# 11. Clinician Scientists in Canada: Supporting Innovations in Patient Care Through Research


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# Contributions and Support

## Acknowledgements

This paper could not have been completed without the contributions and support from the following:

- **Valerie Darkke and Julia Selig**
  Former Royal College staff who helped advance the draft to completion.
- **The CIP Advisory Committee**
  Who reviewed the draft paper and recommendations.
- All of those who provided feedback during the consultation phase.

# PREFACE

In 2011, as part of the Future of Medical Education in Canada – Postgraduate Project, the Royal College released a series of White Papers on the key issues impacting residency medical education. Following the release of the original series of white papers, the Royal College and its Fellows identified the topic of "Clinician Scientists" as an area still in need of development. Recognizing the need for the right mix and distribution of physicians across the spectrum to facilitate the translation of research, the Royal College supported the development of an additional Clinician Scientist white paper for the series. Moreover, as the development of this white paper was nearing completion, the Canadian Institute of Health Research (CIHR) announced its 30-year-old MD/PhD awards program would be ending in 2016. The decision made by the funding agency to cut funding adds an increased sense of urgency in disseminating a better understanding on the importance of the Clinician Scientist's role in Canada.

# ABSTRACT

Clinician Scientists are physicians who have typically undertaken additional research training and, in addition to working in the clinical setting, dedicate a substantial part of their career to research. As both clinicians and researchers, the role of Clinician Scientists is central to the discovery and translation of health-related knowledge. Despite the important contribution of Clinician Scientists, they face many career obstacles and are relatively few in numbers. Developing a career stream for Clinician Scientists is integral to the health system and any efforts to ensure the right mix and distribution of physicians.

This paper outlines the barriers to the recruitment and retention of Clinician Scientists and advances a series of recommendations for the action of the Royal College.

As a primary step in the development of the Clinician Scientist White Paper, a literature review was conducted as a method of identifying existing gaps in the training and retention of Clinician Scientists. Based on the literature review, a draft white paper was developed and launched in August 2014. With the intention of obtaining feedback on the draft, an extensive consultation with key Clinician Scientists and other medical education stakeholders ensued.

The consultation phase spanned several months, concluding in late Fall 2014, and gathered over 30 responses from a wide range of stakeholders. Drawing from these responses and the literature review, six barriers to Clinician Scientists' recruitment and retention were identified: the changing gender balance in the medical profession; residents' exposure to research skills, research mentors and role models; lengthy training time; financial deterrents; Clinician Scientist trainee requirements; and career demands.

To address these identified barriers, stakeholders must work towards increasing the perceived value of Clinician Scientists in Canada as well as continuously advancing and evaluating support mechanisms at every stage of Clinician Scientist's career development. Moreover, further research should be undertaken to identify, and subsequently rectify, gaps in the training pathway to become a Clinician Scientist in Canada.

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# OBJECTIVES

The objectives of this White Paper are twofold:

1. Narratively review the current state of Clinician Scientist in Canada, outlining barriers to Clinician Scientists' recruitment and retention; and to
2. Provide a list of recommendations for the Royal College of Physicians and Surgeons of Canada to act on in an attempt to address the barriers to recruitment and retention of Clinician Scientists in Canada.

# INTRODUCTION AND BACKGROUND

For health-related research to reach its full effectiveness it requires that knowledge flow across a continuum from laboratory-based science to clinical research, to population, health service and policy research, and vice versa. There are apparent gaps in applying research to clinical practice. For instance, studies show that new knowledge generated in the research setting relevant to clinical care is rarely translated into practice (Grimshaw et al., 2012; Yusuf, 2012). A study by Contopoulos-Ioannidis & Ioannidis (2003) concluded that only 0.004% of published high-impact randomized-controlled studies led to the development of clinically useful class of drugs. Similarly, hypotheses made by physicians at the bedside as a component of patient care tend not to be tested empirically. In addition, moving knowledge from simple observations to research to widespread use is often a complex, inefficient process (Harrington, 2009), with numerous barriers (i.e., structural, organizational, professional, and communicational, etc.) hindering its progress (Grimshaw et al., 2012).

## Who are Clinician Scientists?

Clinician Scientists (also known as physician scientists or clinician investigators) are physicians who have typically undertaken additional research training and, in addition to working in the clinical setting, dedicate a substantial part of their career to research. Clinician Scientists play an important role in closing the gap between research and practice. These individuals have undergone additional training in a broad spectrum of health-related research that may include basic science, clinical science, educational research, health professions education, health services, social science, and the humanities. The Canadian Institutes of Health Research (CIHR) embraces four pillars of health research: biomedical, clinical, health systems and services, as well as social, cultural and environmental factors that affect the health of the population (Health Research Roadmap, 2009). Clinician Scientists typically conduct research in all of these pillars, and often do so in other topic areas as well.

### *Clinician Educators*

A small but growing subset of Clinician Scientists in Canada include education scientists (also known as clinician educators or clinician scholars) whose research training is in fields such as health professions education or social sciences (Eisenberg, 2011). The Royal College of Physician and Surgeons of Canada defines a Clinician Educator as:

> "a physician with formal training (e.g., graduate degree, robust diploma program, or formal fellowship) in medical education, providing consultative advice for educational projects undertaken by faculty in the health professions" (Clinician Educator Program, 2014).

Clinician Scientists working in a health education field often practice in academic medical centres. These individuals play an important role in shaping how future doctors and other health professionals are trained. They spend most of their time providing patient care, teaching residents, fellows, medical students and attending to administrative activities (Eisenberg, 2011). Often, but not always, they spend less time on research and more time on educational activities. Their work is broad and varied; they explore the cognitive and the social science of learning, critically examine which education approaches work and which do not, and they strive to advance the theoretical understanding of learning in the health professions. They share the same overarching goal as other Clinician Scientists - to improve human health and wellbeing - but they exercise their influence on human health through the educational processes that shape the way care is delivered. Clinician Educators, therefore, develop research questions from the educational issues they encounter in practice, and work to bridge the gap between learning theory and educational practice.

Clinician Scientists in health education professions are perhaps the most prominent example of a growing cadre of clinicians who perform research activities along with their clinical work. A clinician scientist with advanced training in bioethics, for example, might also do critically important work that helps our society to cope ethically with medical and technological advances. Another example of such a group of individuals is a Clinician Administrator or Clinician in Quality and Innovation. All of these professions, among many others in health-related services, include scholarly work as a part of their job descriptions.

## The Breadth of Clinician Scientists' Work

A unique combination of skills allows Clinician Scientists to participate in clinical work that spans the full breadth of activities — from the researcher's bench (whether real or metaphorical) to the patient's bedside (i.e., where they perform patient care activities), and back again. The Clinician Scientist's skill set and scope of exposure facilitates these individuals' work to translate research results into the clinical setting and to develop research questions based on the clinical issues they encounter in practice. Clinician Scientists' research expertise covers a broad range of topics, from basic science studies in a laboratory to translational and patient-oriented clinical research to population health research and epidemiology (Schafer, 2009) as well as research into the processes and structures of health, illness and healthcare, the patient experience, and the preparation of health professionals to provide competent patient care.

Many consider a true Clinician Scientist to be someone who satisfies the full breadth of translational science. Traditionally, translational science followed the "bench to bedside" approach, defined by Waldman and Terciz (2010). Nevertheless, the bedside is only the beginning of the translational spectrum and this approach applies to a very narrow type of basic/clinical science. Rubio et al (2010) gave translation research a much broader definition:

> "…translational research moves in a bidirectional manner from one type of research to another—from basic research to patient-oriented research, to population-based research, and back —and involves collaboration among scientists from multiple disciplines."

