TRAINEE SECTION

Brian G. Ballios, PhD^{1,2}
Norman D. Rosenblum, MD^{2,3}

¹MD/PhD Program, University of Toronto

²Faculty of Medicine, University of Toronto

³Division of Nephrology, Department of Paediatrics, University of Toronto, Ontario Canada

Challenges Facing Physician Scientist Trainees: a Survey of Trainees in Canada's Largest Undergraduate and Postgraduate Programs in a Single Centre

Abstract

Purpose: A number of indicators suggest that the physician scientist career track is threatened. As such, it is an opportune time to evaluate current training models. Perspectives on physician scientist education and career path were surveyed in trainees at the University of Toronto, home to Canada's longest standing physician scientist training programs.

Methods: Trainees from the Clinician Investigator Program (CIP) and MD/PhD Program at the University of Toronto were surveyed. Likert-style closed-ended questions were used to assess future career goals, present and future perspectives and concerns about and beliefs on training. Demographic information was collected regarding year of study, graduate degree program and focus of clinical and health research. Statistical analysis included non-parametric tests for sub-group comparisons.

Results: Both groups of trainees were motivated to pursue a career as a physician scientist. While confident in their decision to begin and complete physician scientist training, they expressed concerns about the level of integration between clinical and research training in the current programs. They also expressed concerns about career outlook, including the ability to find stable and sustainable careers in academic medicine. Trainees highlighted a number of factors, including career mentorship, as essential for career success.

Conclusion: These findings indicate that while trainees at different stages consistently express career motivation, they identified concerns that are program- and training stage-specific. These concerns mirror those highlighted in the medical education literature regarding threats to the physician scientist career path. Understanding these different and changing perspectives and exploring those differences could form an important basis for trainee program improvements both nationally and internationally.

Correspondence to:

Brian G. Ballios
MD/PhD Program
Faculty of Medicine, University of Toronto
160 College St., 11th Floor
Toronto, ON M5S 3E1
E-mail: brian.ballios@mail.utoronto.ca

Manuscript submitted 28th July, 2014

Manuscript accepted 7th September, 2014

Clin Invest Med 2014; 37 (5): E268-E283.

Physician scientist training has become a key issue in Canada due to the increased need for medical practitioners carrying out research that will, in the short or longer term, impact patients across diverse medical specialties [1]. Indeed, an increasing number of MD/PhD and Clinician Investigator (CI) trainees have enrolled in training in Canada during the last decade [2]. Yet, several indicators from Canada and the USA suggest that the sustainability of the physician scientist career track is threatened. These indicators include decreased numbers of physicians engaged in research careers in the USA, an increase in the average length of training (14-18 years post-secondary) and age at which physician scientists achieve independent research funding, decreased numbers of physicians applying for research grants at the NIH, increased economic pressures that negatively affect the capacity of granting organizations to support physician scientists, lack of institutional models of funding that support physician scientist careers in Canadian academic health science centres and variability in funding to support research at the local/institutional, provincial and federal levels [3]. Finally, trainees often face parallel clinical and scientific training tracks with limited integration, potentially inhibiting the synergy between clinical and research domains that often supports a successful physician scientist career.

The educational models used to train physician scientists have been largely unchanged since these programs were created in the 1960s (US) and 1980s (Canada). The current dynamic educational and research landscape in Canada presents an opportune time to evaluate current training models for physician scientists. Within the Canadian Institutes of Health Research (CIHR), the development of the Strategy for Patient Oriented Research (SPOR) is aimed at increasing the impact of health research on health outcomes. This initiative, and similar programs, combined with continued emphasis on fundamental discovery in the health sciences, not only provides new opportunities in health research but also provides a basis to examine whether current educational models are providing the preparation needed for physician scientists to thrive in an evolving health research environment. These factors, combined with the 2010 and 2012 Association of Faculties of Medicine of Canada (AFMC) Future of Medical Education (FMEC) Reports on undergraduate and postgraduate medical education [4,5], and the 2011 Report on the Global Commission on the Education of Health Professionals [6] provide a foundation for innovation in physician scientist education programs.

A number of studies have emerged in the last decade that are dedicated to understanding the outcomes of physician scientist training programs [7-10], particularly in the USA. There exists a relative paucity of Canadian data, due in part to a

younger cadre of physician scientist training programs. Furthermore, the health care system and economic model for physician scientist support in Canada is significantly distinct with respect to its organization; thus, training and sustainability in Canada must be understood in a Canadian context. While a recent report from the Royal College of Physicians and Surgeons of Canada reported trainee outcomes in the Clinician Investigator Program (CIP), the number of trainees engaged in physician scientist careers and the nature of these careers was not captured in this study [11]. There are even fewer studies that report physician scientist trainee's evaluation of their education and their perspectives on future careers [3,12,13]. The objective of this work was to identify current trainee perspectives on physician scientist education and future career paths as a basis upon which to consider reform of the physician scientist training pathway.

