) than Biospecimen-based biomarker research (by 16 trainees). Across both modalities, nearly two-thirds (64.5%) of the trainees in 2009–2010 were graduate students. See Figure 3.3.7.

FIGURE 3.3.7

NUMBER OF TRAINEES [1] IN EARLY TRANSLATIONAL BIOMARKER RESEARCH BY TRAINING LEVEL, 2005–2006 AND 2009–2010

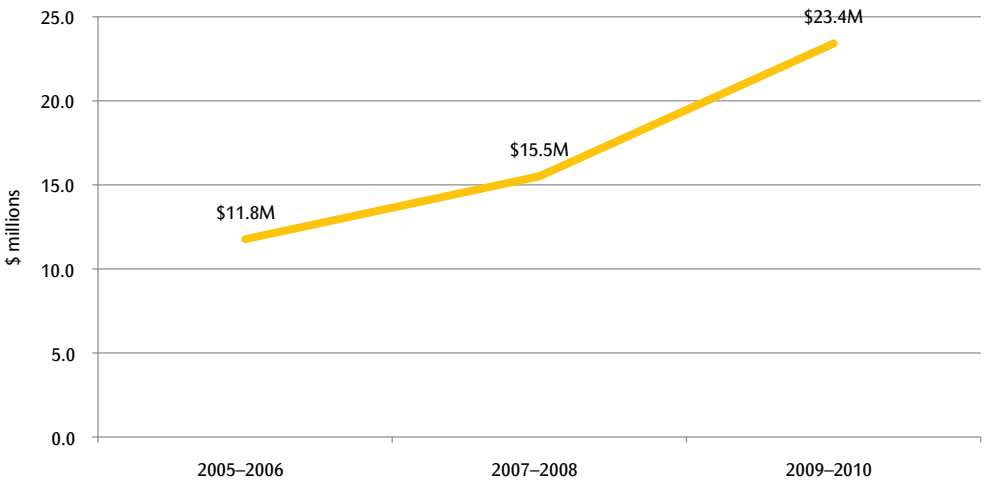


[1] Includes all trainees awarded grants where at least some of the research project involved early translational biomarker research. Trainees awarded grants for more than one training level are included for each time period-training level combination. There were 59 trainees in 2005–2006 and 141 trainees in 2009–2010.

3.4 INVESTMENT IN INTERVENTIVE DEVICES RESEARCH

FIGURE 3.4.1A

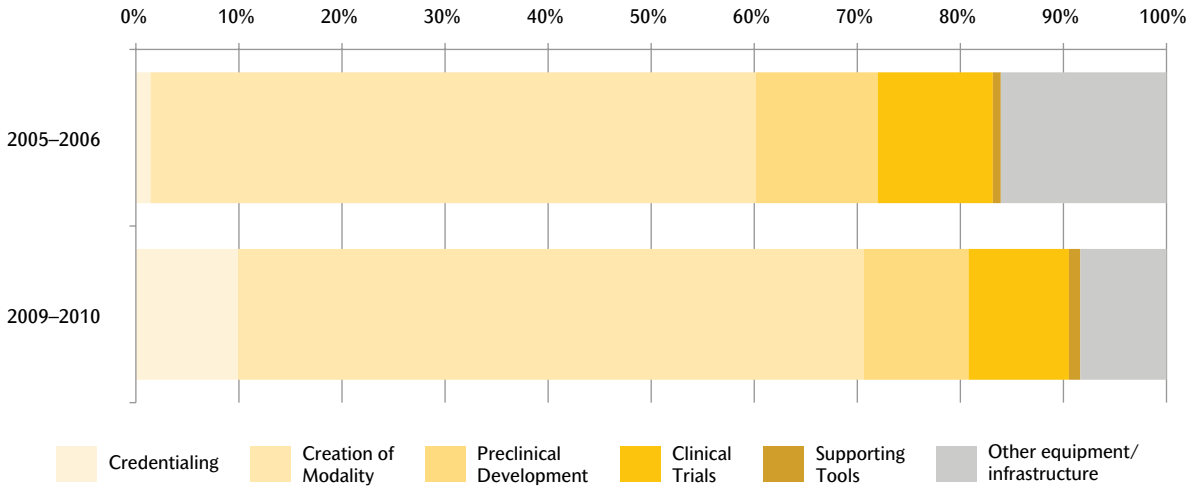
INVESTMENT IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY FUNDING PERIOD



There was $11.6M more invested in early translational Interventive Devices research in 2009–2010 than in 2005–2006, an increase of 99.0% (Figure 3.4.1A). Well over half of this new investment (62.7%) was due to an increased investment in research in the Creation of Modality phase. The Credentialing phase also grew by over $2M from the first to the third biennia (see Figure 3.4.1B).

FIGURE 3.4.1B

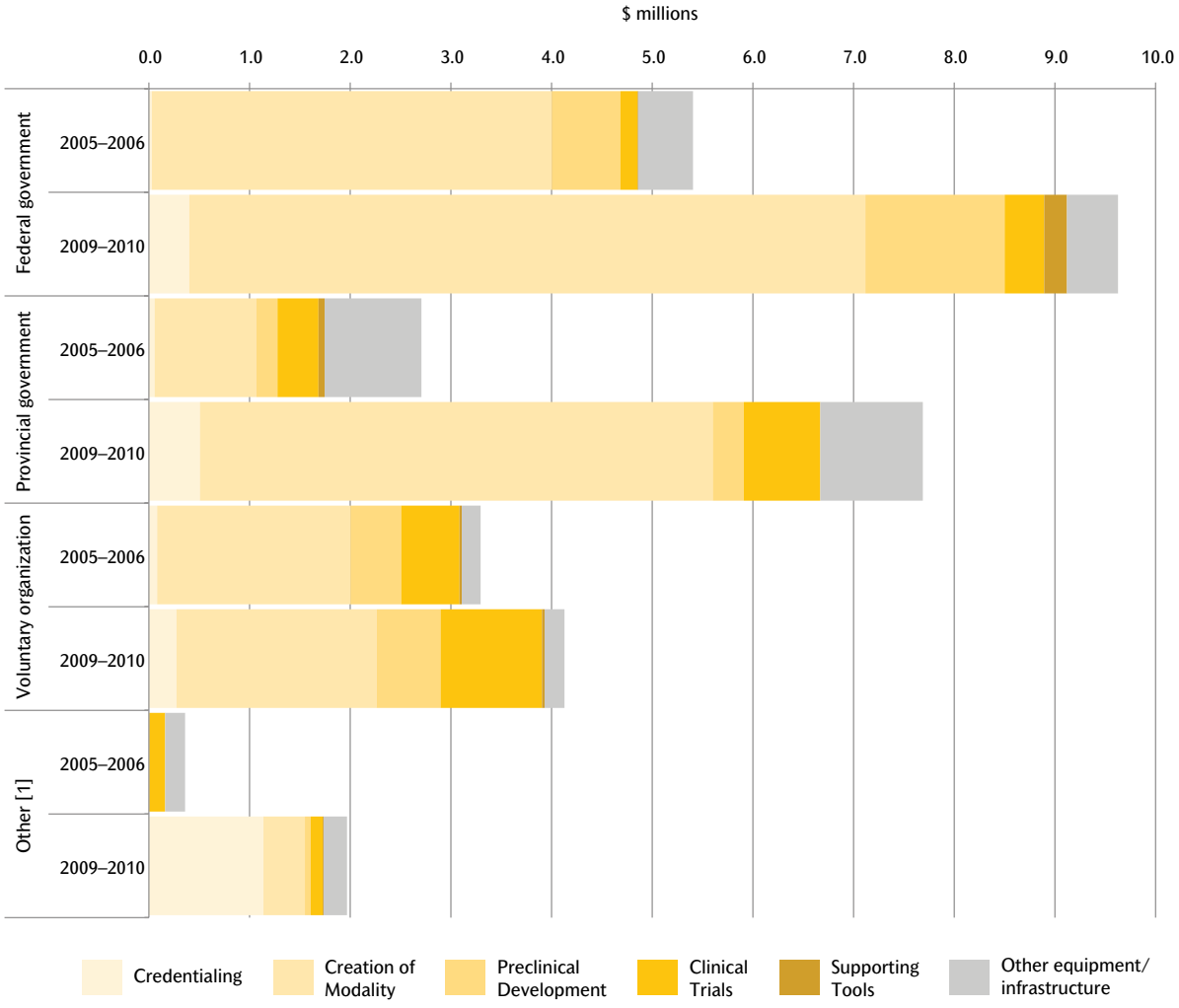
DISTRIBUTION OF INVESTMENT IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY PHASE, 2005–2006 AND 2009–2010



