

Innovations in Training: Toward Mitigating “*Eternal post-docdum*” in Stem Cell Research

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Abstract The Networks of Centres of Excellence (NCE) is an innovative model of large-scale research networks that began in Canada in 1989, and has since been adopted by numerous countries around the globe. The Canadian Stem Cell Network (SCN), an NCE that has fostered stem cell research and innovation in Canada, has supported over 1800 trainees since its inception in 2001. In the present study we assess the impact of such a network on its research trainees professional decision-making and movements. A database populated by the SCN between the years 2001–2013 was utilized to describe trainee professional movement between sectors and geographic regions. Focus groups of SCN trainees ($n=27$) were carried out and major themes and subthemes were derived from the discourse using a thematic analysis approach. We found that most SCN trainees remained in Canada and in academic positions after leaving the SCN. Trainees expressed a desire to work in environments where their scientific interests and ideas are nurtured, where funding is stable, and where supervisor mentorship is readily accessible. SCN trainees value the unique opportunities provided by the NCE, including opportunities to network with peers, to attend various workshops and to broaden their knowledge and interest base beyond science and academia. Challenges faced by postdoctoral fellows and recommendations for future NCEs are also discussed. The findings here can be used to form evidence-based recommendations for future research networks and for

policy pertaining to the recruitment and retention of highly qualified personnel in stem cell research.

Keywords Stem cells · Training · Highly qualified personnel · Networks of excellence · Policy

Introduction

The discovery of stem cells in the 1960s by Drs. James Till and Earnest McCulloch [1] sparked what has become one of the most dynamic and promising avenues in biomedical research around the globe. Stem cell research has been celebrated for its potential to be translated into regenerative therapeutics for a number of diseases and, as such, continuing advancement of the field has become priority for many in the biomedical industry. In 2001, the Canadian Stem Cell Network (SCN) was created to unify researchers and trainees in stem cell research, clinical medicine, commercialization, public policy, law and ethics [2].

The SCN emerged from the Canadian Tri-Council Centres of Excellence initiative focused on innovative partnership. The Networks of Centres of Excellence (NCE) model was initiated in 1989 to support large-scale academically-led networks by mobilizing Canada’s best research and development talent [3]. Since that time, NCEs have provided training to more than 45,000 highly qualified personnel and have invested approximately \$2 billion in research, knowledge translation and commercialization. NCE investments have helped create 143 spin-off companies and 910 start-up companies overall, and have resulted in approximately \$1.5 billion of leverage in the form of contributions from industry and other partners. Through its efforts, the SCN has specifically reached major milestones, including revolutionary discoveries in cancer which have directly lead to three Phase I clinical

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trials, the identification of a number of adult stem cell types, and world-leading research tackling the ethical, legal and social implications of stem cell technologies on society which has served to inform public policy in this arena [4].

The SCN, like other NCEs, invest many of its resources in the education and enhancement of the future generation of Canada's stem cell scientists and innovators. In the 14 years between 2001 and 2015, the SCN has supported over 1800 stem cell trainees through its research and professional development programs. Many SCN trainees have followed traditional academic paths, and others have circulated between government, academic and industry sectors within and outside Canada.

Here we report on the forces in the context of this type of specialized network that motivate stem cell research trainees to move professionally, and the impact of such a network on career decision-making. We use both information about geographic and professional sector movements in the network's database, and focus groups to elaborate and enrich those findings. Our goal is to deliver evidence-based recommendations for scientists entering the stem cell domain, for those training and hiring stem cell scientists, and for future NCEs like the SCN, which serves as a model for excellence with widespread global impact that has been adopted around the world in jurisdictions such as the European Union, Australia, and South Africa.

Materials and Methods

Database of Trainees

The SCN maintains a database of trainees through interim and final reporting by its funded Principal Investigators (PIs). Between 2001 and 2013, approximately 1750 trainees were entered into this database that forms the window for this first of the two-part study. The database includes information on trainee level – undergraduate, Masters, PhD, law, medical and other clinical students, postdoctoral fellows, technical staff, and research associates – nationality, and educational history. In many cases it also includes complete or partial information about trainee movements, professional and geographic, after leaving the SCN. We used the information of trainees for whom data were complete, or whose data was reliably completed using publically accessible online information, to describe the movement of SCN trainees immediately after leaving the network.

Focus Groups

Participants

Focus group participants were recruited through email advertisements circulated by the SCN and by word of mouth at

relevant stem cell conferences under an institutional approved research ethics protocol. To be eligible to take part in focus groups, participants had to be over the age of 19, able to converse in English, and be a trainee holding a graduate student or postdoctoral fellowship position in the SCN.

Focus Group Guide Development and Data Collection

Focus groups were semi-structured and guided by one member of the research team, while another team member served as note-taker. The guide was developed based upon criteria and goals established for NCE trainees, and vetted with other PIs in the network. Questions focused on the motivations, incentives and barriers of professional movement, how personal considerations, funding and stem cell policy affected decisions about professional movements and on SCN activities, and how they impacted training and career decisions. Participants were also given the opportunity to make additional comments not probed a priori by the focus group guide. Focus groups discussions were recorded and transcribed *in extenso*.

Data Analysis

Focus group data were managed with NVivo 10 software (QSR international, 2012). Thematic analytic methods were used to derive major themes and subthemes from the data [5]. The coding frame was developed through an iterative process that involved labeling, organizing and critically conceptualizing the data to describe and interpret the dominant themes in a way that identifies new understandings. Approximately 20 % of the transcripts were double coded by a second coder trained in qualitative methods to ensure rigor. Any coding discrepancies were discussed and resolved between the two coders. Major themes and subthemes are defined by their prominence in the discussion. Quotes are selected to illustrate them.