Methods

Surveying physician scientist trainees

To begin to understand the issues facing the training of future Canadian physician scientists, a Task Force on Physician Scientist Education was struck at the University of Toronto. The overall goal of the Task Force was to examine the approach to educating and supporting the physician scientist at the University of Toronto. One element of the work of the Task Force was to survey trainees enrolled in the CIP and MD/PhD Program. Surveys from 77 CIP students (70.0% response rate) and 36 MD/PhD students (81.8% response rate) were returned (see Supplementary Methods). These questions assessed future career goals, attitudes towards various aspects of the trainee education experience, concerns at various stages during training and opinions on factors critical for success as a functional physician scientist (see Supplementary Methods).

Results

Perspectives shared among CIP and MD/PhD trainees

Training path undertaken and career goals

The perspectives on training and career goals amongst CIP and MD/PhD trainees were very similar (Table 1). Both CIP (95%) and MD/PhD (86%) trainees, despite undertaking their graduate research training during different phases of their medical education, were positive and committed to pursuing a career as a physician scientist (Table 1; Figure S2-7). The majority of CIP students believed they would complete their respective programs (97%), stay in Canada for the bulk of their career (96%), be a principal investigator on grants from major

funding bodies (e.g., CIHR, NIH) (90%), have a career in science (81%), and obtain a position at an academic medical centre (99%) (Figure S2). Interestingly, data also indicated that approximately 35% of MD/PhD students and 50% of CIP students believed that they would not spend greater than 75% of their time on research. A strong majority of trainees within both programs reported that they expected to spend 50% or more of their professional time on research (Figure S2, S5).

The majority of CIP trainees thought it unlikely that they would obtain a position in government or industry (94% and 96%, respectively), though this may reflect their current training for a clinical career. They reported that they were likely to become a physician scientist (92%), run their own laboratory (86%) and were satisfied with completing their current research training concurrently with their post-graduate clinical training (92%), as opposed to during medical school (Figure S3). Similarly, the goal of MD/PhD students was to become a physician scientist at a major academic centre (89%), and a majority (81%) believed that the MD/PhD program was successful in training future physician scientists (Figure S5-7). MD/PhD students expressed optimism for completing the program in its entirety (92%), and did not express regret about entering the MD/PhD program (86%).

Concerns regarding physician scientist training pathways

CIP trainees were concerned about falling behind on clinical skills while undertaking research training (79%), being competitive for grants and other funding (96%), and balancing work and family (99%) (Figure S4). These trends were also observed when analyzed specifically among CIP trainees in the PhD- (vs. Masters-) stream (data not shown). Similarly, MD/PhD students were concerned about the age at which they would obtain their first position (89%), the overall length of training (94%), finding time to pursue research during clinical training (94%), reduced compensation compared to full-time clinical work (86%), balancing work and family (94%) and training “burn out” at the post-graduate level (92%) (Figure S7). The responses to these questions were analysed for each respondent phase of training (pre-PhD; PhD; post-PhD) and found a remarkable degree of congruity in their responses (Figure S8,9).

Factors affecting success as a physician scientist

Both CIP (99%) and MD/PhD trainees recognized that the availability of mentors (99% vs. 94%, respectively) and a passion for research (100% and 100%, respectively) are critical qualities that determine whether one should become a physi-

cian scientist (Figure S10a,b). In addition, they recognized their partner's status (job/location) (90% for CIP and 81% for MD/PhD) and raising a family (88% for CIP and 89% for MD/PhD) as important factors in their career. Both cohorts agreed (>95% of respondents in each program) that perseverance, curiosity and determination are important personal factors for success.

Perspectives that differ between trainees in the CIP and MD/PhD programs

While both CIP and MD/PhD trainees were generally in agreement (Figure S2-4 and S5-7), there were some significant differences in the extent to which they agreed or disagreed with particular survey statements (Table 1). MD/PhD students were more likely to believe that they would complete post-doctoral fellowship after graduate research training ($p=0.0008$, 81% vs. 47%). While a majority of MD/PhD students (58%) did not feel that the MD/PhD program curriculum itself was integrated well with the general MD curriculum, CIP trainees were more satisfied with the level of integration of their program with the clinical curriculum (level of satisfaction, $p=0.0051$, 70% CIP vs. 36% MD/PhD). MD/PhD trainees were more concerned about “burn out” ($p<0.0001$, 92% vs. 81%), balancing work and family ($p=0.0170$, 94% vs. 92%), and their age when they would achieve their first academic position ($p=0.0029$, 89% vs. 82%). CIP trainees showed more concern about being competitive for grants and other funding as an independent researcher ($p=0.0191$, 96% vs. 86%). Together, these responses reflect stage-specific concerns among CIP and MD/PhD trainees about the sustainability of their careers as physician scientists.