There was an influx in investment in Interventive Devices by all funding sectors from 2005–2006 to 2009–2010 (see Figure 3.4.2). The federal government sector represented 41.1% of the 2009–2010 investment, down slightly from 45.9% in 2005–2006 while the provincial government sector investment grew from 23.0% of the 2005–2006 investment to 32.8% of the 2009–2010 investment. The Creation of Modality phase had the highest increased investment from 2005–2006 to 2009–2010 for both the federal and provincial government sectors, with a total of $6.8M more in the third biennia. Among the voluntary sector, over half (51.4%) of the increased investment was accounted for by increased research investment in the Clinical Trials phase.

FIGURE 3.4.2

INVESTMENT IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY PHASE FOR EACH FUNDING SECTOR, 2005–2006 AND 2009–2010

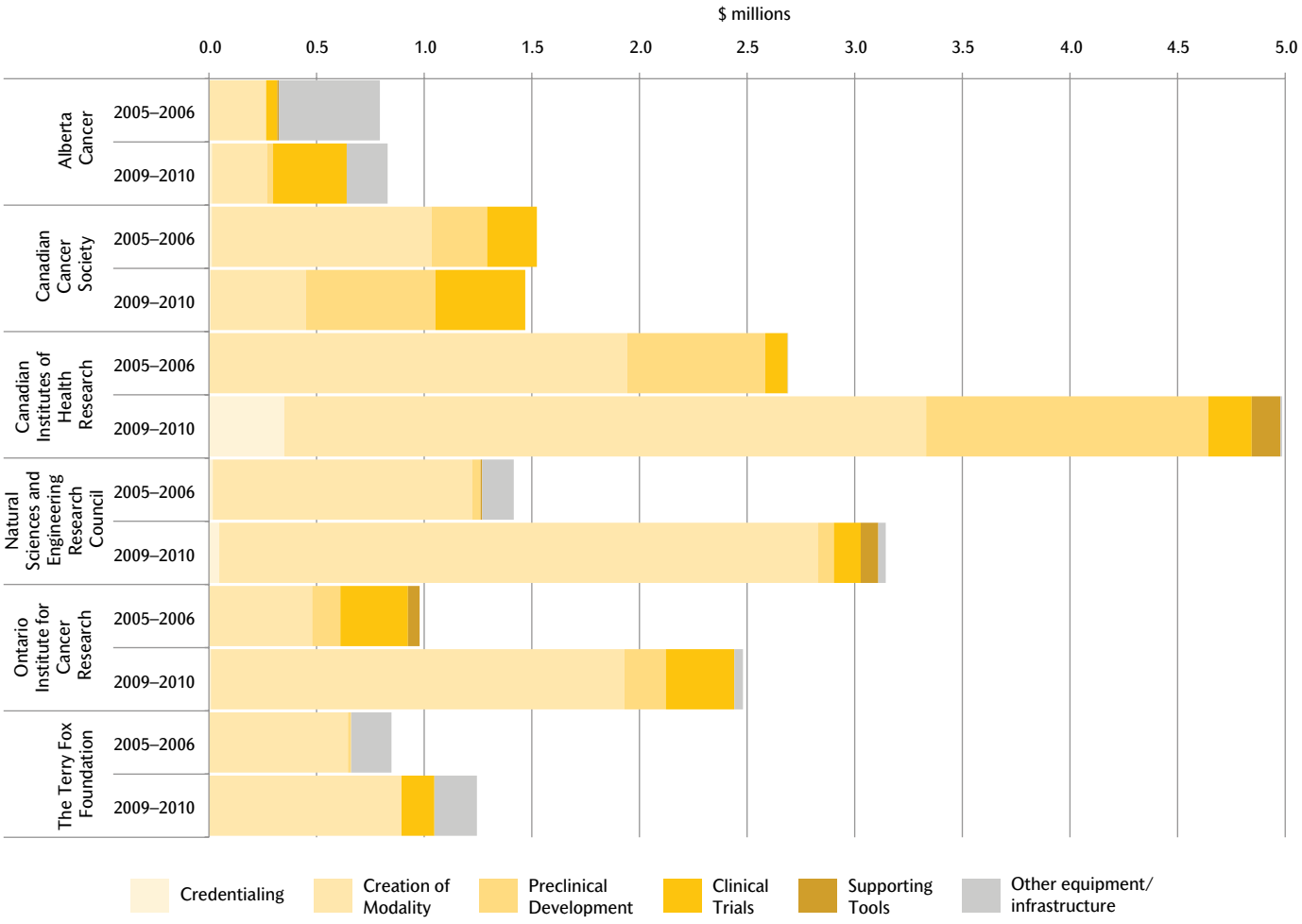


[1] Co-funding of projects supported by CCRS participant organizations by institutional, industry and foreign sources.

Six organizations accounted for 65.8% of the six-year investment in early translational Interventive Devices research. The Canadian Institutes of Health Research had the highest level of investment representing 22.9% and 21.3% of the investments in the first and third biennia, respectively. Investments by the Ontario Institute of Cancer Research and the Natural Sciences and Engineering Research Council more than doubled from 2005–2006 to 2009–2010. Much of the increased investment was in the Creation of Modality phase. The Canadian Cancer Society investment contracted slightly from 2005–2006 to 2009–2010 although the investment distribution in 2009–2010 was largely in the later translational phases, namely, Preclinical Development and Clinical Trials. Investments per phase are detailed for the six organizations in Figure 3.4.3.

FIGURE 3.4.3

INVESTMENT IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY PHASE FOR SELECTED FUNDERS [1], 2005–2006 AND 2009–2010