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No matter the definition adopted, the role played by Clinician Scientists and their contribution to research is critical for driving health care innovation in Canada. As both clinicians and researchers, their integrated training allows them to

> "critically examine the research process; think "out of the box" to develop ways to impact health care by transferring knowledge from and to the bench, bedside, and community; engage in multidisciplinary collaboration; understand successful approaches to community engagement; and develop appropriate techniques to manage multidisciplinary research teams in the future. Using multidisciplinary skills, the translational researcher is able to think and perform in an integrated interdisciplinary manner and become a new type of investigator" (Rubio et al., 2010).

In addition, an effective training program allows Clinician Scientist to apply a "clinical medical perspective to the broad spectrum of biomedical research" and their patient care activities provide opportunities for the formulation of hypotheses that can later be empirically tested, making for a more complex study and thorough understanding of disease than that which is possible within either the medical facility or laboratory environment alone (Bonham, 2014).

***Value of Clinician Scientists' work***

Clinician Scientists add tremendous value to improving human health. Through their study of patients and human subjects, Clinician Scientists have made substantial discoveries in disease mechanisms, pathogenesis and novel interventions. A case for the value of the Clinician Scientist is made by statistics related to Nobel Prize award recipients between 1997 and 2012. Over this period, the majority of recipients were either independent researchers with both an MD and a PhD or recipients who were part of a research team that included at least one individual who had both an MD and a PhD designation (Gottesman, 2013; Bonham, 2014). Canadian Clinicians have had a tremendous international scientific impact in the health field, ranking highly together with the United Kingdom, the United States, Denmark and Netherlands. Furthermore, Canada ranked first in patient-oriented research based on citations in academic journals (see Figure 1).

An example of the substantial productivity that can be generated by Clinician Scientists appears in a set of data collected from the C. T. Lamont Primary Healthcare Research Centre (CTLC) - a research centre which provides support to Clinician Scientists in the field of Family Medicine. This data revealed that within the first five years of their career, 5 Clinician Scientists at CTLC secured 66 small and large grants, published 64 peer-reviewed articles, and presented over 150 presentations at various national and international conferences (Hogg, 2014).

## Distribution of Clinician Scientists' Time

The proportion of the Clinician Scientist's time spent on research, in relation to other clinical, administrative or educational tasks, varies depending on the individual in question and the funding sources, or lack thereof (see Figure 2) (Brass et al., 2010; Eisenberg, 2011). In the 2013–2014 application cycle, CIHR granted a Clinician Scientist salary award only if a minimum of 75 per cent of the applicant's time was protected for research for the duration of the award. However, the role of Clinician Scientists and the subsequent division of their time may fall anywhere along the continuum from research to practice: with some Clinician Scientists doing less research in favour of other activities — clinical, administrative or educational in nature — and others doing more research and spending less time on other activities. For example, some Clinician Scientists may act as clinically trained full-time scientists with limited clinical work; other Clinician Scientists straddle both sides (e.g., maintaining a nationally funded program of research while remaining highly engaged in clinical work), while others may have a principal focus on the translation of newly generated knowledge into clinical practice.

The minimum FTE requirements for Clinician Scientists vary among Canadian medical schools. For example, promotional material for professor status generally includes a breakdown of time between research, clinical work, teaching, administrative and other duties. For those individuals applying for promotion and claiming research as their primary activity, there are expectations related to research funding and peer review publications which often equates to a large portion of clinician's time spent doing research activities.

## Protecting Clinician Scientist's Research Time

In many cases, depending on a chosen career track, Clinician Scientists need to obtain salary awards in order to begin or continue their research activities. Historically, Federal funding agencies such as CIHR in Canada or National Institutes of Health (NIH) in the United States, and provincial or program-specific funding agencies, such as the Heart and Stroke Foundation of Canada or Prostate Cancer Canada have provided salary support for Clinician Scientists (see Table 1 for top funding organizations of salary awards in Canada based on 2014 data). Many of these awards have been available to new or mid-career scientists (Eisenberg, 2011).

In the United States, when awarded an open operating grant, it is permissible to budget a portion of the grant to principal investigator's and co-investigators' salaries. This is not the case in Canada, which makes salary awards, clinical earnings, and funding from the division, department, or research institute the primary sources of protections for Clinician Scientists' research time. As research projects almost always require contributions from an entire team of individuals, not the award recipient alone, it is important that awards are appropriately budgeted to take into consideration the time and work of all staff members involved in the project.

### *The role of a host institution*

In the early stages of Clinician Scientists' career, physicians need three to five years of protected time for research to obtain grants, produce publications, and ultimately obtain a career award (Eisenberg, 2011). Institutional support is pivotal for a Clinician Scientist's research career success. The role of their host institution becomes particularly important when a sought after individual is not quite ready with publications and/or training to initially receive salary awards, research grants and establish his/her own laboratory or research program. In this instance, for example, an established laboratory or program in the institution that has the appropriate complementary interest can provide facilities, mentoring, collaborative expertise and training, help in grant writing, and the foundation and especially the time for the new individual to become successful.

## Paths to Becoming a Clinician Scientist

There are various incentives influencing physicians to become Clinician Scientists, including intellectual challenges posed by research, inspirational researcher-mentors, and previous research experience, among many others. A physician can become a Clinician Scientist early in their MD training or late in their career (Eisenberg, 2011; Kearney et al., 2007). Currently, there are two well-established, formal pathways for one to become a Clinician Scientist in Canada: through a joint MD/PhD or MD/MSc program or through the Royal College's Clinician Investigator Program (CIP).

### *CIP and MD/PhD training*

The main goal of the Royal College's CIP program is to assist in the career development of Clinician Investigators in Canada. CIP is a formal postgraduate medical education program providing integrated, structured, and rigorous research training. Varying by institution, CIP training often includes traditional laboratory and clinical research, as well as other non-traditional areas of research including, but not limited to: economics, management, social, behavioural, and others as they apply to healthcare. CIP involves a minimum of

24 months of study (longer if doctoral studies are pursued) and typically commences during the third or fourth year of residency. Three pathways are offered under the CIP program: The Continuous Training (CT) pathway which involves continuous, intensive research training which can be done at different points in residency; the Fractionated Training (FT) pathway, designed for clinical epidemiology research and includes intensive research activities separated by long waiting periods; and the Distributive Curriculum Training (DCT) pathway, which is intended for outstanding residents who have research experience prior to entering a residency program. The DCT pathway is designed to maintain research momentum during residency and to integrate clinical training with research.

A joint MD/PhD or MD/MSc program and the CIP pathways are not mutually exclusive. MD/PhD or MD/MSc students engage in undergraduate medical and PhD/MSc studies, which culminate in the receipt of the dual-degree designation. Joint MD/PhD programs take approximately seven to nine years to complete and MD/MSc programs can be completed in about five to six years. Alternatively, CIP trainees engage in research training at the level of a graduate degree program or post-doctoral fellowship (if the trainee has prior graduate degrees) concurrently with postgraduate medical education (see Appendix C).

### *Other types of training*

There are other less formal but common pathways that may have led professionals to practise as Clinician Scientists. For instance, these may include: enrolment into a post-residency research fellowship program by physicians or surgeons who enter into clinical research later in their career without a previous graduate degree such as a PhD, or those who acquire a PhD, Master's Degree or Nursing before their medical training or after beginning their clinical practice. Kearney et al (2007) notes that physicians who obtain a PhD after medical training seem to have a career that is more focused on research than those who enter medical school with a PhD (Kearney et al., 2007).