Discussion

Identifying threats to sustainable physician scientist training

Our data indicate that the MD/PhD and CIP training programs at the University of Toronto, the largest such programs in Canada, are educating highly motivated graduates who are thinking critically about the challenges and choices that lie ahead in their careers. Concern about specific choices related to career sustainability as physician scientists include hiring, time dedicated to research vs. clinical activity and competitiveness for research funding. Trainees in both the CIP and MD/PhD Programs expect to spend at least 50% of their professional time dedicated to research. The significance of this result with respect to trainee's understanding of the dedicated time needed, on average, to succeed as a physician scientist is unclear, particularly since views on dedicated research time do

TABLE 1. Summary of the pertinent goals, perspectives, concerns and beliefs of the PhD-stream CIP trainees and MD/PhD trainees.

Summary of Physician Scientist Trainee Survey Responses			
Goals	Agreement across CIP and MD/PhD Programs <i>Both cohorts feel strongly that they...</i>	CIP Scores (PhD-stream) (N=40)	MD/PhD Scores (N=35)
		Very unlikely (1) - Very likely (6)	
	Will become principal investigators.	5.2 ± 0.8	4.7 ± 1.4
	Will have a career in science.	5.1 ± 1.3	5.1 ± 1.3
	Will complete the program in its entirety.	5.9 ± 0.5	5.7 ± 0.8
		Strongly disagree (1) – Strongly agree (6)	
	Want to become physician scientists.	5.8 ± 0.4	5.1 ± 1.1
	Do not regret their decision to enter their respective Programs.	5.4 ± 0.7	4.9 ± 1.1
	<i>MD/PhD students are more likely to believe...</i>		
	They will do a postdoctoral fellowship after graduate training.	3.4 ± 1.9	4.9 ± 1.2
Curriculum	<i>CIP students are more likely to believe that they are...</i>		
		Strongly disagree (1) – Strongly agree (6)	
	Satisfied with the level of integration of their Program with the clinical curriculum.	3.9 ± 1.1	3.0 ± 1.6
Sustainability	Agreement across Programs <i>Both cohorts are concerned about...</i>		
		Not at all concerned (1) – Very concerned (4)	
	Being hired into their first position.	3.0 ± 1.0	2.8 ± 0.8
	Reduced compensation compared with full-time clinical work.	2.8 ± 0.9	2.9 ± 0.9
	<i>MD/PhD students show higher level of concern about...</i>		
	Career “burn out”.	2.2 ± 0.9	2.9 ± 0.8
	Balancing work and family.	3.3 ± 0.6	3.6 ± 0.7
	Age at acceptance to first position.	2.5 ± 1.0	3.1 ± 0.9
	<i>CIP students show higher level of concern about...</i>		
	Being competitive for grants and other funding.	3.1 ± 0.9	2.6 ± 0.9

Footnotes: Values for responses are given as mean ± standard deviation. Responses between groups were compared using two-sided non-parametric tests (p-value cutoff, p<0.05). Responses in blue are statistically similar between CIP and MD/PhD trainees, while responses in red are statistically different. The distribution of Likert-scale responses for all questions can be found in the Supplementary Information.

vary among physician scientists in different research domains [7]. Accordingly, an absolute definition of dedicated time for research was not specified in the survey. Thus, further inquiry is needed to determine whether trainees have developed a realistic perspective of the interface of dedicated research time vs. probable success as a physician scientist.

In this current study, MD/PhD and CIP trainees expressed considerable concern regarding balancing work and “life” and avoiding “burn out”, balancing clinical and research activities, maintaining excellence in both clinical practice and research and obtaining reasonable competitive monetary compensation as a physician scientist; however, they also expressed differing concerns about early physician scientist careers. Many MD/PhD trainees were more concerned than CIP trainees about their age when obtaining their first position and “burn out”. This may reflect the fact that MD/PhD trainees are generally younger than their CIP counterparts, and most have completed neither their graduate nor undergraduate MD training. Differences in responses may also reflect the fact that MD/PhD trainees, in contrast to CIP trainees, have not yet selected their clinical area of specialty; they may, therefore, feel less certain regarding their ability to visualize their ultimate career path.

