ORIGINAL RESEARCH

The number, scope and geographic distribution of clinical researchers in Canada

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Abstract

Purpose: Despite international concerns about declining numbers of clinical researchers, the number of clinical researchers in Canada remains undocumented.

Methods: The number and geographic distribution of clinical researchers in Canada and the scope of their research activities were estimated using, as an indicator, the data on clinical research projects funded by the Canadian Institutes for Health Research (CIHR).

Results: Between fiscal years 1999-00 and 2006-07, 1,041 individual researchers—approximately 130 per year—were principal investigators (PIs) on clinical research grants. One hundred and 26 researchers received salary awards; 449 supervisors oversaw the clinical research activities of 230 fellows and 223 students with trainee awards. An additional 2,305 individuals served only as co-investigators on grants. Most (863 [83%]) PIs received funding for operating grants; 196 (19%) PIs received funding for randomized controlled trials. The institute of neurosciences, mental health and addiction funded the highest number of researchers (187 [18%] PIs, 40 [17%] fellows, and 73 [33%] students). Among provinces, Quebec led the nation with the highest number (45) of PIs per million population. Ontario had the highest number of clinical research fellows (10 per million population) while Quebec and Saskatchewan each hosted more students (11 per million).

Conclusion: The number of Canadian investigators with funding for clinical research from CIHR was low. Although the ideal ratio of clinical to basic research capacity is not known, the possibility that the gap between laboratory-based research and clinical research is larger in Canada than in the United States is discussed.

For over two decades concerns have been raised internationally about the decline in the number of clinician-scientists.¹⁻⁴ More recently, it has been argued that the principal issue is not the number of clinician-scientists but rather the number that is engaged in clinical research, specifically, in patient-oriented research.⁵ In Canada, growth in clinical research funded by the Canadian Institutes for Health Research (CIHR), the government of Canada's health research funding agency, was shown to be slower than growth in other research themes, namely biomedical, population-based health and health services research at multiple levels.⁶ The number of clinician-scientists involved in federally-funded patient-oriented research in Canada in the year 1997 was estimated, based on National Institutes of Health (NIH) statistics from the United States, to be fewer than 100 MDs and MD/PhDs in Canada.⁵

Canada is preparing to compete in a knowledge-based global economy, specifically, in the development of an integrated globally competitive Canadian Program in Clinical Research.⁷ Now, more than ever, it will be necessary to assess the country's manpower and infrastructure in clinical research and determine the resources needed to enhance Canadian capacity in this area. There are no Canadian data-based statistics

on the number of active clinical researchers in the country. The primary objective of the present descriptive study, therefore, was to document retrospectively the number and scope of clinical investigators across Canada using, as an indicator, the funding received for clinical research from the CIHR. A secondary objective was to describe trends in publishing original clinical research articles in Canada.

Materials & Methods

The CIHR Funded-Research database is a publicly-available, project-based online database that provides basic information on all funding granted by the CIHR since its inception in 2000.⁸ Project commitments made previously by the Medical Research Council of Canada (MRC) and duly honoured by the CIHR are also included in the database, which is comprised of text fields such as principal investigator (PI), supervisor, co-investigator (Co-I), funding program, and research theme. Numerical fields report the amounts funded and date fields include the effective and expiry dates of funding.

CIHR categorizes health research in four broad themes: bio-medical; clinical; social, cultural, environmental and population health; and health services.⁹ Clinical research is defined as 'research with the goal of improving the diagnosis, and treatment (including rehabilitation and palliation), of disease and injury; improving the health and quality of life of individuals as they pass through normal life stages; research on, or for the treatment of, patients'.⁹ Data on all grants and awards funded under the theme 'clinical research' in fiscal years 1999-00 to 2006-07 were downloaded in November 2007 from the CIHR website. Multiple investigator names, separated by semicolons and embedded in single text fields, were edited in a Microsoft Excel spreadsheet¹⁰ so that the resulting database contained one investigator name per column. From this project-based data structure, an investigator-specific database was built using SAS codes and data steps.¹¹

For each investigator, the total number of projects funded in the capacity of PI or Co-I; average number of years per funded project; multiple responsibilities held such as PI, supervisor, Co-I or trainee; and different types of awards received were tabulated. Investigator's area(s) of research was assigned based on the Institute(s) through which funding was received. Cumulative research funding (CRF) received by each investigator was calculated as the sum total of all clinical research grant funding received by the individual in the capacity of a PI. For projects with two or more investigators, the funded amounts were split evenly among the listed PIs, irrespective of the number of Co-Is listed on the project. For example, if a project with two PIs and 10 Co-Is was funded a total amount of \$100,000, then \$50,000 was assigned to each PI. A PI who served as a Co-I on any additional projects was assigned \$0 on account of those additional projects. Amounts received as awards, if any, were not included in the CRF.