Some may argue that proper research training does not necessarily require an additional, formal degree, although having such a degree can carry some professional influence. The important factor, however, is that the individual becomes highly trained in their field of interest and is well versed in fundamental theories, techniques, and methods of their respective area. Such knowledge can, of course, be obtained in properly selected research laboratories rather than in a formal research-driven educational program.

## Collaboration between Clinician Scientists and Non-Clinician Scientists

A significant amount of collaboration occurs between Clinician Scientists and Basic Scientists (who are non-clinician, and may include epidemiologists as well as other researchers) in the health research field. Both professions play pivotal roles in addressing gaps in patient care and, in fact, collaboration between these two different professionals may even accelerate their respective work. The importance of collaboration between Clinician Scientists and Non-Clinician Scientists has been emphasized and recognized in the recent years (Niessen & Krieg, 2014). Such benefits often include: the generation of new ideas based on a symbiotic relationship between the researchers, whereby each can benefit from expertise of the other; a better understanding of clinically relevant basic science questions; and the comprehensiveness of a multidisciplinary approach (Niessen & Krieg, 2014). One may ask why a clinician is important in the research enterprise particularly when clinicians cost significantly more than Basic Scientists who may, on the surface, appear to be doing the same thing. Clinician Scientists understand both basic physiologic mechanisms and the subtle aspects of human diseases. Their involvement is essential in accelerating the application of molecular breakthroughs to the diagnosis of diseases and the development of treatments (Donowitz et al., 2007).

The importance of clinical input to ensure relevance of the research program cannot be understated. The special nature and utmost importance of the clinician scientist rests in the medical inter-relationship of what goes on at the bench and with the patient in clinical practice. This is unique to the Clinician Scientist. Moreover, given the interaction of Clinician Scientists with their clinician colleagues, they may formally and informally keep them up to date on medical advancements.

The complexity of contemporary scientific challenges requires multidisciplinary approaches that can be developed through sustained collaborations of scientists from different disciplines. Lack of collaboration between the two groups leads to barriers in the translation of research (Homer-Vanniasinkam &Tsui, 2012; Weldon & Wyngaarden, 2004). Such partnerships in science have proven to be highly successful and have led to ground-breaking discoveries (Goldstein & Brown, 1997) that highlight the important work of both – the Clinician and Non-Clinician Scientists.

## Clinician Scientist Workforce in Canada

National-level data on the exact number of Clinician Scientists currently practising in Canada cannot be ascertained with accuracy; however, it remains clear that this unique training results in a relatively small group of individuals. In order to contextualize this discussion, one high-level estimate suggests that 4,522 Clinician Scientists are practising across the country. This data set encompasses investigators, including MDs and RNs without a PhD and those with a PhD, who had received a CIHR grant since 2000.

During the period from 2004 to 2013, the total number of graduates of combined MD/PhD programs in Canadian Faculties of Medicine varied from 11 at the lowest to 35 at the highest. A total of 234 graduates have come through this pathway during the nine-year period (see Figure 3).

It has been estimated that since the program's first graduate in 1997, the Royal College's CIP has produced 404 individuals with this unique designation, at a rate of approximately 29 per year. In 2010-2011, 209 trainees were actively involved in the CIP program across Canada. As for the other formal training pathway, the majority of Canada's medical schools offer a joint MD/PhD and/or MD/MSc with the total of 243 trainees enrolled in 2010-2011 (Appleton, 2013).

Over the past decade, enrolment in Canadian Clinician Scientist training programs has approximately quadrupled (Appleton et al., 2013). However, some of these individuals may not intend to practice as Clinician Scientists upon graduation. For example, Canadian residents might be completing these training programs not because they want to be a Clinician Scientist, but to compete with their US graduate counterparts for a number of reasons. Reasons to acquire or maintain a competitive edge may include: acceptance to fellowship programs in surgical subspecialties in the US, a perception of limited available jobs in their chosen specialty, the hidden curriculum and the perceived value of such training programs, or because of the recent and common hiring criterion in academic centres, for even a clinical job, of holding a Masters' Degree. The implication is that the number of Clinicians Scientists might not grow despite the increase in enrolment in Canadian Clinician Scientist training programs.

Unfortunately, there are limited records to show fulsome data on the more critical indicators of Clinician Scientist growth, such as successful completion of these programs and achieving a Clinician Scientist career (Appleton et al., 2013). However, there are some data on the academic appointments of CIP graduates. Numbers obtained from the CIP program trainee survey conducted in 2008 indicate that approximately 67% (97/145) of the CIP alumni surveyed had attained an academic position. Of those who had attained a position, it was often in a clinical department (n=71/97, 73%), as an assistant professor (n=79/97, 81%) or as an associate professor (n=12/97, 12%) (Hayward et al., 2011). However, data are lacking

on Canadian MD trainees who may be studying abroad in preparation for a career as a Clinician Scientist. For these reasons, Appleton et al. (2013) suggest that it is too early to know to what extent an increase in Clinician Scientist training in Canada will sustain this workforce (Appleton et al., 2013). Although, one thing seems to be apparent: given the increasing knowledge in the fundamental biological sciences and the burden of disease, the importance of developing Clinician Scientists is critical (Garrison, 2014).

# AREAS REQUIRING CHANGE

Scientists are intelligent, creative, inquisitive people who are excited by discovery and filled with the desire to increase knowledge and understanding. Apart from inherent personal characteristics, functioning as a research scientist also depends on a number of practical issues including: adequate research training, a proper research environment, satisfactory physical, financial, and human resources, time protection, and the freedom to be creative in one's occupation. While there is no argument about the critically important role played by Clinician Scientists and the increase of CIP programs across Canada, many factors threaten their role within the Canadian medical system.

Some scholars have pointed to a decline in the number of Clinician Scientists in both Canada and internationally (Lander et al., 2010; Ley & Rosenberg, 2005; Rosenberg, 1999; Rosenblum, 2012 29; Schafer, 2009). More recently, others have raised concerns about the amount of time Clinician Scientists have to allot to their intended purpose, namely direct investigation (Phillipson, 2002). The diminishing role of Clinician Scientists is not a symptom of declining need: in fact, with the ever-increasing expansion and complexity of heath care knowledge and services, as well as the imperative of hospital efficiencies in light of stretched fiscal resources, Clinician Scientists are needed now more than ever (Phillipson, 2002).

Scholars have identified various obstacles that make it difficult for individuals to maintain a productive research career and, at the same time, fulfill their clinical responsibilities. Potential Clinician Scientists are likely to be dissuaded from research as a result of these obstacles, which include: lack of residents' exposure to research skills, lengthy training time, overwhelming trainee requirements, insufficient guidance in the research environment, career demands (Lander et al., 2010), other life transitions such as family formation, home purchases, etc., and, of course, financial deterrents.

## The Changing Gender Balance in the Medical Profession

Key shifts in gender representation are occurring across the medical profession at large, and these shifts can be expected to exert an impact on the demographics of Clinician Scientists as well. Statistics Canada marked 1997 as the first year that more women than men entered training in medical school. Today, more women are continuing to enter residency programs and graduating. (AFMC, 2014). According to the Association of Faculties of Medicine of Canada, 58% of women and 42% of men have received a medical degree in 2014 (AFMC, 2014).