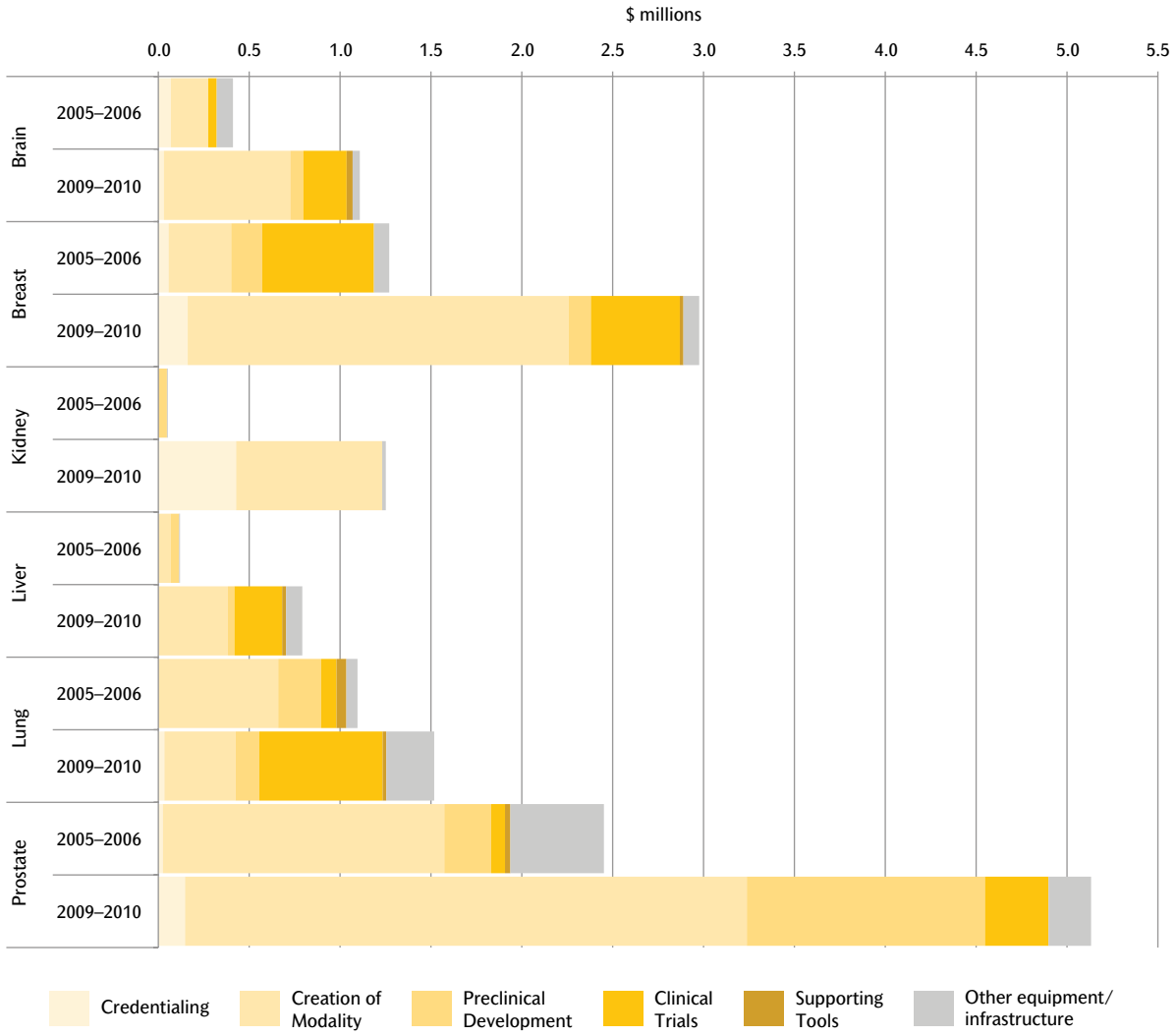


[1] Organizations shown have an average annual investment in early translational interventive devices research of $0.5M or more.

Figure 3.4.4 shows the investment in early translational Interventive Devices research by selected cancer sites for the two biennia. The six cancer sites shown represented 51.0% of the overall six-year investment in this modality and investments for all sites but lung cancer more than doubled from the first to the third biennia. Nearly one-quarter (23.0%) of the increased investments from 2005–2006 to 2009–2010 was accounted for by the increased investment in prostate cancer, especially for the phases Creation of Modality and Preclinical Development. The increased investment in lung cancer from the first to the third biennia was in the Clinical Trials phase.

FIGURE 3.4.4

INVESTMENT IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY PHASE FOR SELECTED CANCER SITES [1], 2005–2006 AND 2009–2010

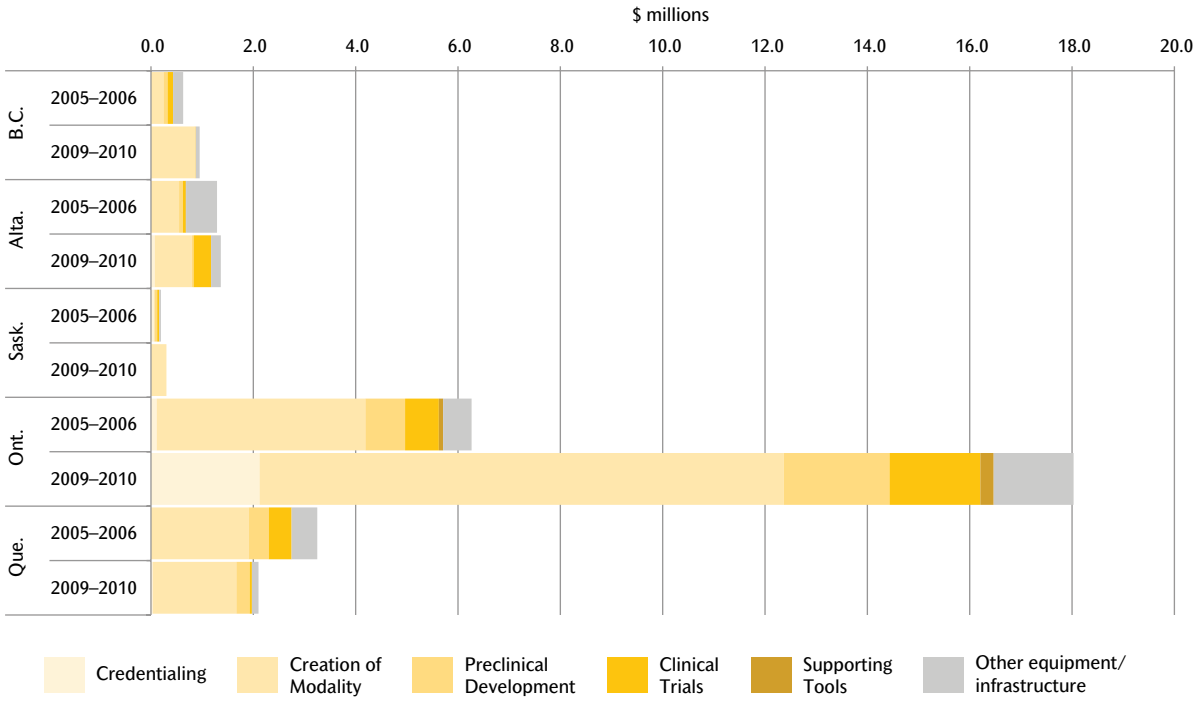


[1] Cancers shown have an average annual investment in early translational interventive devices research of $0.2M or more.

The investments in early translational Interventive Devices research by province of nominated principal investigator are provided in Figure 3.4.5. The 2009–2010 period was dominated by Ontario, which represented 77.0% of the investment. Most of the increased investment in Ontario was in the Creation of Modality phase. In contrast to the other provinces shown, the 2009–2010 investment in Quebec was lower than in 2005–2006.

FIGURE 3.4.5

INVESTMENT IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY PHASE AND PROVINCE OF NOMINATED PRINCIPAL INVESTIGATOR [1], 2005–2006 AND 2009–2010



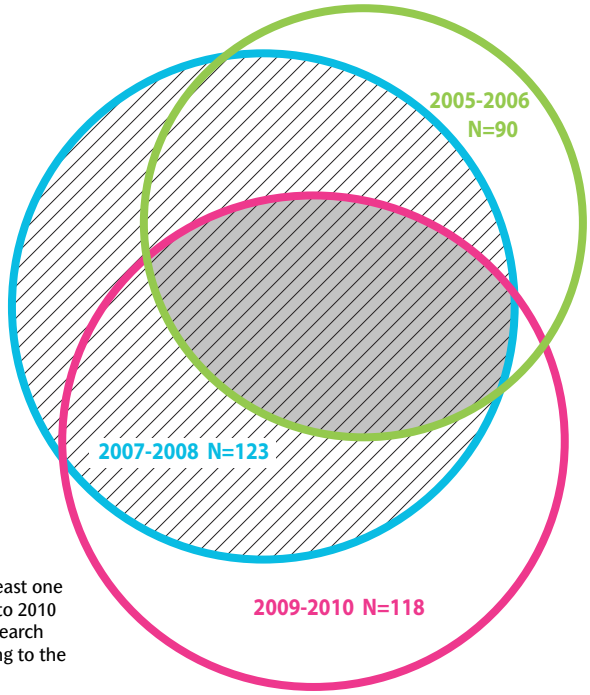
[1] Provinces shown have an average annual investment in early translational interventive devices research of $0.1M or more.