To contextualize these results, there are a number of studies that highlight the eroding sustainability of the physician scientist's career in academic medicine. Recent studies of NIH-funded MD/PhD training programs have focused on the career choices of MD/PhD graduates: in significant numbers, these graduates entered and generally progressed to graduation in academic medicine, with a clear trend of directing their studies towards research rather than patient care [12-19]. The 1998 NIH study of MSTP (Medical Scientist Training Programs) programs [20] indicated that 75% of graduates were successful in obtaining NIH research grants, indicating a high proportion of competitive researchers. More recently, however, Brass et al.[7] analyzed the career choices made by graduates of 24 USA MD/PhD programs in 2007-2008, and reported a trend of graduates moving towards clinical-oriented activities (research or otherwise) and away from basic science. In the USA, this represented a decline in the proportion of alumni working in academia with their primary appointment in a nonclinical department. Furthermore, many graduates with basic science PhDs reported shifting engagement towards clinical and translational research. In addition, the increase in primary clinical appointments may speak to the commitment of MD/PhD graduates to pursue disease-related research that finds a comfortable home in clinical departments. A shift in physician scientists to clinical departments was also noted in 2000 [21].

These observations may represent the evolving definition of a sustainable physician scientist career path in response to pressures against establishing a productive career in academic medicine, such as those highlighted in our study.

Interpretation and recommendations: fostering sustainable physician scientist careers

The threats to sustainable physician scientist education identified above underscore the need for reform in the delivery of physician scientist education. How might these results influence the restructuring of physician scientist education programs? Our results must be considered in the context of a trend toward the adoption of tailored, individualized and competency-based training pathways in medical education. The 2010 AFMC Future of Medical Education Report on Undergraduate Medical Training [4] and Postgraduate Medical Training [5], as well as a 2010 report in the Lancet,[6] which reviewed health professions training globally, recommend that training programs build on the scientific basis of medicine. These reports suggest that programs adopt competency-based models of training and allow for more individualized and flexible models for trainees. Furthermore, LCME/CACMS/CFPC/Royal College accreditation requirements for undergraduate and postgraduate medical education are shifting from traditional time-based models of training towards competency-based assessment. The existing pilot programs for postgraduate medical education in Orthopedic Surgery [22] as well as in International Medical Graduate (IMG) training, [23] show that competency-based models of training and assessment can be successful. This model may provide opportunities for accelerated training and customized educational programs that would respond to the concerns of trainees making the transition to junior physician scientist researchers [24]. Certainly, a number of studies have called for a fundamental restructuring of clinical research training programs [25,26] if they are to sustain trainees with diverse career aspirations. The end result may be combined research and clinical training programs that integrate medical and research curricula to provide trainees with credit for competencies achieved in both streams.

Education in science within the existing MD/PhD and CIP training programs exist in parallel with clinical training. The majority (58%) of current MD/PhD trainees at the University of Toronto believed that integration of PhD and MD training needs to be improved, while only 6% of the class strongly agreed that the program is well integrated. In contrast, current CIP trainees were more positive, with almost 75% in agreement that CIP training is integrated with their residency training. The two main motivations behind inte-

grated MD/PhD curricula are to shorten the program and to help students stay connected with both disciplines during the entire duration of their studies. In 1994, 66% of USA schools had exactly the same curricula for the MD and MD portion of joint MD/PhD programs. The MD/PhD programs that differed had fewer basic science requirements, fewer electives or fewer core rotations [27]. Programs made use of summers to shorten thesis work and, in some cases, students received some transfer credits from graduate schooling, which allowed them to complete medical school courses in an accelerated fashion. On the other hand, keeping students continuously involved with activities related to their dual fields of study helped students stay up-to-date on essential and relevant skills.

Career mentorship was also highlighted as important during training. While the criteria for truly effective mentoring in academic medicine has been difficult to define [28], a recent study has suggested that mentorship should involve “mentor networks” with multiple points of contact for junior faculty researchers beginning their careers [29]. These included peers, senior faculty and physicians not undertaking research. How these principles might be translated to trainees at earlier stages of career development is an area open for exploration.

Based on this analysis and on the data obtained from surveying the trainees, the Task Force on Physician Scientist Training at the University of Toronto made a number of recommendations for physician scientist education reform:

1. integration of curriculum across graduate and medical studies and across undergraduate and postgraduate phases of education;
2. customization and personalized education;
3. competency-based assessment, and resulting potential acceleration of studies; and,
4. flexibility with respect to entry into and from a physician scientist training pathway.