Despite the growth in the proportion of females entering and graduating from medical residency programs, data from the CITAC census survey revealed that in 2010/2011 the number of female Clinician Scientist trainees was lower than the number of male Clinician Scientist trainees in all training programs across Canada, with the exception of the MD/MSc program (Appleton, 2013). Furthermore, the numbers of women who reach full professorship or become principal investigators are worrisome (Zhuge et al., 2011). A study from the US, for example, revealed that woman comprise only 34% of medical school faculty and only 17% are full professors (AAMC, 2008). It has also been shown that female clinicians spend less time on research activities than their male counterparts (Wietsma, 2014) and that more women are dropping out of the MD/PhD programs than men (Andriole et al, 2008; Bickel

et al., 2002; 2015 60). Given the change in the proportion of women entering medicine, strategies should be adopted to encourage and advance the research careers of women to prevent further decline of Clinician Scientists.

## Lack of Residents' Exposure to Research Skills

The clinical residency environment offers an unprecedented opportunity to expose residents to the impact and the need for research to improve patient care. However, some specialty education programs do not offer a research block and some offer research only in the form of an elective. Several clinical training programs allow for a very limited number of internships in research during training. Such limited access, in turn, can make it very difficult or impossible for many residents to enroll in CIP or PhD/MSc training because trainees do not have enough elective courses available for research purposes.

In addition, the limited exposure to research may also exert an influence on career choice. Evidence suggests that completion of a research project during residency makes a clinician's future involvement in research more likely (Chan et al., 2009; Leahy et al., 2008). Bammeke et al. lists barriers to resident scholarly work: lack of time, interest, and research skills (Bammeke et al., 2015). The main solutions were to allow full research days to be used in half-day increments and to offer a journal club that teaches research skills to residents.

## Lengthy Training Time

The length of time required to complete the necessary training is a great obstacle to the recruitment and retention of Clinician Scientists (Bosse et al., 2011; Rosenberg, 1999; Rosenblum, 2012; Schrier, 1998). Research has revealed that approximately one-third (31%) of CIP trainees noted that lengthy completion time was a deterrent to pursuing the Clinician Scientist path (Hayward et al., 2011). Similarly, it is generally accepted that students in joint MD/PhD programs also require approximately seven or nine years to complete all of their undergraduate training requirements, and many may subsequently undertake postgraduate (i.e., fellowship) training (see Figure 4). Compared to the three to four years required to complete an MD program, such durations are significantly lengthy and may pose a deterrent.

Just like in conducting research itself, arguably, the dedication of lengthy training time may be an unavoidable reality of a dual career path that should be accepted (Bosse et al., 2011). As such, shortening training time might not be the best option, as it would limit extensive training during a critical time. One can argue that if the lengthy training time reflects the nature of the career choice and its challenges, the trainees' acceptance of such training time may reflect well upon their motivation to conduct research which requires a spirit of inquiry, patience, persistence, optimism, and determination in answering questions that matter.

## Clinician Scientist Trainee Requirements

***Balancing research and clinical training***

Residents face extraordinary pressure to master a vast amount of knowledge and skills throughout their training. The tension between mastering clinical knowledge while gaining experience as a Clinician Scientist can be overwhelming for trainees. Because the primary focus of MD and residency programs is on patients and care delivery, those pursuing additional research training experience more challenges as they try to balance both the required competencies to reach key milestones in their clinical work and, at the same time, earn the designation of scientist (Bosse et al., 2011; Hayward et al., 2011; Rosenberg, 1999; Rosenblum, 2012; Rosier, 2006). For example, in a recent survey conducted by the University of Toronto of the MD/PhD program, 58% of trainees believed that integration between clinical training and research needed to be improved (Rosenblum, 2012).

The design of programs like CIP could be optimized through added flexibility. For example, the CIP route that removes a resident from their clinical program to devote two years exclusively to research training can pose some problems, as this period in training appears to be a critical time for skill and knowledge acquisition and retention. Some argue that less emphasis should be made on encouraging students to do research during medical school and they should be encouraged to delay research training until later in their training. Residents could have difficulty re-integrating into their clinical programs after these two years as skills and knowledge have regressed and remediation is sometimes required, thereby extending the training period even further. For many specialist physicians there can be a break of 5-7 years between completion of the MD/PhD and the end of clinical residency and fellowship. Better strategies are needed to help these people return to research activities after their clinical training, and provide opportunities to gain more contemporary research exposure to ensure they are competitive when launching their own research programs. Moreover, trainees who enter medical school with scientific training need to continue to be productive in the scientific realm in conjunction with their research activities.

***Insufficient mentorship for Clinician Scientist trainees***

A significant body of literature points to the importance of mentorship for students in medical schools and those continuing in residency education (Hayward et al., 2011; Rosenblum, 2012; Schrier, 1998). A meta-analysis related to mentorship in corporate settings reports that effective mentoring is associated with higher job satisfaction, greater self-esteem, greater organizational commitment, greater perception of promotion opportunities, lower work stress, and lower levels of work-family conflict (Rubio et al., 2011).

Although less quantifiable, a lack of mentorship has been reported specifically for female physicians (Wietsma, 2014). To see mastery in action is a very motivating factor in achieving excellence. Mentorship is perhaps one of the best ways to guide an individual's interest in establishing the "questions that matter" and opening doors into the career path involving meaningful research (Archer, 2007).

Despite the perceived importance of mentoring, evidence suggests that there is inadequate mentorship for trainees in some Clinician Scientist tracks (Chew et al., 2003; Hauser & McArthur; 2006 18; Mark & Kelch, 2001). Due to the demands placed on trainees, who often struggle to balance a mastery of research with clinical competencies, the importance of role modelling may be particularly heightened for those training to be Clinician Scientists. In this kind of practice, role models are an enormous source of support and guidance (Hayward et al., 2011). A literature review and an environmental scan revealed that mentorship is key to the success of the Clinician Scientist during training and career path development (Rosenblum, 2012; Schrier, 1998).

In response, some organizations (such as the American Neurological Association) and scholars have identified increased and improved mentorship, particularly for junior trainees, as a key priority to improve the training of Clinician Scientists.

***Lack of support for trainees in the research environment***

Many Clinician Scientist trainees may not receive sufficient support for conducting research. For instance, students who train in a research-driven environment typically have many resources available, such as grant administration staff, institutional review boards, animal protocol review committees, etc. (Harrington et al., 2009; Rosier, 2006). These supports can help students navigate regulatory and funding agency requirements, institutional grant sign-offs, biostatistical analyses, database management and other functions critical to research activities (Rosier, 2006). However, for Clinician Scientist trainees, having to navigate these research-related tasks alone may be an additional source of stress and could delay or preclude research activities.

***Insufficient infrastructural support***

One of the largest threats to the present and future sustainability of Clinician Scientist training may be the absence of infrastructure support for those who pursue this career. The CIP program was specifically developed in response to the need for more formalized, coordinated training in research for those who are interested in the Clinician Scientist path. However, apart from the CIP path, there is no identified physician scientist training track where the Clinician Scientist is the primary outcome of the program (Rosenblum, 2012). This reality

> "limits trainees in being able to identify a clear career path, universities in designing a cohesive curriculum, academic health science centres in creating sustainable careers, governments in setting aside resources to train and support physician scientists, and regulatory bodies in recognizing/certifying physician scientist careers." (Rosier, 2006).

A survey of MD/PhD students and alumni at the University of Toronto revealed that Clinician Scientist trainees appear to be sensing the lack of a national career trajectory for Clinician Scientists. Even though the goal of the CIP program aimed to specifically graduate Clinician Scientists, trainees of this program have noted that there does not appear to be a clear career path upon completion of their training, are unsure about the job market for Clinician Scientists, and are uncertain about the source of their future salary (Rosenblum, 2012).