There were 184 nominated principal investigators who were funded for early translational Interventive Devices research at some point over the six-year period, with a core of 42 researchers who were funded during all three biennia (Figure 3.4.6). The number of researchers increased from 2005–2006 to 2006–2007, but dropped slightly in 2009–2010.

The number of trainees receiving grant funding for early translational Interventive Devices research increased from 2005–2006 to 2009–2010 by 55 (see Figure 3.4.7). Nearly three-quarters of the trainees (73.3%) in 2009–2010 were graduate students.

FIGURE 3.4.6

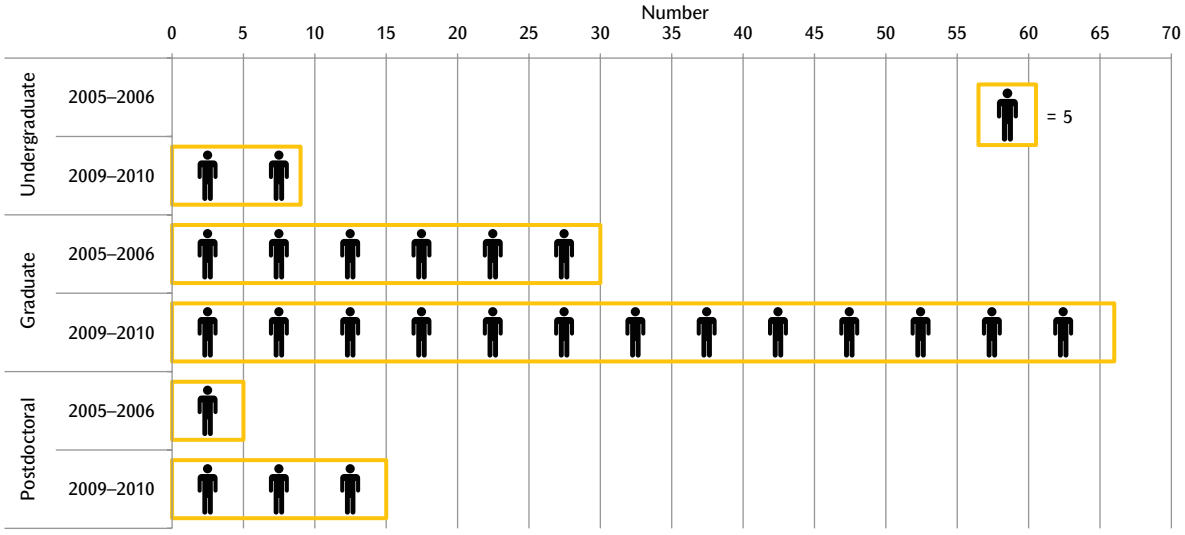
NUMBER OF NOMINATED PRINCIPAL INVESTIGATORS [1] FUNDED FOR EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY FUNDING PERIOD



[1] There were 184 nominated principal investigators who had at least one operating grant, equipment award or career award in the 2005 to 2010 period in the area of early translational interventives device research weighted at 50% or higher. Investigators were grouped according to the years in which they received funding.

FIGURE 3.4.7

NUMBER OF TRAINEES [1] IN EARLY TRANSLATIONAL INTERVENTIVE DEVICES RESEARCH BY TRAINING LEVEL, 2005–2006 AND 2009–2010

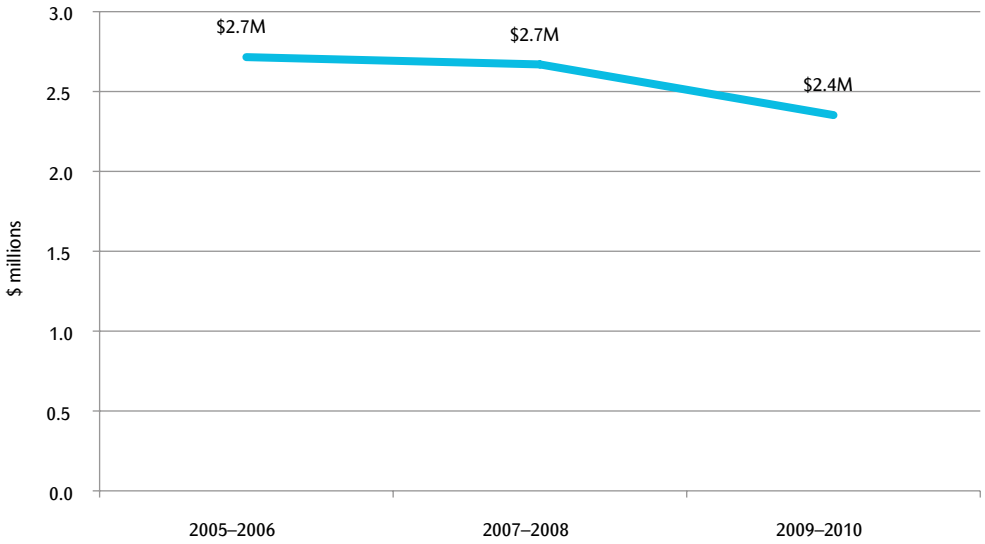


[1] Includes all trainees awarded grants where at least some of the research project involved early translational interventive devices research. Trainees awarded grants for more than one training level are included for each time period-training level combination. There were 35 trainees in 2005–2006 and 89 trainees in 2009–2010.

3.5 INVESTMENT IN LIFESTYLE ALTERATIONS RESEARCH

FIGURE 3.5.1A

INVESTMENT IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY FUNDING PERIOD

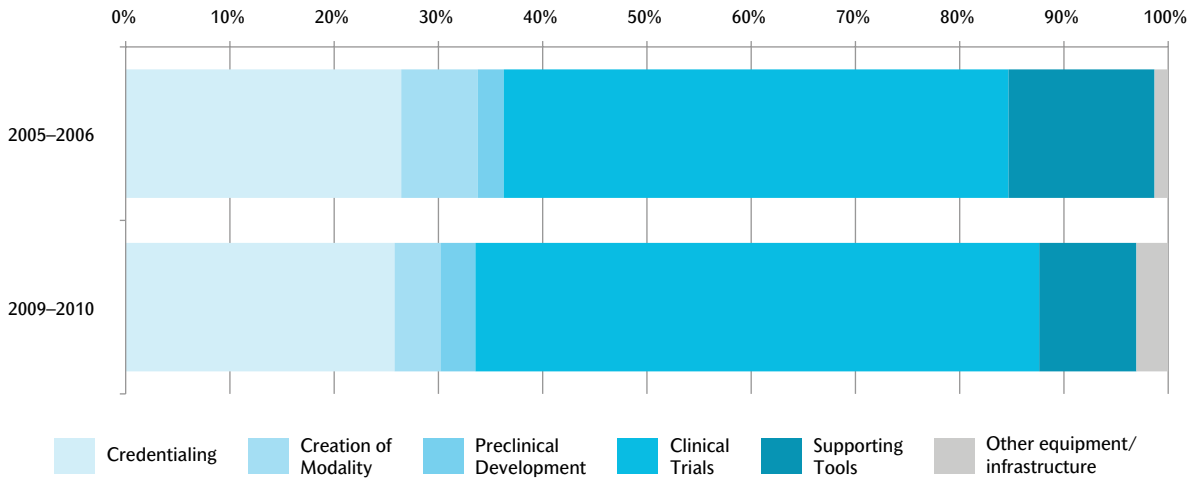


The reader is cautioned that this modality has a low level of investment so minor changes in the number of projects and the dollar value of the projects can dramatically affect the investment trends. Project equivalents were 36.0 for 2005–2006, 41.7 for 2007–2008, and 40.2 for 2009–2010. The reader is also reminded to consult Table 2.2.2 for definitions of the research included in the translational phases for Lifestyle Alterations because these phase distinctions are not conventionally applied to this area of science.