These recommendations form the basis of a proposal for an Integrated Physician Scientist Training Pathway (IPSTP). All accreditation requirements through the LCME/CACMS/CFPC, Royal College and School of Graduate Studies would be satisfied within the IPSTP. Integration would occur at numerous levels: between levels of training; between clinical and research training; and integration of learner goals into the curriculum. Streamlining such a program would likely necessitate the shift to a competency-based medicine/research training format that eliminates redundancy in overlapping medical and research curricula. Support for the IPSTP would include providing opportunities for learners to integrate greater scientific content into their curriculum, establishing formalized career mentorship programs and alignment of physician scientist ca-

reer development and retention strategies across academic departments, hospitals and research institutes. Furthermore, a successful local IPSTP in Toronto could serve as a model at the national level for physician scientist education reform.

Strengths and limitations

This analysis represents one of the first attempts to qualify and compare the educational process and experience of current physician scientist trainees in MD/PhD and CIP programs in Canada. The University of Toronto was the first university to offer this type of training in Canada (since 1984). Both the MD/PhD and CIP programs at the University of Toronto are the largest of such programs in Canada, and have the highest number of graduates to date.

Our response rate for both MD/PhD and CIP trainees was quite high compared to previous studies of physician scientist trainee cohorts [3,12,13], and is certainly higher than typical rates (54-60%) expected of this survey population [30]; however, no sampling analysis of nonrespondents was performed, and so a measurement of nonresponder bias cannot be excluded from our analysis. Our response rate is a conservative estimate, because we were unable to verify or document an actual refusal to participate. Our study design is a cross-sectional study performed at a single time, and thus does not allow us to follow changing attitudes amongst a particular cohort throughout the course of their training, which would potentially give important insight into time-dependent variables (e.g., changes in curriculum and program size). We did not adjust the significance level for multiple tests; however, significant p-values suggest real differences in the groups being compared.

The questions in these surveys focused on opinions and self-reflection of trainee intentions, and not on objective measures. Wherever possible, we have tried to contextualize these responses in the current post-graduate physician scientist landscape, both nationally and internationally. It should be stressed, however, that this study only focuses on the perspectives of a group of trainees at a single Canadian institution. The Toronto programs have a number of unique qualities compared with other training programs across Canada, including a larger cohort of current trainees and a large network of academic health science centres in which to train. This is very different compared with many other centres across Canada, and may influence the response of trainees compared with their counterparts in smaller programs at comparatively smaller institutions. Beyond the recommendations for physician scientist education reform proposed by the Task Force on Physician Scientist Training (see above), future recommendations would

include a broader, national study based on this survey instrument. This might provide useful data on the trainee perspective on the landscape of physician scientist training across Canada. In addition, understanding the differences in perspectives between trainees of various clinical sub-disciplines and areas of research may reveal issues unique to training in a particular field. Heterogeneity amongst subgroups of CIP trainees, for example those engaged in medicine or surgery training, may reflect the differences in clinical training programs at the post-graduate level, and the extent to which individual residency programs support the goals of physician scientist training.

Conclusion

Our analysis indicates that while trainees at different stages generally agree on their career motivations, they report concerns that are program- and training stage-specific. These concerns mirror those highlighted in the medical education literature regarding threats to the physician scientist career path, and represent threats to the sustainability of the physician scientist career track. Nurturing a sustainable physician scientist career path in Canada will depend on reform and improvements at the level of both local and national training programs. It will also depend critically on early career support for new investigators looking to establish themselves in the clinical practice landscape. Attention to both will be addressing the concerns of both pre- and post-graduate physicians training for careers in science. Importantly, the paucity of data at the national level on the perspectives and concerns of Canadian physician scientist trainees demands multicentre studies to contextualize these concerns, and to ensure Canada continues to remain a leader in academic health research on the international stage.

Acknowledgements

This study was supported by input from the University of Toronto Task Force on Physician Scientist Training in the Faculty of Medicine, convened in 2011-2012 by Dr. Norman Rosenblum, Associate Dean, Physician Scientist Training Programs. The authors thank Dr. Gregory Costain for his assistance with data analysis and interpretation. The authors also wish to acknowledge the review of pertinent literature and environmental scan of physician scientist training programs in North America performed by Dr. Beata Gallay. The members of the Task Force include: Norman Rosenblum, Associate Dean, Physician Scientist Training Programs; Brian Corman, Dean, School of Graduate Studies; Alison Buchan, Vice-Dean, Research and International Relations; Jay Rosenfield, Vice-Dean, Undergraduate Medical Education; Sal Spadafora, Vice-Dean,