## Financial Deterrents

Funding challenges can be broken down into four categories – delayed financial reward, protecting research time, reduced remuneration, and competing for research grants. The latter challenge is not unique to Clinician Scientists but can be seen as applicable to all scientists.

***Delayed financial reward***

Sizeable student loans incurred by medical students and the delay in earning a salary act as deterrents to potential Clinician Scientist trainees. Prolonged research training is likely to be devalued when Clinician Scientist trainees are at the point when they could expect to benefit from significant clinical earnings (Lander et al., 2010 3; Schrier, 1998). For many of these trainees at a critical stage in their career, it may seem as though there is no direct economic benefit to completing research training.

***Protecting research time***

Salary support is critical for junior scientists such that they may pursue the career of a Clinician Scientist after graduation. Although internal awards may be available at some institutions, many scientists rely on provincial or national level awards. Unfortunately, CIHR's count of career/salary awards have decreased almost three fold since 2000 (see Figure 3). CIHR funded a total of 127 MD/PhD studentships between 2000/2001 and 2008/2009; however, over 70% of these awards were received between 2000/2001 and 2004/2005. These rates indicate that a smaller number of awards were available in the latter years (Lander, 2010). Further to the gradual decrease in the number of career/salary awards being offered, in June 2015, CIHR announced that its 30-year-old Clinician Scientist MD/PhD training awards program will end in 2016 (CIHR, 24-6-2015). The MD/PhD awards program has provided "multiyear grants of about $22,000 to some 20 trainees annually", therefore, the decision to end this program undoubtedly adds to the financial challenges encountered on the path to becoming a Clinician Scientist (Webster, 2015).

In addition to the challenges of securing funding, the work that goes into preparing awards applications takes a great amount of time and effort, which is especially problematic given the limited nature of a clinician's time. Repeatedly being turned down a salary award to protect time for one's research can be discouraging. Hogg et al (2014) reported

that, even with institutional support, only 1 of 5 clinicians at CTLC was able to secure external salary support in the form of a career award during the first 5 years of their career as scientists at the CTLC (Hogg et al., 2014).

***Challenges related to securing funding for research***

There is dearth of funding for applied research in Canada; the overall level of funding is relatively low compared to the US and the UK. In 2010/11, $1 billion (CND) of funding was provided by CIHR for research which equated to only about a third of what US counterpart agencies invested per capita (Yusuf and Cairns, 2012). Second, randomized controlled trials are funded at a disproportionately low level compared to other forms of health research in Canada (Yusuf and Cairns, 2012).

The need to secure grant funding is a common source of stress amongst Clinician Scientists; this was reported by 42 per cent of CIP alumni (Hayward et al., 2011). It appears that much of this stress is likely due to the perception that Clinician Scientists are at a disadvantage when they apply for funding (Schrier, 1998). Lander et al (2010) noted that because the research experience of the applicant is a factor when funding applications are judged, Clinician Scientists competing with full-time research scientists felt that they were less likely to accumulate grants than were researchers who had no clinical responsibilities (Lander et al., 2010). Archer (2007) argues that it is expected that Clinician Scientists be competent in both domains – clinical and research work (Archer, 2007). Excelling in the "dual arts" of clinical practice as well as research offers a stimulating nature of a clinician scientist's career but, as evidence suggests, can also present an additional number of challenges.

Furthermore, single sources of funding are typically not sufficient to support Clinician Scientists in training. For example, available data on funding for CIP trainees highlights the variability in the sources of funding obtained. For first-, second- and additional-year CIP trainees, funding sources were varied and included universities, hospitals, ministries of health, granting agencies and trainees' clinical earnings. Typically, trainees needed to seek additional, and often lower, sources of funding from sources other than the agencies (i.e., ministries of health) that support their clinical specialty and subspecialty training (Hayward et al., 2011).

Over the past decade and a half, a review of the number of awards granted by CIHR has decreased substantially. Recently, there has been some growth in the research dollar funding and support for Clinician Scientist trainees, however, this encouraging development has been slighted by the recent announcement by CIHR to cut funding to the MD/PhD awards program. Furthermore, despite the fact that the dollar shares of the awards increased recently, the relative importance of the salary/career awards within CIHR's overall expenditures has decreased from 8.6% of CIHR's overall grants and awards expenditures to only 3.7% (CIHR, 2012). Therefore, securing funding for research has become a barrier requiring urgent attention.

***Reduced remuneration***

In Canada, physicians and surgeons may be paid according to a variety of models, such as a salary or fee-for-service model, depending on individual circumstances. Many Clinician Scientists working on a fee-for-service model may receive a reduced income, as compared with full-time clinicians, owing to the fact that they may be claiming fewer direct, patient-care activities as part of their fee-for-service. Clinician Scientists need to derive their salary by way of clinical earnings and/or university salaries, leading many in the field to either conduct research in their off-hours or sacrifice their clinical time (Schafer, 2009). Taken into consideration with potentially heavy debt burdens and delayed financial reward, these potential discrepancies in salary are often a significant drawback to embarking on a research career (Bosse et al., 2011; Lander et al., 2010; Rosenberg, 1999; Rosier, 2006).

***Other financial challenges***

There are distinct subgroups of clinicians who do not fit the typical scheme of salary awards and who require special attention. For instance, many women choose to become researchers when their children become more autonomous. Additionally, a proportion of our Clinician Scientists, independent of gender, initiate research careers following several years of building competency in clinical practice. For both of these groups, the restricted time to apply for Clinician Scientist awards, such as those of CIHR, may be a deterrent.

## Career Demands and the Primacy of Patient Care

Upon completion of formal training, practising Clinician Scientists face many competing career demands, such as fulfilling institutional expectations for patient care, research activities and education. Institutional pressures to commit to more clinical work while balancing academic responsibilities can be very challenging for Clinician Scientists who wish to devote time to research activities (Rosenberg, 1999 24; Rosier, 2006). The "patient comes first" prioritization, in tandem with hospital-based rules and regulations and coupled with the inability to claim salary time for research hours, can have an impact on the ability of Clinician Scientists to protect time to focus on research (Rosier, 2006).

# POSSIBLE SOLUTIONS

Despite the barriers to becoming a Clinician Scientist in Canada, there has never been a better time to utilize the vast available knowledge to improve human health. Multiple recommendations have been put forward by experts to bolster the recruitment and career development of Clinician Scientists in Canada. In addition, many of the issues faced by Clinician Scientists and trainees are not unique to Canada, and many other countries, including the United States, the United Kingdom, and Germany, have also engaged in similar discussions. As such, possible solutions generated both nationally and internationally are presented in this section.

## Integrating Clinical and Research Training Requirements with Enhanced Flexibility

For both Clinician Scientist pathways (MD/PHD program and CIP), the time periods dedicated to clinical and research training are generally distinct (Rosenblum, 2012). When clinical and scientific tracks are run in parallel, the integration between the two domains is limited. Better integration of curricula between clinical and scientific programs would likely enhance a learner's knowledge of the links between science and clinical medicine and help the learner better conceptualize medical problems within a scientific framework (Rosenblum, 2012). In addition, creating a better integration between the clinical and scientific programs may help to decrease the stress associated with mastering both fields, shorten the length of training and better prepare trainees for career opportunities (Rosenblum, 2012). In order to encourage this integration, it has been recommended that a coherent Clinician Scientist education platform be developed, one that differs from the undergraduate medical and PhD programs (Rosenblum, 2012), and is inherently flexible and tailored to better meet the needs of the individual trainee.