Provincial affiliation of investigators was determined based on the province of the research institution paid. For projects with more than one investigator, it was assumed that all investigators listed were affiliated with the research institution (province) paid. If an investigator listed on multiple projects appeared to be affiliated with more than one province simultaneously, then the primary research institution (province) of the investigator was located by conducting a search on the internet. If provincial affiliation varied with time, then the investigator contributed to the investigator count in each of the affiliated provinces. Provincial distribution of clinical investigators and clinical research funding was adjusted for the average provincial population in the years 2000-2007, as reported by Statistics Canada,¹² and expressed per million population per province.

Clinical Publications

All Canadian researchers' contributions to clinical literature, relative to the contribution of world research-

ers, were assessed quantitatively by searching the Science Citation Index Expanded (SCI-Expanded) database¹³ in January 2008. Publication of original research articles during the time period 2002-2007 was the primary focus of this study but trends from this period were compared with those from two previous periods (1990-1995 and 1996-2001). Articles with a potential to be clinically relevant were identified through 3 independent searches by using the field tag 'TS' in the Advanced Search feature: TS = clinical; TS = clinical research; TS = clinical medicine.ⁱ

Statistical Analyses

Data were summarized using descriptive statistics. Significant differences in population means were determined using T-tests for normally distributed data and Wilcoxon rank sum test for non-parametric data. Correlation between non-normally distributed variables was assessed by calculating Spearman correlation coefficient. Categorical variables were reported using frequency distribution and tested for differential distribution using χ^2 goodness of fit tests. Statistical significance was determined at P -value < 0.05.

Results

Number

Between fiscal years 1999-00 and 2006-07, 1,041 individual PIs—approximately 130 a year—received CIHR grants for clinical research; 126 investigators—approximately 16 per year—received salary awards.ⁱⁱ (Figure 1). Adjusting for the population of

Canada, the number of CIHR-funded clinical investigators was determined to be 4 per million per year.

Four hundred and fifty three research trainees (including 56 trainees who transitioned to an independent, non-trainee role during the study period), overseen by 449 supervisors, received 247 clinical research fellowship awards (distributed among 230 fellows) and 227 clinical research studentship awards (distributed among 223 students).^{iii,iv} Approximately 29 fellows and 28 students per year received clinical research trainee awards. A large number of individuals ($n=2,952$) served as co-investigators on grants (Figure 1). In all, 3,646 individuals carried out 1 or more types of non-trainee investigator roles. While 709 investigators fulfilled more than 1 type of role, 111 carried out all 3 investigator roles.

Scope

Total funding received for clinical research during the study period was CAD\$468,744,744 and represented 11% of the total amount of funding distributed by the CIHR.⁸ The majority (\$415,393,441 [88.6%]) was received in the form of grants—\$254,453,664 (54.3%) for 917 operating grants and \$159,959,594 (34.1%) for 195 randomized controlled trials (RCTs). The median amounts of total funding received for operating grants and RCTs (after excluding ongoing projects) were \$139,378 and \$350,348, respectively. The median number of years of funding per project was 3.

The median number of PIs on all grants was 1 (only 15% of the grants listed >1 PI), but the median number of Co-Is on RCTs was higher than on operat-

ⁱ Although articles with the following subject categories could potentially include some clinical research in areas such as food safety, zoonoses and vector-borne diseases, they were excluded from all summaries in this study: Veterinary Sciences; Agriculture, Dairy & Animal Sciences; Marine & Freshwater Biology; Fisheries; Zoology; Plant Sciences.

ⁱⁱ The total number of salary awards distributed was 129.