Investment in early translational Lifestyle Alterations research dropped slightly from $2.7M in 2005–2006 to $2.4M in 2009–2010 (Figure 3.5.1A). The distributions by translational phase also shifted only slightly (see Figure 3.5.1B).

FIGURE 3.5.1B

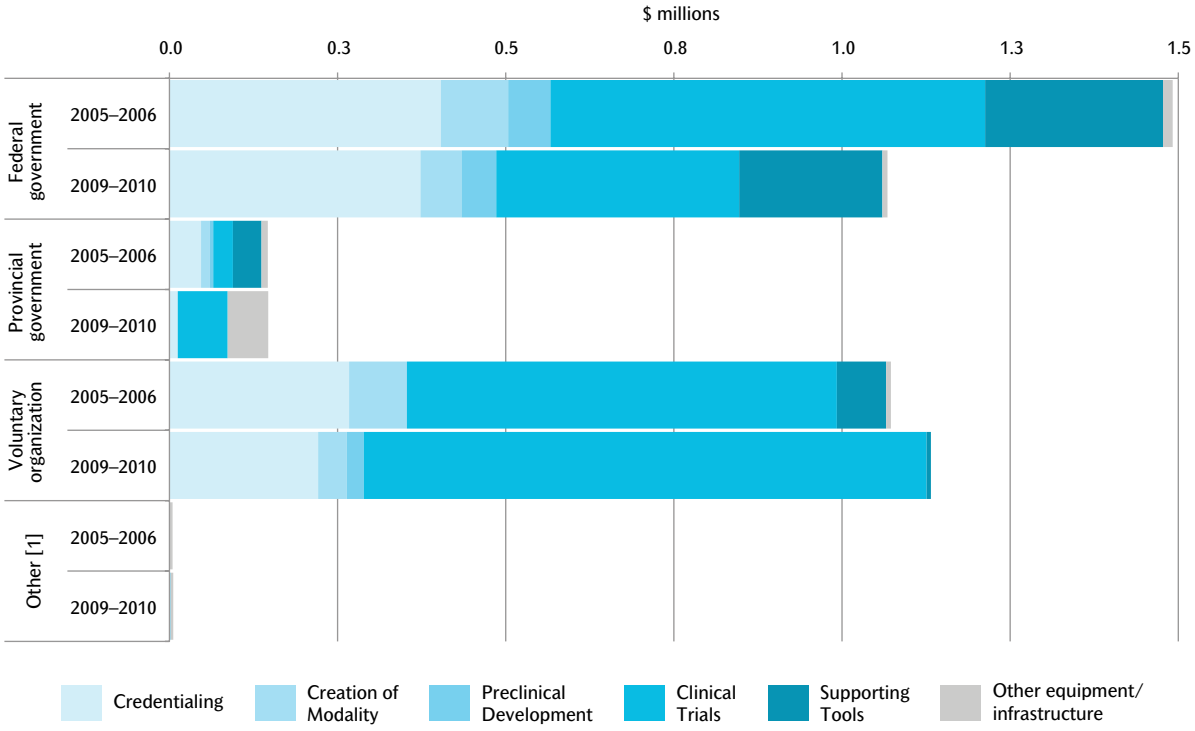
DISTRIBUTION OF INVESTMENT IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY PHASE, 2005–2006 AND 2009–2010



Investment by the Federal government contracted slightly. Investment by the voluntary sector increased slightly from 2005–2006 to 2009–2010, largely due to increased investment in research in the Clinical Trials phase. These data are depicted in Figure 3.5.2.

FIGURE 3.5.2

INVESTMENT IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY PHASE FOR EACH FUNDING SECTOR, 2005–2006 AND 2009–2010

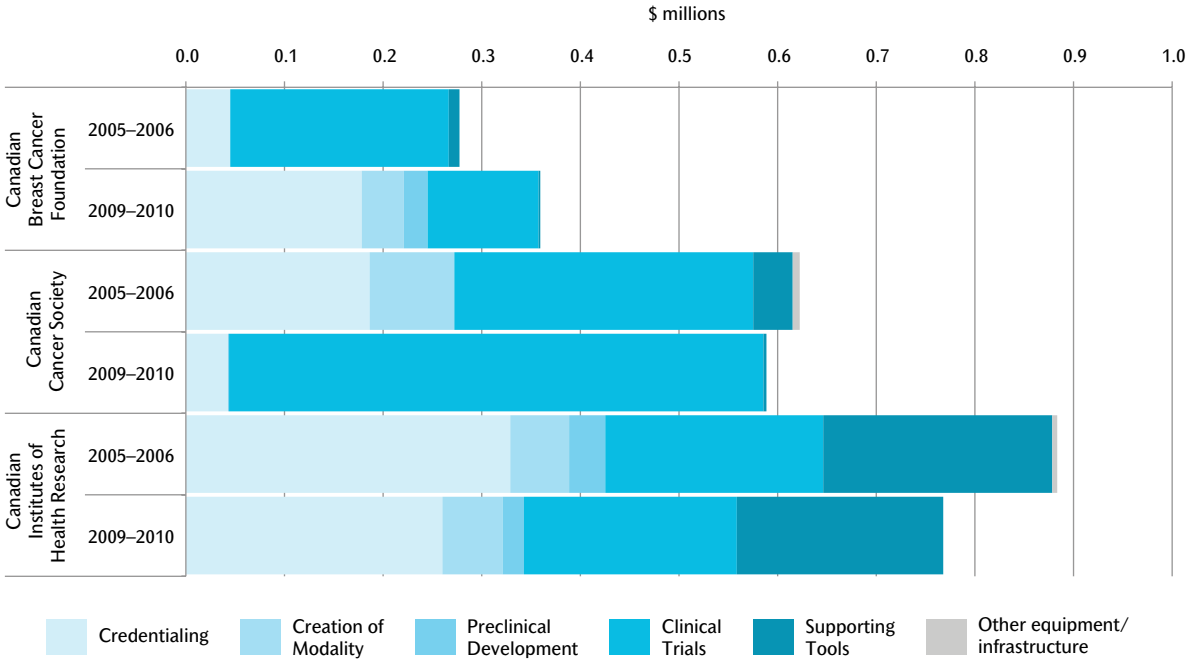


[1] Co-funding of projects supported by CCRS participant organizations by institutional, industry and foreign sources.

Two-thirds of the six-year investment in early translational lifestyle alterations was accounted for by three organizations (see Figure 3.5.3). The 2009–2010 investments for the Canadian Institutes of Health Research and Canadian Cancer Society were slightly lower than in 2005–2006 while the Canadian Breast Cancer Foundation had a slightly increased investment from the first to the third biennia. The most dramatic change in terms of translational phases was the increased investment in the Clinical Trials phase by the Canadian Cancer Society, largely the result of its "Interventions to Prevent Cancer" grants.