Post-graduate Medical Education; Avrum Gotlieb, Acting Vice-Dean, Graduate Affairs; Allan Kaplan, Director, Institute of Medical Science; Don Branch, Director, CREMS Programs; Howard Lipshitz, Chair, Department of Molecular Genetics; Arthur Slutsky, Vice-President, Research, St. Michael's Hospital, Toronto; Sandra Black, Physician Scientist; Jill Hamilton, Physician Scientist, CIP Graduate; Gillian Hawker, Physician Scientist, Chief of Medicine, Women's College Hospital, Toronto; Heather Reich, Physician Scientist, CIP Graduate; Lisa Robinson, Physician Scientist; Aaron Schimmer, Physician Scientist; Ross Upshur, Physician Scientist; Brian Ballios, MD/PhD trainee; Greg Costain, MD/PhD trainee; Sandy McGugan, Senior Administrator, Physician Scientist Training Programs; Morag Paton, Education Vice-Deans Administration; Ann Vuletin, Physician Scientist Training Programs Administration.

Contributions

Surveys of current MD/PhD and CIP trainees, and program alumni, were generated and administered under the leadership of BGB and NDR. Analyses of results were generated by BGB and GC and presented to the Task Force for critical feedback. BGB and NDR participated in writing and editing the manuscript, and approved the final version submitted for publication.

References

1. Lander, B., Hanley, G. E. & Atkinson-Grosjean, J. Clinician-scientists in Canada: barriers to career entry and progress. *PLoS ONE* 5, (2010).
2. Appleton, C. T., Belrose, J., Ward, M. R. & Young, F. B. Strength in numbers: growth of Canadian clinician investigator training in the 21st century. *Clin Invest Med* 36, E163-9 (2013).
3. Ahn, J., Watt, C. D., Man, L. X., Greeley, S. A. & Shea, J. A. Educating future leaders of medical research: analysis of student opinions and goals from the MD-PhD SAGE (Students' Attitudes, Goals, and Education) survey. *Acad Med* 82, 633-645 (2007).
4. AFMC Future of Medical Education Report on Undergraduate Medical Training. (2010).
5. AFMC Future of Medical Education Report on Postgraduate Medical Training. (2010).
6. Frenk, J. et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *Lancet* 376, 1923-1958 (2010).
7. Brass, L. F. et al. Are MD-PhD programs meeting their goals? An analysis of career choices made by graduates of 24 MD-PhD programs. *Acad Med* 85, 692-701 (2010).

8. Andriole, D. A., Whelan, A. J. & Jeffe, D. B. Characteristics and career intentions of the emerging MD/PhD workforce. *JAMA* 300, 1165-1173 (2008).
9. O'Connor Grochowski, C., Halperin, E. C. & Buckley, E. G. A curricular model for the training of physician scientists: the evolution of the Duke University School of Medicine curriculum. *Acad Med* 82, 375-382 (2007).
10. Fang, D. & Meyer, R. E. Effect of two Howard Hughes Medical Institute research training programs for medical students on the likelihood of pursuing research careers. *Acad Med* 78, 1271-1280 (2003).
11. Hayward, C. P. et al. Clinician investigator training in Canada: a review. *Clin Invest Med* 34, E192 (2011).
12. Watt, C. D., Greeley, S. A., Shea, J. A. & Ahn, J. Educational views and attitudes, and career goals of MD-PhD students at the University of Pennsylvania School of Medicine. *Acad Med* 80, 193-198 (2005).
13. Ahn, J., Watt, C. D., Greeley, S. A. & Bernstein, J. MD-PhD students in a major training program show strong interest in becoming surgeon-scientists. *Clin Orthop Relat Res* 258-263 (2004).
14. Sutton, J. & Killian, C. D. The MD-PhD researcher: what species of investigator? *Acad Med* 71, 454-459 (1996).
15. Lee, J. S. MD-PhD students in the 1990s: finding a niche for the dual degree. *JAMA* 274, 1736-1737 (1995).
16. Schwartz, P. & Gaulton, G. N. Addressing the needs of basic and clinical research: analysis of graduates of the University of Pennsylvania MD-PhD program. *JAMA* 281, 96-7, 99 (1999).
17. Paik, J. C., Howard, G. & Lorenz, R. G. Postgraduate choices of graduates from medical scientist training programs, 2004-2008. *JAMA* 302, 1271-1273 (2009).
18. Wu, J. J. et al. MD/PhDs are more likely than MDs to choose a career in academic dermatology. *Dermatol Online J* 14, 27 (2008).
19. Ahn, J., Man, L. X., Wanderer, J., Bernstein, J. & Iannotti, J. P. The future of the orthopaedic clinician-scientist. Part I: The potential role of MD-PhD students considering orthopaedic surgery. *J Bone Joint Surg Am* 90, 1794-1799 (2008).
20. MSTP Study: The Careers and Professional Activities of Graduates of the NIGMS Medical Scientist Training Program. (1998).
21. Zemlo, T. R., Garrison, H. H., Partridge, N. C. & Ley, T. J. The physician-scientist: career issues and challenges at the year 2000. *FASEB J* 14, 221-230 (2000).
22. Wadey, V. M., Dev, P., Buckley, R., Walker, D. & Hedden, D. Competencies for a Canadian orthopaedic surgery core curriculum. *J Bone Joint Surg Br* 91, 1618-1622 (2009).
23. Takahashi, S. G., Rothman, A., Nayer, M., Urowitz, M. B. & Crescenzi, A. M. Validation of a large-scale clinical examination for international medical graduates. *Can Fam Physician* 58, e408-17 (2012).
24. Lipner, R. S., Lelieveld, C. & Holmboe, E. S. Performance of physicians trained through the research pathway in internal medicine. *Acad Med* 87, 1594-1599 (2012).
25. Nathan, D. G. Clinical research: perceptions, reality, and proposed solutions. National Institutes of Health Director's Panel on Clinical Research. *JAMA* 280, 1427-1431 (1998).
26. Dickler, H. B., Korn, D. & Gabbe, S. G. Promoting translational and clinical science: the critical role of medical schools and teaching hospitals. *PLoS Med* 3, e378 (2006).
27. Kirkland, R. T. & Huckins, C. MD-PhD curricula. *Acad Med* 71(4), 313 (1996).
28. Sambunjak, D., Straus, S. E. & Marusic, A. A systematic review of qualitative research on the meaning and characteristics of mentoring in academic medicine. *J. Gen. Intern. Med.* 25, 72-78 (2010).
29. Decastro, R., Sambuco, D., Ubel, P. A., Stewart, A. & Jagsi, R. Mentor Networks in Academic Medicine: Moving Beyond a Dyadic Conception of Mentoring for Junior Faculty Researchers. *Acad Med* (2013).
30. Asch, D. A., Jedrzejewski, M. K. & Christakis, N. A. Response rates to mail surveys published in medical journals. *J. Clin. Epidemiol.* 50, 1129-1136 (1997).