ⁱⁱⁱ The largest program categories of the 247 fellowship awards were CIHR Fellowship (105 awards), CIHR/Rx&D Research Program – Fellowships (27), and CIHR Clinician Scientist – Phase I (15).

^{iv} The largest program categories of the 227 studentship awards were Frederick Banting and Charles Best Canada Graduate Scholarships – Master's Award (67 awards), CIHR Doctoral Research Award (63), and Frederick Banting and Charles Best Canada Graduate Scholarships – Doctoral Award (37).

FIGURE 1. A Venn-diagram representing the different capacities of 3,646 independent researchers* who received CIHR grants or awards for clinical research from fiscal year 1999-00 through 2006-07.[†]

* 397 clinical research trainees not included.

[†] 126 researchers were awarded salary for research in clinical theme. The number and proportion of salary award recipients with additional CIHR-funded clinical research activities is given in italics.

FIGURE 2. Provincial distribution of clinical research investigators in Canada and the scope of their research activities funded by the CIHR in fiscal years 1999-00 to 2006-07, adjusted for population*.

*Average population in the years 2000-07 as reported by Statistics Canada.

ing grants (6 vs. 3; P -value < 0.001). Project-level funding was not correlated with the number of PIs listed (Spearman correlation coefficient ' r ' = 0.01, P -value = 0.74 for operating grants; ' r ' = 0.02, P -value = 0.76 for RCTs) but was correlated with the number of Co-Is (' r ' = 0.11, P -value = 0.001 for operating grants; ' r ' = 0.35, P -value < 0.0001 for RCTs).

Most (764 [73.4%]) of the 1,041 PIs received funding for 1 grant. The median (maximum) CRF received by a single PI, after adjusting for the number of other PIs on each grant, was CAD\$154,900 (\$15,809,658). Two hundred and nine (20%) PIs received CRF $\geq$ \$500,000, while 76 (7.3%) PIs received $\geq$ \$1,000,000. Most PIs (806 [77.4%]) received funding for operating grants only but PIs who received funding for both operating grants and RCTs had significantly (P -value < 0.001) higher median CRF (\$722,835).

Relatively more PIs and trainees received funding for clinical research in the areas of 'Neurosciences, Mental Health and Addiction' (NMHA) (Table 1). NMHA ranked first in the amount of operating grants

received (\$62,974,436) while 'Circulatory and Respiratory Health' ranked first in the amount of funding received for RCTs (\$58,858,726).

Geographic distribution

Quebec had the highest number of PIs (45 per million population) with grants or salary awards for clinical research (Table 2, Figure 2). Investigators from British Columbia received more funding for operating grants (\$13,100,997 per million population) while those from Ontario received more funding for RCTs (\$8,227,362). Ontario also ranked highest in the number of clinical research fellows (10 per million population), while both Quebec and Saskatchewan hosted the highest number of student award recipients (11). Forty two (55.3%; P -value < 0.0001) of 76 PIs with CRF $\geq$ \$1,000,000 were from Ontario; 19 (25.0%) from Quebec; 9 (11.8%) from British Columbia; 3 (3.9%) from Alberta; 2 (2.6%) from Manitoba; and 1 (1.3%) from Nova Scotia.

TABLE 1. Research area of clinical research investigators and trainees funded by the CIHR in fiscal years 1999-00 to 2006-07