## Designing Innovative Models of Training and Education

Many jurisdictions worldwide have considered competency-based models of medical education in both the undergraduate and postgraduate realms in an effort to ensure that training is optimally designed and focused on the achievement and demonstration of competencies. The Royal College of Physicians and Surgeons of Canada launched the Competence by Design program, which

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is intended to usher in a new era of competency-based medical education. As part of this and other related initiatives to reconsider the design of medical education, it may be prudent to engage further expertise to determine how a competency-based model could be employed within training programs such as the CIP and joint MD/PhD programs to optimal advantage.

In addition to considerations of competency-based education, innovative models may also involve the deployment of accelerated training. Retrospective evidence from an accelerated MD program at the University of Miami Miller School of Medicine has important implications for the development of Clinician Scientists. The "PhD to MD" program was instituted in the 1970s and was in place for 18 years. Identified as a "radically different approach to medical education," the program was designed to take students with a prior PhD in the sciences, mathematics or engineering and grant them entry into a two-year, accelerated MD program. Research from a 2008 study focused on the long-term outcomes for these students suggests promising results: the majority of graduates were working in academic university medical departments. Twenty years post-graduation, graduates held many senior positions, including 85 full professors, 11 university directors/division heads, 14 academic chairs, 2 medical school deans, and 1 astronaut (Koniaris et al., 2010 16 /id).

In a study investigating the impact of having a reduced clinical training period on a physician's ability to provide good patient care, the American Board of Internal Medicine compared the outcomes of a sample of trainees who followed a research pathway with a shortened clinical training period versus those who followed a typical clinical training pathway (Lipner, 2012). Results from this study revealed that the trainees in the short-track research pathway did as well as the other trainees when they wrote their American Board of Internal Medicine exams. These data strongly support the notion of creating a Research Track within clinical residency for Clinician Scientists trainees.

## The Importance of Mentorship as One Prepares for Practice

It has been recommended that mentorship and guidance programs be developed to help guide trainees from their initial decision to join the Clinician Scientist program through to employment (Mark & Kelch, 2001; Sackett, 2001). Specific support should be available for the various obstacles trainees may face, including making transitions, looking for a job, making academic or career choices, maintaining a work/life balance, and integrating clinical and research roles (Rosenblum, 2012).

## Minimizing Financial Disincentives

In order to recruit more Clinician Scientist trainees, programs must offer financial incentives, including attractive stipends, loan repayment programs, and a higher likelihood of built-in success (Rosenberg, 1999). However, as it stands, potential Clinician Scientists face various economic disincentives such as perceived difficulty obtaining funding, lower salaries, and delayed remuneration. These economic disincentives are thought to be a key factor for Clinician Scientists choosing to spend more time in clinical practice as opposed to research.

Possible solutions for increasing salaries have been recommended and some have been implemented. For instance, it has been recommended that funding agencies be lobbied to increase the number and size of career support awards for Clinician Scientists, thereby reducing their dependency on clinical practice for their income (Schrier, 1998). Others have recommended that uniform policies for salary and infrastructure support for Clinician Scientists be created on an institutional level in order to encourage an increase in the number of Clinician Scientists (Lander, 2010; Rosenblum, 2012)

Salary supports/career awards for Clinician Scientists are available from both public and private organizations, as well as through some provinces. For example, a career award that covers from 50% to 75% of a Clinician Scientist's salary has been introduced in Quebec. An evaluation of CIHR's salary awards in general showed that recipients were able to set aside more time for research and were more productive (e.g., publishing, presenting findings at conferences) a finding that emphasizes the importance of a federal funding agency as an essential element in supporting the development and sustainability of Clinical Scientists in the country.

Alternative Funding Plans, such as Career Development and Compensation Plans, have been highlighted in the literature as potential opportunities for providing financial incentives to clinician scientists as they embark upon their research endeavours (O'Brodovich et al., 2007; O'Brodovich et al., 2003; Bridges et al., 2007; 2014 64). Another example of an alternative funding plan is The Alternative Relationship Plans (ARP) which was introduced in Alberta (2015 65; Bridges, 2007) and responds to some of the funding challenges associated with a fee-for-service model. This alternative, available to physicians by application under either a Clinical or Academic ARP, is offered with the intention of providing clinicians with optimized compensation for academic and clinical contributions.

In the United States, initiatives have been passed to encourage heavily indebted young professionals to enter careers in clinical research. For example, individuals may qualify for up to $35,000 in tax-free debt relief for two years with eligibility for a third year (Ley & Rosenberg, 2005).

## Protecting Research Time

Possible solutions have been identified for creating opportunities for Clinician Scientists to maintain clinical practice while having protected research time. Institutions in Germany, for example, have introduced a program designed to employ part-time replacement clinicians who take over the clinical duties of Clinician Scientists on a rotational basis. Qualitative findings have revealed that this initiative has allowed Clinician Scientists to spend more time focusing on their research activities (Bosse et al., 2011).

# BARRIERS TO CHANGE

As noted above, some progress has been made in reducing barriers to the recruitment and maintenance of Clinician Scientists in Canada. However, Clinician Scientists and their trainees still perceive important barriers to working in this area — barriers they believe act as fundamental disincentives toward pursuing a career as a Clinician Scientist (Lander et al., 2010). At the present time, the programs and policies that have been implemented have been piecemeal initiatives rather than an overarching strategy (Lander et al., 2010). Unfortunately, large-scale change is daunting, as it will require that medical schools, postgraduate training programs, teaching hospitals, funding agencies and governments become involved in the process (Phillipson, 2002).

In order for transformation to occur, the perceived value of the Clinician Scientist must be enhanced. The Clinician Scientist in many groups is seen as another clinician to help take the load off full time clinicians. Furthermore, there appears to be a lack of understanding of the Clinician Scientist's role at the national, provincial, and institutional levels (Rosenblum, 2012). While there is a recognition of the role of clinicians in patient care, it is not balanced with the equally important recognition of the clinician as a key — and essential — participant in medical research, a role that has the potential to improve the health of all (Rosenberg, 1999). Furthermore, while generalism is an important value in medical care delivery, the clinical research undertaken by this highly focused group of individuals speaks to the significant need to ensure a meaningful balance between both generalists and specialists in the health care system.

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This lack of understanding for the role of the Clinician Scientist threatens the sustainability of programs, funding, salary allotments, protected time and enthusiasm by faculty and mentors. In order to introduce change in recruitment and retention, an environment must be created within medical schools and postgraduate programs that places greater value on health-related research and the Clinician Scientist's career path (Kearney et al., 2007; Phillipson, 2002). In order to attract a new generation of Clinician Scientists, the academic environment must emphasize that their efforts are essential to improving the health of people everywhere. This may occur by communicating to students the importance of — and excitement in being involved in — future discoveries in the many fascinating disciplines that make up health-related research (Phillipson, 2002; Schrier, 1998).

To face these challenges, the various stakeholders — all of whom have a common commitment to change — must work to increase the perceived value of Clinician Scientists in Canada.