Supplementary Methods

Participants

In fall 2011, all 110 trainees enrolled in the Clinician Investigator Program (CIP) at the University of Toronto were contacted. Trainees were asked to complete an online questionnaire made up of 44 Likert-style closed-ended questions. The closed-ended questions assayed future career goals, attitudes towards various aspects of the trainee education experience, concerns at various stages during training, and opinions on factors critical for success as a functional physician scientist. Information was also collected regarding trainee demographics; including year of study, degree program (MSc, PhD or post-doctoral fellowship), main area of health research (biomedical, clinical, translational, health services or policy, social, cultural environmental, or population/public health), funding status (external salary award), current level of post-graduate clinical training, and primary clinical specialty. The survey was open to all CIP trainees, regardless of whether they were currently engaged in the research phase of their training.

All 44 MD/PhD trainees who were enrolled at that time in the University of Toronto MD/PhD Program were also contacted. Trainees were asked to complete an online questionnaire made up of 44 Likert-style closed-ended questions, similar to those posed for the CIP trainees, and three open-ended questions. Information was also collected regarding trainee demographics, including phase of training (MD, pre-PhD, PhD, MD and post-PhD).

All questions in this manuscript were developed with input of the expert panel that comprised the University of Toronto Task Force on Physician Scientist Training in the Faculty of Medicine. The survey was designed to supplement and inform the discussion of the Task Force.

Regarding the structure of the MD/PhD at the University of Toronto, trainees begin the program by completing the first year of medical school. During the course of the year, students decide on a graduate supervisor and on a department in which to undertake their research training. In the second year of the program, students formally register in graduate school and begin their PhD degree. Students typically progress through their PhD in 4-5 years, depending on the research topic selected and their progress through their own projects; there is no time restriction. When the thesis has been completed, with supervisory and departmental approval, students return to complete years 2-4 of the MD program.

The CIP program follows guidelines set out by the Royal College of Physicians and Surgeons of Canada. The three pathways (Continuous Training; Distributive Curriculum

Training; Fractionated Training) involves a minimum of 24-27 months dedicated to research training which can be undertaken at various points during residency training. Additional information can be found at (<http://cip.utoronto.ca/>).

Recruitment protocol

All eligible trainees were sent recruitment invitations via three group e-mails, each of which included a link to the survey and described the purpose of the study. E-mail addresses were provided by the program leaders. No incentives were offered. Responses were de-identified at the level of the survey for MD/PhD students by only asking demographics regarding phase of training. No other identifying information was collected.