Research area*	Investigators			Trainees		Cumulative funding (grants and awards)	
	PIs	Co-Is	Salaried	Fellows	Students	CAD\$	Ranking
	N (%)†	N (%)	N (%)	N (%)	N (%)		
Neurosciences, Mental Health & Addiction	187 (18.0)	511 (17.3)	23 (18.3)	40 (17.4)	73 (32.7)	89694947	2
Circulatory & Respiratory Health	167 (16.0)	668 (22.6)	25 (19.8)	36 (15.7)	12 (5.4)	99407372	1
Musculoskeletal Health & Arthritis	148 (14.2)	366 (12.4)	11 (8.7)	21 (9.1)	15 (6.7)	30040140	6
Human Development, Child & Youth Health	130 (12.5)	490 (16.6)	19 (15.1)	28 (12.2)	28 (12.6)	72720479	3
Nutrition, Metabolism & Diabetes	93 (8.9)	209 (7.1)	10 (7.9)	10 (4.4)	20 (9.0)	36537565	5
Cancer Research	92 (8.8)	266 (9.1)	13 (10.3)	19 (8.3)	15 (6.7)	21037383	6
Aging	79 (7.6)	273 (9.3)	6 (4.8)	21 (9.1)	25 (11.2)	18408379	7
Infection & Immunity	62 (6.0)	168 (5.7)	5 (4.0)	20 (8.7)	9 (4.0)	41834962	4
Health Services & Policy Research	46 (4.4)	130 (4.4)	4 (3.2)	10 (4.4)	4 (1.8)	17809741	8
Gender & Health	42 (4.0)	143 (4.8)	6 (4.8)	6 (2.6)	6 (2.7)	13969103	9
Population & Public Health	37 (3.6)	140 (4.7)	1 (0.8)	8 (3.5)	5 (2.2)	12707673	10
Genetics	12 (1.2)	22 (0.8)	1 (0.8)	5 (2.2)	8 (3.6)	4278603	12
Aboriginal Peoples' Health	11 (1.1)	36 (1.2)	0 (0.0)	1 (0.4)	0 (0.0)	1284467	13
Not Applicable/Specified	36 (3.5)	68 (2.3)	2 (1.6)	7 (3.0)	5 (2.2)	9013930	11
All	1,041 (100)	2,952 (100)	126 (100)	230 (100)	223 (100)	468744744	

* Based on the Institute through which funding was received

† Adds up to greater than the total number (100%) of investigators within each column because research area categories were not mutually exclusive.

TABLE 2. Provincial distribution of clinical research investigators in Canada and the scope of their research activities funded by CIHR in fiscal years 1999-00 to 2006-07*

	Population†		Research Institutions		Investigators				Trainees				Cumulative funding (grants and awards)	
					PIs		Salaried		Fellows		Students			
	N	%	N	%	N	%	N	%	N	%	N	%	CAD \$	%
Canada	32321780		137		1041		126		229		223		468744744	
Ontario	12551500	38.8	52	38.0	430	41.3	59	46.8	125	54.6	80	35.9	215444016	46.0
Quebec	7598700	23.5	49	35.8	326	31.3	23	18.3	56	24.5	86	38.6	126563816	27.0
British Columbia	4264000	13.2	22	16.1	125	12.0	17	13.5	19	8.3	27	12.1	80562469	17.2
Alberta	3298980	10.2	6	4.4	70	6.7	16	13.0	16	7.0	15	6.7	22494457	4.8
Manitoba	1174380	3.6	2	1.5	38	3.7	3	2.4	5	2.2	0	0.0	9112698	1.9
Saskatchewan	992800	3.1	1	0.7	14	1.3	1	0.8	3	1.3	0	0.0	2696709	0.6
Nova Scotia	935940	2.9	3	2.2	26	2.5	6	4.8	5	2.2	4	1.8	9873495	2.1
New Brunswick	750660	2.3	1	0.7	1	0.0	0	0.0	0	0.0	0	0.0	19388	<0.1
Newfoundland & Labrador	513200	1.6	1	0.7	9	0.9	1	0.8	0	0.0	0	0.0	1918031	0.4

* Based on province of research institution paid

† Average population in the years 2000-07 as reported by Statistics Canada.

CIHR grant funding for clinical research was received at 137 research institutions across Canada (Table 2). The top 20 research institutions received \$298,725,882 (63.7%) of total clinical research funding. Ten (50%) of the top 20 research institutions were located in Ontario and 5 (25%) in Quebec; 2 (10%) each in Alberta and British Columbia; and 1 (5%) in Manitoba. The top 3 research institutions were McMaster University (\$11,526,311 for operating grants and \$32,200,430 for RCTs); University of British Columbia (\$22,376,808 and \$18,199,866); and St. Paul's Hospital, Vancouver (\$23,884,460 and \$147,650). CIHR salary, fellowship and student

awards in clinical research were received at 41, 68 and 53 research institutions, respectively.

Publications

Canada's overall ranking in clinical publication productivity in the years 2002-07 appeared consistent with productivity in 2 previous time periods (Table 3). Summary of results from this point onwards is focused on the set of articles identified under the search term 'clinical.'