# CAREER SATISFACTION

Although in this white paper the authors focus on the issues Clinician Scientists face along the entire spectrum of their career, it is important to note numerous reasons Clinician Scientists decided to pursue this rewarding career, with one of the main reasons being an interest in discovery and new knowledge. A considerable amount of literature speaks to the advantages and rewards of a career as a Clinician Scientist (Rubio et al., 2011; Bosse et al., 2011 23; Neul, 2010; March, 2014; Sackett, 2001; Lee, 2013 73). Career gratification stems from personal sense of accomplishment, external recognition, physician-patient relationship, funding opportunities, potential for translating science to the bedside (Neul, 2010), meeting likeminded individuals and forming partnership and fun, just to name a few. With the appropriate support, Clinician Scientists are capable of balancing the clinical and research aspects of their career with personal life. Discipline as well as hard work may seem daunting; some days will be long but "there is nothing more rewarding and gratifying than the thrill and joy of discovery." (Santos-Martinez et al., 2005).

# CONCLUSION

Supporting the development and career sustainability of Clinician Scientists brings a multitude of benefits. The role of the Clinician Scientist is central to the discovery, application, and communication of health-related knowledge. Clinician Scientists are in a unique position to participate in and speed up the translation of clinical work that spans the full breadth of activities from research to practice, enabling them to translate their research results into the clinic and to develop research questions based on issues they encounter in clinical practice. This breadth of knowledge is critical to advancing science; increasing knowledge and understanding mechanisms of disease; contributing to clinical trials; developing novel medical technology; ensuring patient safety; promoting health; understanding the patient experience; elucidating the processes and structures of health, illness, and disease; improving the training of health professionals; and creating evidence that will have an impact on public policy (Rosenblum, 2012). Therefore, if Canada strives to lead in medical innovation, and maintain a health care system that cultivates better health for all Canadians, it is essential that Clinician Scientists continue to be supported through enhanced training, evaluation, and career-support mechanisms, thereby ensuring the production of high-quality scientific knowledge is translated to the patient (Rosenblum, 2012).

# RECOMMENDATIONS

Given the mandate of the Royal College to improve the health and care of Canadians by leading in medical education, professional standards, physician competence and continuous enhancement of the health system, below are recommendations that will enable better training, recruitment and retentions of Clinician Scientists in Canada. Although there are other key organizations that have the capacity to support Clinician Scientists in Canada, the following recommendations are pertinent to the Royal College and its policy direction.

**1.** The Royal College should support the development of the next generation of Clinician Scientists by re-evaluating the existing pathways to becoming a Clinician Scientist and assisting in the development of an integrative approach of combining clinical training with research initiatives. The Royal College should work with all residency programs to ensure that, as the change initiative entitled Competence by Design progresses, exposure to research opportunities is integrated into the clinical training framework and organized in a manner that is flexible, suited to the individual, and likely to foster success.

**2.** The Royal College should advocate for enhanced exposure and awareness to Clinician Scientists' career opportunities across the medical education continuum. Specifically, the Royal College should better market the various pathways to becoming a Clinician Scientist through the CIP program (continuous, fractionated, or distributed) and MD/PhD/MSc programs. Additionally, in collaboration with the university programs, the Royal College should develop mechanisms to enable flexibility and permit smooth transitions from medical school to residency and from residency to early Clinician Scientist practice, with continued opportunities to pursue research over the course of training right into employment.

**3.** The Royal College should explore and recommend different mechanisms for research award funding for prospective, new, and established Clinician Scientists. This would include investigating novel funding sources, and advocating for the re-institution of funding sources which have been previously abolished. Specifically, the Royal College should work to enhance awareness of the importance of Clinician Scientists and, accordingly, advocate for the re-introduction of the CIHR MD/PhD training awards program.

**4.** The Royal College should advocate for the development of an evolving, national database to track the numbers and status of Clinician Scientists. The collection of this information would:

- improve the understanding of the Clinician Scientists' population and its distribution (i.e. the distribution of Clinician Scientists across specialties)
- prospectively follow MD/PhD, MD/MSc, and CIP students to help understand the outcomes and success of the various programs
- Identify gaps in the training and retention of Clinician Scientists

Moreover, the analysis of this data would provide guidance in addressing the barriers to recruitment and retention of Clinician Scientists in Canada.

**5.** The Royal College should advocate that universities develop a mechanism that will guide programs in ensuring they have the appropriate infrastructure required to support the development and sustainability of Clinician Scientists at their institution. A "protected time" policy, for example, that is consistent across programs and universities could be considered and potentially reviewed as part of the Royal College accreditation processes.

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**6.** The Royal College should advocate for the promotion of a Clinician Scientists' career. This could be accomplished by facilitating opportunities for researchers to collaborate and network, and by recognizing the successes of Clinician Scientists via the Royal College communication tools. Furthermore, through the Maintenance of Certification credits program, the Royal College should continue to develop evaluation tools that will encourage commitment to research and innovation as the Clinician Scientists progress throughout their careers by providing incentives and credits for their accomplishments.

**7.** The Royal College should facilitate a national mentorship program for Clinician Scientists. The program would identify and assign established Clinician Scientists as mentors who would guide and offer advice to prospective and newly trained Clinician Scientists in areas such as applying for funding, finding jobs, integrating research with clinical activities, and maintaining a work/life balance.

**8.** In addition to the above recommendations, the Royal College should launch and support a working group with a mandate to develop a plan for the advancement and sustainability of the careers of Clinician Scientists, as well as address gaps outside the Royal College's mandate.

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# METHODS

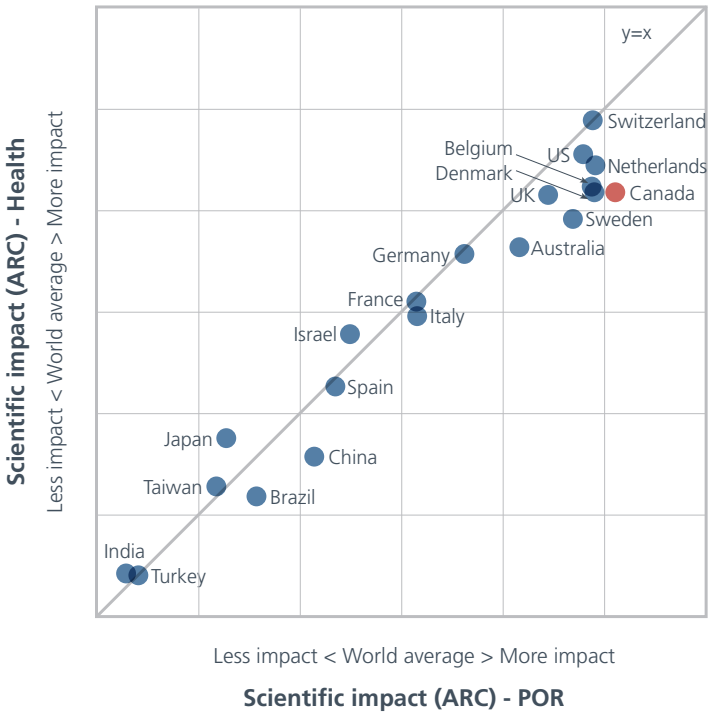
The method to develop the Clinician Scientist in Canada: Supporting Innovations in Patient Care through Research white paper included three steps. First, to formulate the first draft of the paper, we performed a thematic narrative review of literature (Green, 2006) to discuss rather than exhaust the existing gaps in training and retention of Clinician Scientists in Canada. Second, we concluded the consultation on the Clinician Scientist in Canada white paper with over 30 responses received.

The feedback represented a wide range of stakeholders from primary and specialty care organizations including Canadian Faculties of Medicine, le Collège des médecins du Québec, the Association of Faculties of Medicine of Canada, the College of Family Physicians Canada, members of the Royal College Council, as well as many other clinicians, leaders in medical education and researchers who are affected by and concerned about this subject. Steps one and two formed evidence from which the recommendations were developed and refined. Step three included a final review of the manuscript by stakeholders.