FIGURE 3.5.3

INVESTMENT IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY PHASE FOR SELECTED FUNDERS [1], 2005–2006 AND 2009–2010

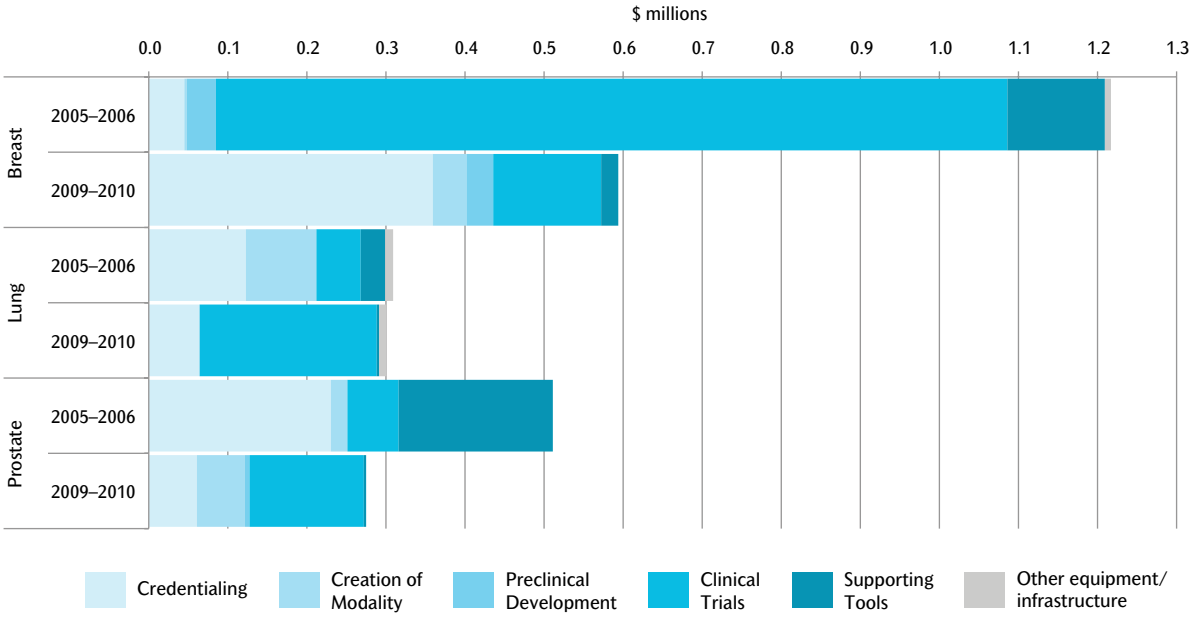


[1] Organizations shown have an average annual investment in early translational lifestyle alterations research of $150,000 or more.

Investment in three cancer sites accounted for 66.1% of the early translational Lifestyle Alterations investment over the six-year period (see Figure 3.5.4). The investment in breast cancer fell by $0.6M and the prostate cancer investment by $0.2M from the first to third biennia. The drop in investment in lung cancer was negligible. This may seem somewhat contradictory given the data on funders above, but what it fails to reflect is the start of two projects in the 2009-2010 period funded by the Canadian Cancer Society, which were not directed to specific cancer sites and both within the Clinical Trial phase.

FIGURE 3.5.4

INVESTMENT IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY PHASE FOR SELECTED CANCER SITES [1], 2005–2006 AND 2009–2010

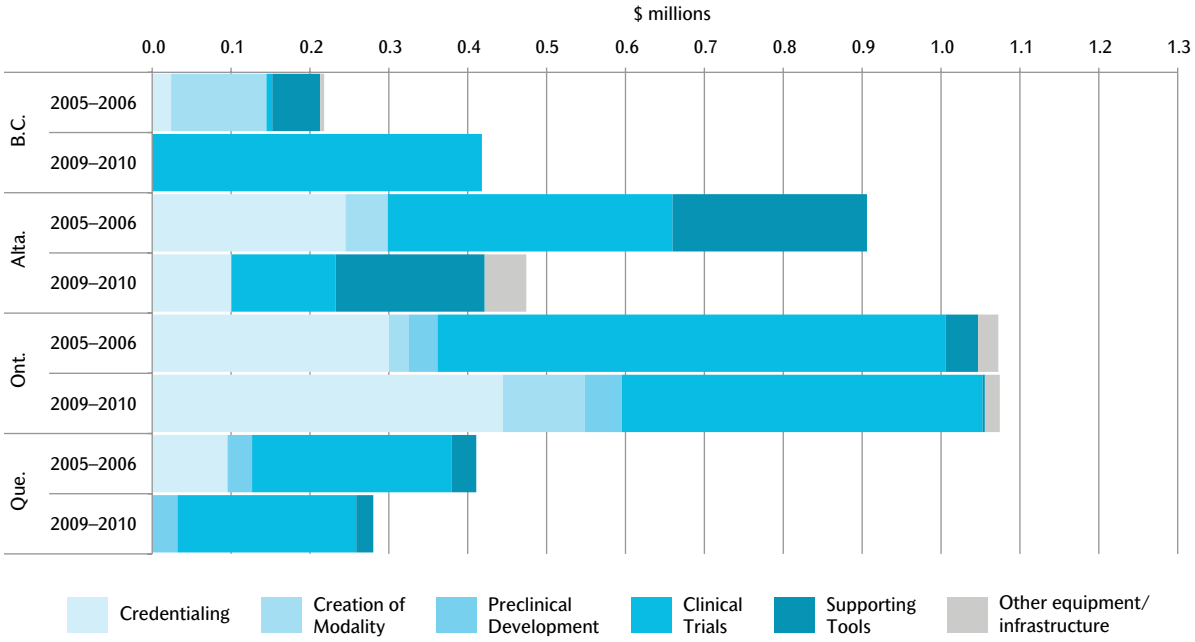


[1] Cancers shown have an average annual investment in early translational lifestyle alterations research of $100,000 or more.

The investment in early translational Lifestyle Alterations research by province of nominated principal investigator is provided in Figure 3.5.5. Combined, four provinces accounted for 96.1% of the total six-year investment in early translational Lifestyle Alterations. The investment from the first to the third biennia dropped for Alberta and Quebec, increased negligibly for Ontario, and increased most markedly for British Columbia. The provincial patterns of phase-specific investment showed varying changes from 2005-2006 to 2009-2010, particularly for Clinical Trials and Credentialing.

FIGURE 3.5.5

INVESTMENT IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY PHASE AND PROVINCE OF NOMINATED PRINCIPAL INVESTIGATOR [1], 2005–2006 AND 2009–2010



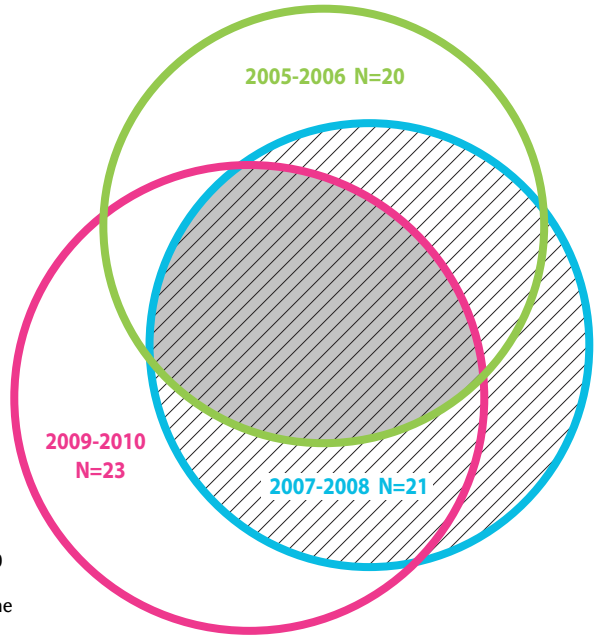
[1] Provinces shown have an average annual investment in early translational lifestyle alterations research of $100,000 or more.