Demographic information

In addition to the survey questions, data were collected from the participants in the following areas:

1. MD/PhD trainees' phase of training was categorized as MD program (pre-PhD), graduate school (PhD thesis), MD program (post-PhD); this categorization is based on a general paradigm used by MD/PhD programs. CIP trainees' phase of training was categorized by degree stream as MSc, MSc (intention to transfer to PhD), PhD and post-doctoral fellowship.
2. CIP trainees' area of research was defined as either biomedical (i.e., "basic science") or a choice of various non-biomedical disciplines (see below). This represents an important division in research focus, as trainees in physician scientist programs have been predominantly focused on biomedical laboratory research in the past, though there is some evidence for increasing interest in non-biomedical research (i.e., clinical, translational, health services or policy, public health) [7].
3. CIP trainees' clinical specialty, defined as either surgical or medical (non-surgical, including choices of medicine, psychiatry, pediatrics, imaging or other). Historically, physician scientists have gravitated to non-surgical specialties, which may be more in line with their desire to devote greater than 75% of their time to research [7].

A complete presentation of survey questions and results can be found online in Supplementary Information.

Statistical analysis

Descriptive statistics (frequencies, medians and modes) were used to characterize Likert-type scale responses. Two-sided non-parametric tests (Mann-Whitney U) were used for within- and between-group comparisons, unless otherwise

stated. All analyses were performed using SAS 9.2 (SAS Institute Inc. 1997). Statistical significance was defined as $p < 0.05$, to account for multiple testing.

Respondent Demographics

Surveys from 77 CIP students were returned (70.0% response rate). Of the 77 respondents, seven were MSc students, 64 were PhD students and six were pursuing a post-doctoral fellowship. Of the 76 respondents, 69 confirmed that their current intention was to practice as a physician-scientist in the future, two were unsure, and six responded in the negative. Those who did not plan on practicing as a physician scientists cited reasons such as switching career paths, including a shift to a focus on medical education, concerns about being a competent clinician and researcher, and concerns over length of train-

ing. The majority of the respondents were within years 1-2 of their training in the CIP program (Figure S1a). Of the students pursuing a PhD stream, however, the respondents were evenly distributed across the years of the program (Figure S1b). The current main areas of health research were predominantly biomedical (40%) and clinical (43%) (Figure S1c). Of the 76 respondents, 70 provided information on their clinical specialty, with 30% being categorized as surgical and 70% as medical (non-surgical). The majority of trainees who responded to the survey were finished their clinical residency training (49.4%), while the remainder were either finished post-graduate year (PGY) three or four (29.9%), or PGY5 or six (16.9%). Surveys from 36 MD/PhD students were returned (81.8% response rate). Of the 36 respondents, the majority were in the PhD phase of their training (Figure S1d).

FIGURE S1. Demographics and background for respondents to the CIP and MD/PhD surveys.

Footnotes: (a) Current phase in the CIP program, (b) current phase in the CIP program (PhD-stream trainees only, includes $n=4$ in MSc stream with intention of transferring to PhD), (c) current main areas of health research for CIP trainees (respondents could select more than one area, should their focus overlap multiple fields) and (d) current phase in the MD/PhD program.

FIGURE S2. Responses to CIP survey assessing goals

Footnotes: Responses include the number of respondents in each category.

FIGURE S3. Responses to CIP survey assessing attitudes.

Footnotes: Responses include the number of respondents in each category.

FIGURE S4. Responses to CIP survey assessing concerns.

Footnotes: Responses include the number of respondents in each category.

FIGURE S5. Responses to MD/PhD survey assessing goals.

Footnotes: Responses include the number of respondents in each category.

FIGURE S6. Responses to MD/PhD survey assessing attitudes.

Footnotes: Responses include the number of respondents in each category.

FIGURE S7. Responses to MD/PhD survey assessing concerns.

Footnotes: Responses include the number of respondents in each category.

FIGURE S8. Select questions/responses comparing MD/PhD students at different phases of training

Footnotes: Phases of training include pre-PhD, PhD and post-PhD; assessing (a) future practice in Canada and (b) beliefs around factors motivating a successful career as a physician scientist.

FIGURE S9. Select questions/responses comparing MD/PhD students at different phases of training

Footnotes: Phases of training include pre-PhD, PhD and post-PhD; assessing (a) concerns and (b) attitudes motivating a successful career as a physician scientist.

Figure S10. Responses to the survey assessing beliefs around factors motivating a successful career as a physician scientist
Footnotes: (a) CIP and (b) MD/PhD trainees.