The top ten subject categories (not mutually exclusive) in 'clinical' publications in the world in the years 2002-2007 were surgery; clinical neurology;

TABLE 3. Clinical publications* from Canada in the years 2002 – 2007: subject categories and ranking in the world based on number of publications.

	2002-2007			1996-2001			1990-1995		
	Number of publications		Canada's ranking in the world	Number of publications		Canada's ranking in the world	Number of publications		Canada's ranking in the world
	Canada	World		Canada	World		Canada	World	
Search topics [†]									
Clinical medicine	690	10876	4*	450	6757	4	140	2412	4
Clinical research	1934	25394	3§	985	14126	4	431	6538	3
Clinical	16108	321317	7¶	10920	236285	7	6030	135847	7
Top Ten Subject Categories**									
Clinical neurology	1639	29540	7	1105	21695	8	533	10631	7
Oncology	1427	28119	7	900	20829	8	419	11064	8
Cardiac & cardiovascular systems	1187	16949	6	738	13177	7	446	8451	6
Surgery	1150	31021	7	891	23789	7	560	13381	6
Medicine, general & internal	861	17899	5	791	16384	5	472	12642	9
Pharmacology & pharmacy	856	19648	8	600	15282	7	323	9089	7
Psychiatry	795	13990	4	610	10835	4	366	5873	4
Neurosciences	791	15743	7	566	11165	7	238	4565	7
Radiology, nuclear medicine & medical imaging	751	15322	7	535	12059	7	328	6704	5
Pediatrics	682	12747	4	493	10262	7	278	5828	6

* Defined as original research articles

† Using field tag 'TS' in SCI-Expanded database made available by the Thompson Corporation Web of Science®

‡ After USA (4,756 articles), England (1,010) and Germany (954). Some articles were assigned to more than one country simultaneously owing to international research collaborations.

§ After USA (12,384 articles) and England (2,986)

¶ After USA (116,332 articles), Germany (30,491), England (27,189), Italy (21,260), Japan (20,706), and France (18,261).

** Not mutually exclusive.

oncology; pharmacology & pharmacy; medicine, general & internal; cardiac & cardiovascular systems; neurosciences; radiology, nuclear medicine & medical imaging; psychiatry; immunology. During the same period, the highest number of clinical publications from Canada was in the category of clinical neurology (Table 3). Canada's 4th place ranking in the world in the area of pediatrics is an improvement over its ranking during earlier time periods (6th and 7th).

During the years 2002-07, provincial contributions to clinical publications were as follows: Ontario (8,554 original clinical research articles [686 articles per million population]), Quebec (3,791 [501]) and Alberta (2,376 [727]), British Columbia (2,290 [540]), Nova Scotia (732 [782]), Manitoba (687 [587]), Saskatchewan (317 [319]), Newfoundland & Labrador (145 [282]), New Brunswick (59 [79]) and Prince Edward Island (17 [123]).^v

Discussion

A trend^{14,15} in the 1990s of diminishing number of applications to MRC funding programs from health professionals was alarming because a balance between the numbers of basic and clinical researchers is crucial for the rapid application of laboratory-based discoveries in the clinical setting with minimal bottleneck effect. Beginning in 2001 several concerted discussions, dialogues and initiatives aimed at improving the capacity and infrastructure for clinical research in Canada were launched.^{4,7,16,17} The results of the present study—that 130 PIs, 16 salaried investigators, 29 fellows and 28 students a year received CIHR funding for clinical research during the years 1999-00 to 2006-07—give, for the first time, a snapshot of a selected subset of the Canadian clinical research community. Owing to a lack of historical data it is not possible to comment on the direction and magnitude of change, if

any, in the number of CIHR-funded clinical researchers in the country.