There were 35 nominated principal investigators who were funded for early translational Lifestyle Interventions research at some point over the six-year period, with a core of 8 researchers who were funded during all three biennia (Figure 3.5.6). There were 3 more nominated principal investigators in 2009–2010 than in 2005–2006.

There were 9 more trainees receiving grant funding for early translational lifestyle alterations research in 2009–2010 than 2005–2006 (see Figure 3.5.7). Thirteen of the 18 trainees in 2009–2010 were graduate students. Unlike the other modalities, there were no undergraduate trainees for Lifestyle Alterations in either 2005–2006 or 2009–2010.

FIGURE 3.5.6

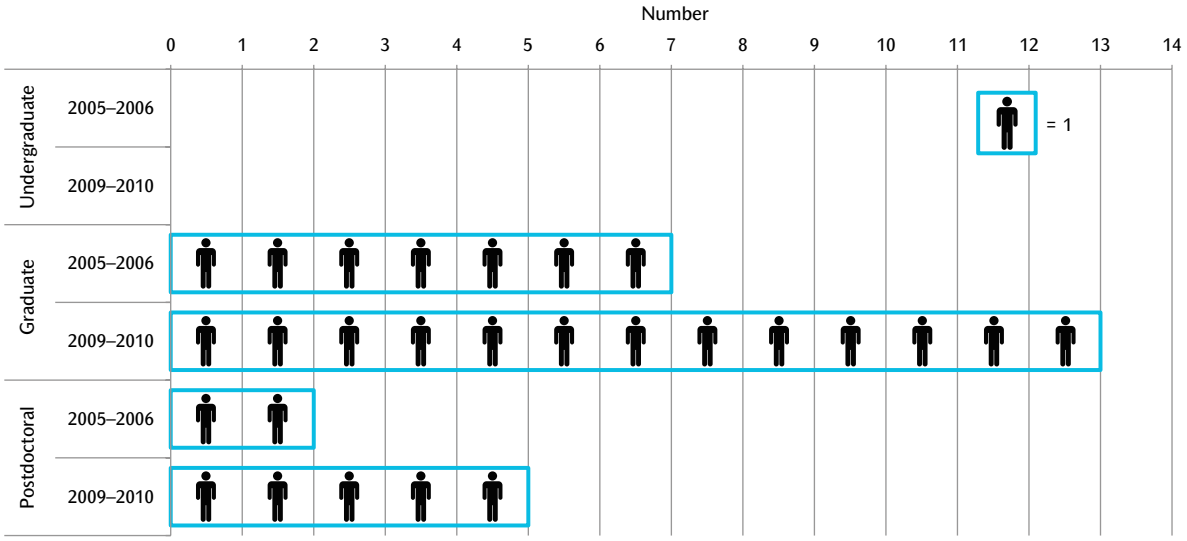
NUMBER OF NOMINATED PRINCIPAL INVESTIGATORS [1] FUNDED FOR EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY FUNDING PERIOD



[1] There were 35 nominated principal investigators who had at least one operating grant, equipment award or career award in the 2005 to 2010 period in the area of early translational lifestyle alterations research weighted at 50% or higher. Investigators were grouped according to the years in which they received funding.

FIGURE 3.5.7

NUMBER OF TRAINEES [1] IN EARLY TRANSLATIONAL LIFESTYLE ALTERATIONS RESEARCH BY TRAINING LEVEL, 2005–2006 AND 2009–2010



[1] Includes all trainees awarded grants where at least some of the research project involved early translational lifestyle alterations research. Trainees awarded grants for more than one training level are included for each time period-training level combination. There were 9 trainees in 2005–2006 and 18 trainees in 2009–2010.

4. Summary

KEY FINDINGS

- The investment in early translational cancer research outpaced that for cancer research overall and grew for all funding sectors from 2005–2006 to 2009–2010.
- Provincial government organizations primarily in Ontario and, to a lesser extent, Alberta were the key drivers of the increased investment.
- The distribution of the investment across the four main modalities—drugs, biomarkers, interventive devices, and lifestyle alterations—did not shift significantly from 2005–2006 to 2009–2010.
- Creation of Modality, the phase where translational modalities are created and/or refined, had the highest increased level of investment—$44.0M more was investment in 2009–2010 than 2005–2006.
- Breast cancer, prostate cancer, leukemia, and brain cancer represented 64.4% of the site-specific early translational research investment in the third biennia, up from 53.8% in the first. There was $43.6M more invested in 2009–2010 than 2005–2006 for these four cancer sites.
- There were 358 principal investigators funded for early translational research projects in all three biennia, which represents about 30% of all cancer researchers funded in all biennia.
- An increasing number of trainees received grants for research within the early translational research area. A large proportion of the increased investment in trainee research in 2009–2010 came from the federally-supported Canada Graduate Scholarships program.

This report takes an in-depth look at early translational cancer research conducted in academic environments and funded by major peer-reviewed programs offered by governments and charitable organizations in Canada. It is estimated to represent about one-third of the overall early translational research environment, with industry being the key player not captured in this analysis.

The findings suggest the following:

- Strategic funding makes a difference. For example, the aggressive and concentrated investment by the Ontario Institute for Cancer Research in translational research and supporting platforms has changed the research landscape in Ontario in just a few short years— enhancing research capacity and strengthening the province's innovation potential.

- Translational research capacity in Canada may have increased. Despite some modality-specific exceptions, there were more principal investigators and graduate trainees being funded in 2009–2010 than 2005–2006. Furthermore, operating grants focused on translational research were not the main drivers of this increase, suggesting perhaps that translational researchers may be more successful in securing the available open operating grant funding and/or that there has been a shift to early translation in the overall cancer science enterprise.
- The level of investment in early translational breast cancer research bodes well for future drug and imaging innovations. Furthermore, the Terry Fox Research Institute's support of pan-Canadian research teams that include researchers with diverse research backgrounds and expertise has augmented and advanced translational biomarker research focused on prostate and ovarian cancers.
- Federal government organizations have been key players in supporting capacity building and foundational equipment/infrastructure support, including biorepositories. Efforts to harmonize strategic priorities around translational research across federal organizations may help to facilitate sustained growth in this area. Programs like the Canadian Tumour Repository Network (CTRNet) play a critical role in supporting early translational research by raising the quality of biospecimens and facilitating researcher access to biorepositories.
- The low level of investment in Lifestyle Alterations is consistent with the CCRA report on investment in cancer risk and prevention research[8]. Compared with trials for drugs or other interventions, intervention studies designed to address behaviours or exposures are often complex, planning-intensive, and rife with logistical, environmental, and financial hurdles. How best to support research on Lifestyle Alterations needs to be addressed and this is one of the emphases in the strategic framework on cancer prevention research in Canada published by CCRA in 2012.[9]
- Given that 2010 was the first year where the total cancer research investment dropped from its year-upon-year increase, it will be important to continue to track the early translational cancer research investment to see how the investment evolves in terms of dollar amount and modality-phase composition. The ramp-up of translational programs by the Terry Fox Research Institute, starting in 2009, will be an important component of the post-2010 investment picture.
- Assessing research impact or the return on this investment in early translational research is an important area of future investigation. An evaluation should include consideration of outputs (e.g., material transfer agreements, filed patent applications, commercialized patents, new intellectual property, spin-off companies, etc.) as well as tracking on how the investment has affected subsequent investment in late translational research and the eventual dissemination and adoption of new drugs, devices, and population interventions.