## Figure 1: Canada's Scientific Impact in the Health Field in the International Context

Source: **Science-Metrix, Patient-Oriented Research in Canada: A Bibliometric Analysis.** 2009

In 2009, Canada ranked highly, together with the United Kingdom, Belgium, the Netherlands, Denmark and the United States in scientific impact for the health sector as a whole, but ranked first in patient-oriented research based on their citation in academic journals.



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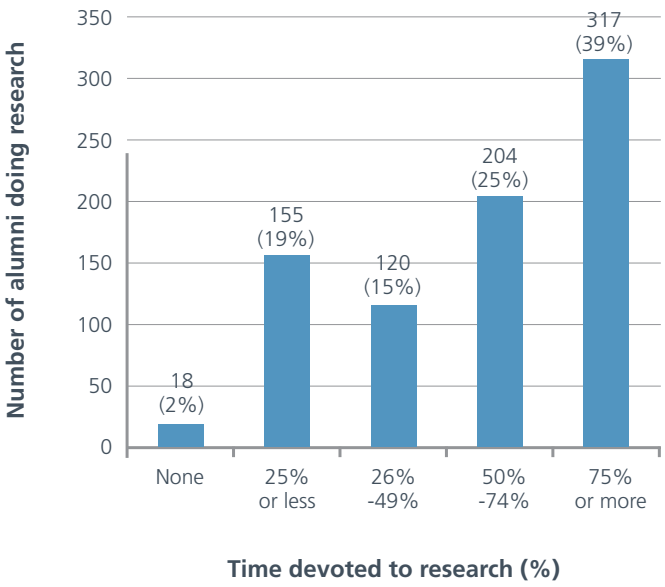
## Figure 2: Time Devoted to Research

Source: Brass LF, Akabas MH, Burnley LD, Engman DM, Wiley CA, Andersen OS. Are MD-PhD programs meeting their goals? An analysis of career choices made by graduates of 24 MD-PhD programs. Acad Med. 2010 Apr;85(4):692-701.

Figure 2: MD/PhD Graduates' responses to questions about their recent research activities. Responses from 814 alumni of 16 MD/PhD programs in the US who are now in academia.



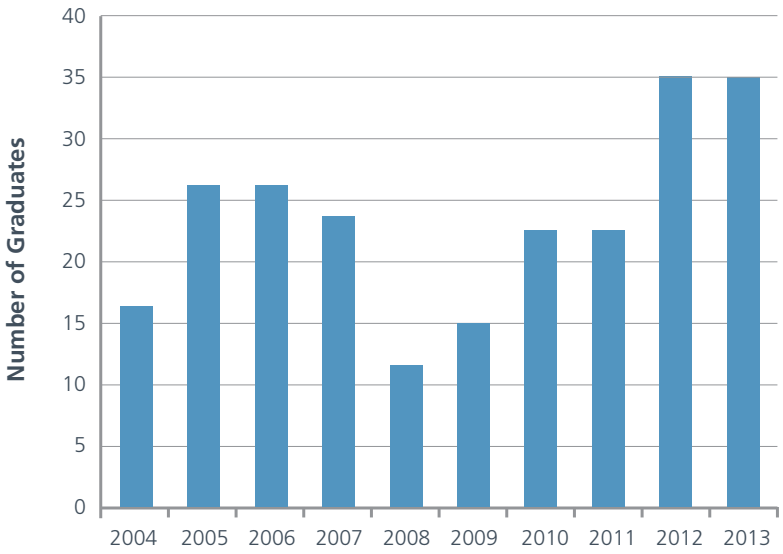

## Table 1: Top Salary Award Funders in Canada

Source: CIHR. A Pan-Canadian Vision and Strategy for Health Services and Policy Research. Phase 1: Building the Foundation. 2014 www.cihr-irsc.gc.ca/e/47946.html

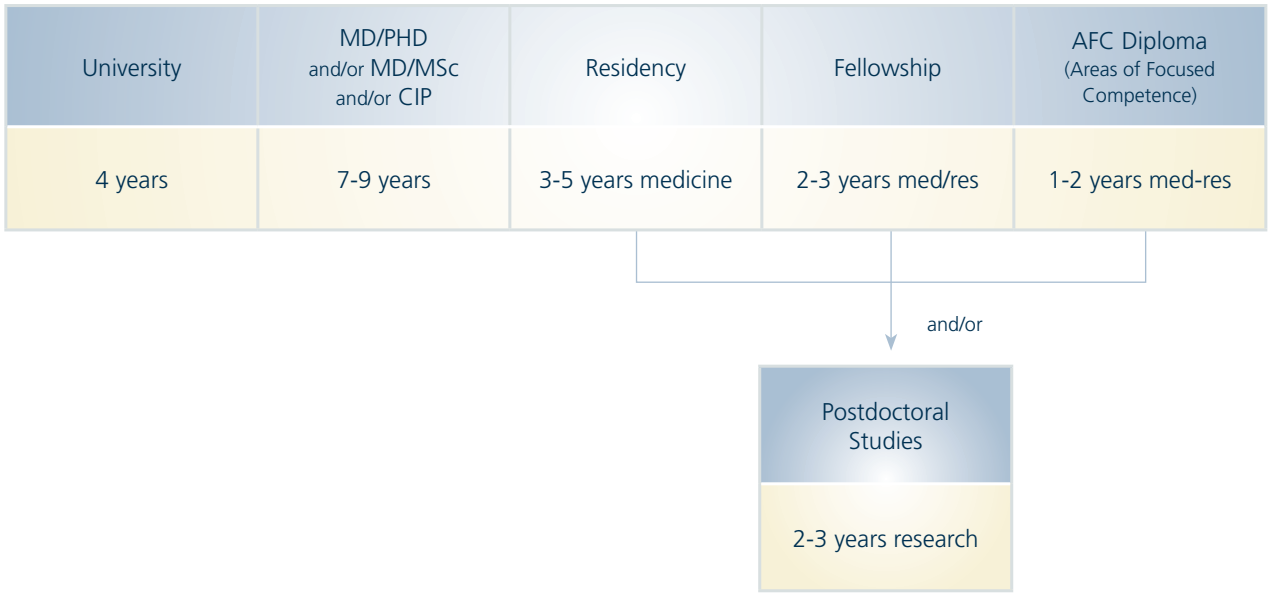
| Funder | Total | Percent |
|---|---|---|
| Fonds de recherche du Québec - Santé | $21,732,093.0 | 25.4% |
| Canadian Institute of Health Research | $16,247,044.4 | 19.0% |
| Canada Research Chairs | $9,800,000.0 | 11.5% |
| Ontario Institute of Cancer Research | $7,900,000.0 | 9.2% |
| Alberta Innovates - Health Solutions | $7,822,723.0 | 9.1% |

## Figure 3: Graduates of Combined MD/PhD Programs in Canadian Faculties of Medicine, 2004 to 2013

Source: Association of Faculties of Medicine of Canada, January 2014.




## Figure 4: Traditional Clinician Scientists' Education Path



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## Figure 5: Percentage of Annual Salary Awards Expenditures as a Proportion of the Total CIHR Grants and Awards Budget and Number of Newly Paid Awards

Source: Brass et al., Are MD-PhD Programs Meeting Their Goals? Academic Medicine, Vol. 85, No. 4, April 2010.