The ideal ratio of clinical to basic research capacity is not known but the numbers of CIHR salary-, fellowship- and studentship-awards for clinical researchers reported here (129, 247 and 227, respectively) represent only about 6%, 13% and 8%, respectively, of the total number of CIHR awards.⁸ Based on the proportion of overall funding granted for clinical research in the US, it is clear that in Canada we have a gap between our capacity for laboratory-based research and our ability to bring discoveries to the bedside. Thirty-two to 38% of the NIH research funding in the U.S. went towards clinical research, the definition of which encompassed population-based research and health systems and services research.¹⁸⁻²⁰ In 1997, 2,767 (23%) investigators—approximately 10 per million U.S. population^{vi}—received funding for clinical research from the NIH.¹⁸ Using the NIH definition, it could be said that 22% of CIHR funding was granted for clinical research.⁸ However, as the present study is facilitated by CIHR's relatively more exclusive definition of clinical theme research,⁹ a direct comparison of the numbers of researchers in the two countries cannot be made. RCTs,²¹ designed with the highest order of methodological rigor among clinical studies and considered the most important of treatment evaluation studies, represented about 12% of NIH's total budget.¹⁹ Only about 4% of CIHR's funding went towards RCTs.⁸

The 137 research institutions that received CIHR grants for clinical research represented 40% of 342 institutions across Canada with CIHR funding.⁸ In order to create more robust clinical research in Canada, the infrastructure subcommittee of the MUST Taskforce on clinical research proposed the creation of Clinical Research Centres (CRCs) in which health researchers working across disciplines can be brought

^v Articles were assigned to more than one province simultaneously owing to inter-provincial research collaborations.

^{vi} According to the U.S. Bureau of Census, in 1997 there were 266,490,000 people in the United States.

together to work on common health research problems in a spoke and hub fashion.⁷ Yet inadequate number of clinicians committing to and training for clinical research can diminish the potential for growth in clinical research even at future CRCs. Investigator awards may partially alleviate some difficulties especially in provinces without easy access to salary awards. Until now, for every 3 institutions with CIHR clinical research grants, there has been about 1 institution with CIHR salary awards for clinical research.

The overview of the scope of clinical research activities across Canada, primarily provided by CIHR funding, was partly illustrated and partly evaluated with supplementary data on number of publications from a parallel time period. Canada's overall ranking in the world with respect to publication productivity in clinically relevant areas remained unchanged over 3 study periods. In pediatrics, an area that benefited from multi-disciplinary, nationally integrated clinical research programs,⁷ Canada's ranking in the years 2002 to 2007 was an improvement over its ranking in earlier periods. Perhaps, the pediatrics model could prove to be a successful prototype for future development.

Limitations

The MRC/CIHR is not the only source of research funding in Canada. In 2005-06, other major sources of all biomedical and healthcare research revenues at 16 faculties of medicine in Canada were provincial, regional and municipal government agencies such as Fonds de la recherche en santé du Québec (FRSQ) and Alberta Heritage Foundation for Medical Research (AHFMR); national not-for-profit and charitable organizations such as the Michael Smith Foundation for Health Research (MSFHR); and local community sources including affiliated teaching hospitals such as The Hospital for Sick Children, Toronto.²² Although what proportion of these revenues went towards clinical research is not known, it is clear that the results of the study do not establish the overall

number of clinical researchers in the country or the proportion that is represented by the number of CIHR funded clinical researchers. For the same reason, the number of publications cannot be directly and totally attributed to CIHR funding or correlated with number of CIHR funded researchers. Data on publications may also be considered incomplete as there was likely a potential lag between funding, received towards the tail end of the study period, and corresponding publications. The study does not report the ratio of clinical to basic biomedical researchers.

Our assumption, that trends in CIHR funding can be indicative of trends in regional research activities, can be justified for the following reasons. CIHR is the most prestigious and influential peer-reviewed health research funding agency in Canada. Having contributed 20 - 24% of all biomedical and health research revenues received at 16 faculties of medicine in Canada in the years from 1996/97 to 2005/06, CIHR was the single, largest source of revenue for health research in Canadian faculties of medicine in those years.²² Among past recipients of a specialty-specific research awards program, the CIHR was the most frequently identified source of peer-reviewed grant funding.²³

In conclusion, the previously undocumented number of clinical researchers funded by a major, federal health research funding agency in Canada is alarmingly small. We emphasize caution in interpretation as our analysis does not distinguish between investigator initiated applications and responses to requests for applications; between traditional funding programs and strategic clinical research initiatives; between MD applicants and non-MD applicants; between patient-oriented research and other forms of clinical research. Future studies should evaluate the effectiveness of specific initiatives aimed at enhancing the numbers of clinical researchers across Canada.

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