8. As a general caveat, this report looked specifically at projects with a stated intention of cancer prevention and did not include studies that were more generally focused on chronic disease prevention.
9. Canadian Cancer Research Alliance. (2012). *Cancer Prevention Research in Canada: A Strategic Framework for Collaborative Action.* Toronto: CCRA.

APPENDIX A.

EARLY TRANSLATIONAL CANCER RESEARCH INVESTMENT BY PARTICIPATING ORGANIZATIONS/PROGRAMS AND FUNDING PERIOD

ORGANIZATION [1]	$			Percent change from 2005–2006 to 2009–2010	Organization's cancer research investment relevant to early translation, 2009-2010 (%)
	2005-2006	2007-2008	2009-2010		
FEDERAL GOVERNMENT	**62,931,367**	**71,197,526**	**92,965,094**	**47.7**	**18.3**
Canada Foundation for Innovation	1,744,220	2,680,308	3,078,819	76.5	3.2
Canada Research Chairs Program	4,813,955	5,479,316	5,420,438	12.6	12.4
Canadian Institutes of Health Research	37,189,869	42,563,486	50,722,033	36.4	18.8
Canadian Partnership Against Cancer	-	178,167	2,004,360	-	9.4
Genome Canada	6,426,023	2,507,174	3,438,981	-46.5	24.6
National Research Council of Canada	5,043,978	7,592,432	10,616,923	110.5	59.1
Natural Sciences and Engineering Research Council	5,144,030	8,277,125	15,480,684	200.9	53.6
Networks of Centres of Excellence [2]	297,091	558,997	778,795	162.1	60.4
Public Health Agency of Canada	2,191,433	1,339,521	1,207,393	-44.9	20.6
Social Sciences and Humanities Research Council	80,768	21,000	80,000	-1.0	1.3
Other Federal agency	-	-	136,669		10.8
PROVINCIAL GOVERNMENT	**33,606,011**	**58,966,528**	**96,461,758**	**187.0**	**33.5**
PROVINCIAL CANCER AGENCY	6,518,553	17,877,318	16,571,823	154.2	30.3
Alberta Cancer [3]	5,111,801	14,435,048	12,984,494	154.0	34.2
CancerCare Manitoba	761,315	655,328	470,388	-38.2	24.3
Cancer Care Nova Scotia	25,000	45,000	37,000	48.0	9.2
Cancer Care Ontario	412,031	2,497,847	2,740,946	565.2	20.1
Saskatchewan Cancer Agency	208,406	244,096	338,996	62.7	50.5
PROVINCIAL HEALTH RESEARCH ORGANIZATION	23,277,753	37,898,269	76,511,792	228.7	43.7
Alberta Innovates – Health Solutions	1,611,977	1,567,205	1,827,765	13.4	16.1
Fonds de recherche du Québec - Santé	2,164,290	2,426,815	3,336,228	54.1	14.3
Manitoba Health Research Council	261,160	420,963	502,862	92.5	27.0
Michael Smith Foundation for Health Research	2,581,830	3,545,042	2,418,062	-6.3	22.8
New Brunswick Health Research Foundation	30,000	28,698	6,233	-79.2	4.3
Newfoundland and Labrador Centre for Applied Health Research	-	-	-	-	-
Nova Scotia Health Research Foundation	261,561	205,386	190,337	-27.2	15.7
Ontario Institute for Cancer Research	16,050,337	28,124,881	59,036,166	267.8	58.1
Ontario Ministry of Research and Innovation	15,750	1,299,618	9,126,383	57,845.3	38.4
Saskatchewan Health Research Foundation	300,849	279,661	67,756	-77.5	7.4
OTHER PROVINCIAL AGENCY	3,809,706	3,190,941	3,378,143	-11.3	5.8
VOLUNTARY ORGANIZATION	**35,086,772**	**43,376,830**	**51,297,412**	**46.2**	**26.9**
Brain Tumour Foundation of Canada	87,143	192,935	169,436	94.4	39.7
C^{17} Research Network	62,925	227,979	88,704	41.0	9.8
Canadian Association of Radiation Oncology	262,382	488,724	622,643	137.3	78.7
Canadian Breast Cancer Foundation	3,988,929	5,473,925	7,567,446	89.7	26.2
Canadian Cancer Society	14,557,402	16,426,517	15,189,091	4.3	17.8
Canary Foundation of Canada	170,445	1,900,875	191,600	12.4	79.6
Cancer Research Society	2,593,720	2,668,472	1,745,555	-32.7	17.9
Fondation du cancer du sein du Québec	-	9,750	1,173,054	-	47.0
Ovarian Cancer Canada	7,750	127,916	202,040	2,507.0	39.8
PROCURE	-	-	-	-	-
Pediatric Oncology Group of Ontario	-	-	-	-	-
Prostate Cancer Canada	1,237,485	855,473	3,198,443	158.5	68.1
The Kidney Foundation of Canada	148,359	-	12,438	-91.6	3.0
The Leukemia & Lymphoma Society of Canada	601,250	1,020,000	1,176,216	95.6	34.9
The Terry Fox Foundation	10,477,130	13,250,486	19,325,847	84.5	39.9
Other charitable organization	891,852	733,779	634,902	-28.8	21.4
OTHER [4]	**9,110,841**	**9,499,904**	**12,215,460**	**34.1**	**12.4**
TOTAL	**140,734,991**	**183,040,789**	**252,939,725**	**79.7**	**23.3**

[1] Organizations are listed alphabetically under the relevant funding sector (sector totals are shown in boldfaced, upper case letters).

[2] NCE figure does not include funding from CIHR, NSERC or SSHRC for network management and activities, but does reflect investment in early translational research projects supported by specific networks.

[3] Alberta Cancer represents an amalgamation of different funding sources, including Alberta Cancer Board, Alberta Cancer Foundation, Alberta Health Services, and the Alberta Cancer Prevention Legacy Fund administered by Alberta Innovates – Health Solutions. For the sake of simplicity, Alberta Cancer is grouped under provincial cancer agencies.

[4] Co-funding of projects supported by CCRS participating organizations by institutional, industry, and foreign sources.

Our Members

Alberta Cancer Foundation

Alberta Innovates Health Solutions

braintumour foundation of Canada

BC Cancer Agency
Care & Research

Children's Cancer & Blood Disorders

CAPCA

caro acro
Canadian Association of Radiation Oncology / Association canadienne de radio-oncologie

Canadian Breast Cancer Foundation | Fondation canadienne du cancer du sein

Canadian Cancer Society | Société canadienne du cancer

CIHR IRSC
Canadian Institutes of Health Research | Instituts de recherche en santé du Canada

Canadian Partnership Against Cancer | Partenariat canadien contre le cancer

CancerCare Manitoba

Cancer Care Nova Scotia

Ontario
Cancer Care Ontario
Action Cancer Ontario

Cancer Research Society | Société de recherche sur le cancer

Fonds de recherche Santé Québec

GenomeCanada

Government of Canada | Gouvernement du Canada

Leukemia & Lymphoma Society® Canada
fighting blood cancers

Manitoba Health Research Council

Michael Smith Foundation for Health Research
Discover. Connect. Engage.

NRC·CNRC

New Nouveau Brunswick

Nova Scotia Health Research Foundation

OICR
Ontario Institute for Cancer Research

Ovarian Cancer Canada
Cancer de l'ovaire Canada

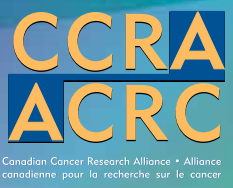
PROCURE
Halte au cancer de la prostate.
The Force Against Prostate Cancer.

Prostate Cancer Canada

Quebec Breast Cancer Foundation

Saskatchewan Cancer Agency

A single dream. A world of hope.
The Terry Fox Foundation



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