Results

Geographic and Sector Movements

The majority (71 %) of trainees remained in Canada after leaving the network environment. When we examined the geographic movements of trainees differentiated by Canadian ($n=592$) and non-Canadian ($n=158$) nationality (Fig. 1) we found that, predictably, a larger proportion of Canadian citizens remained in the country (81 %) than trainees originating from international locations (35 %). Canadian trainees who left Canada tended to go the United States (US) (11 %). Non-Canadian trainees tended to go to Europe (22 %) and Asia (22 %), in particular, France, Germany and Japan.

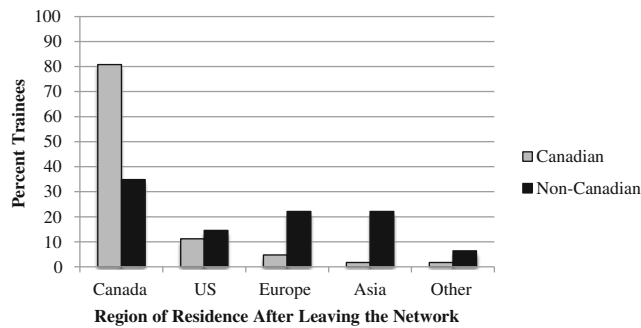


Fig. 1 First geographic movements of Canadian trainees ($n=592$) and non-Canadian trainees ($n=158$) after leaving the SCN

The data also reveal that more trainees tend to move away from Canada as they get farther along in their training, irrespective of country of origin. Approximately 78 % of master’s students remained in Canada after leaving the network, while fewer than 50 % of postdoctoral fellows remained (Fig. 2).

Overall, the proportion of SCN trainees that remained in Canada per year generally increased with time from 2001 to 2013 (Fig. 3).

The majority of master’s students (70 %), PhD students (74 %) and postdoctoral fellows (85 %) remained in academic positions while small percentages moved to industry, government and a private sector not related to life sciences after leaving the network (Fig. 4).

Focus Groups

A total of 27 trainees across six focus groups were consented to participate in this study that produced over 360 min of audio-recorded data. Focus groups generally comprised a mix of genders and of graduate students and postdoctoral fellows. Table 1 provides participant demographics. Most trainees reported that they learned about the SCN only after they joined an SCN-affiliated research group.

Four major themes arose from the discourse about participant experiences: unique opportunities provided by the

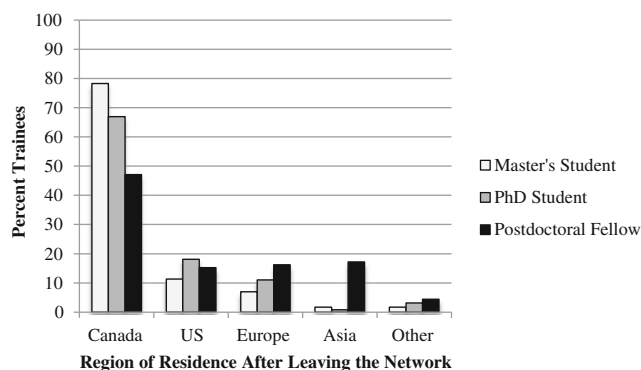


Fig. 2 First geographic movements of graduate students and postdoctoral fellows after leaving the SCN (total $n=446$)



Fig. 3 Yearly geographic movements of trainees after leaving the SCN (total $n=750$). Number of trainees who moved each year is shown in parentheses on the x-axis

network, features of a desirable training environment, personal considerations, and challenges pertaining to postdoctoral positions. Stem cell policy, per se, was not a factor when making professional choices. Two additional themes emerged as recommendations: bridging the gap between postdoctoral work and professorship, and network advocacy for trainees. These themes as well as subthemes are summarized in Table 2.

Unique Opportunities Provided by a Network One of the greatest attributes of large-scale networks like the SCN are the educational opportunities that they afford. These may take the form of in-person or online seminars, technical workshops, and opportunities to be an active member on a number of committees, among others. Trainees emphasized the value of SCN-held educational activities:

“...attending those kind of workshops...they provide kind of real examples...and it’s very inspiring...” (P14),

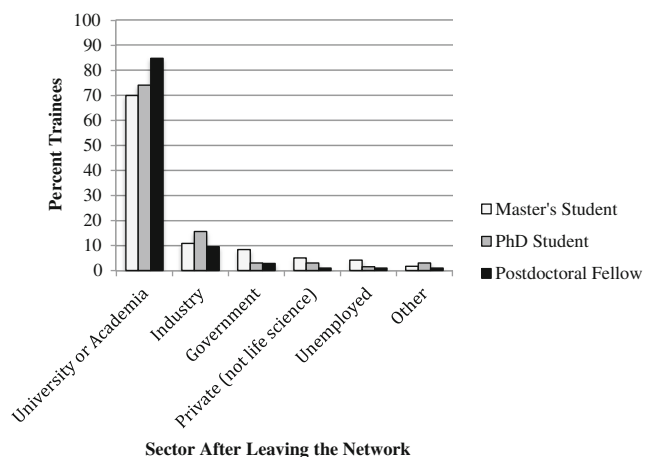


Fig. 4 First sector movements of graduate students and postdoctoral fellows after leaving the SCN (total $n=466$)

Table 1 Focus group participant demographics ($n=27$)

Gender	n
Male	17
Female	10
Location of training	n
Toronto, ON, Canada	18
Vancouver, BC, Canada	5
Calgary, AB, Canada	2
Ottawa, ON, Canada	2
Academic rank	n
Graduate Student	14
Postdoctoral Fellow	13

“...[the flow cytometry workshop gave] me the confidence...to...move forward...do something more...” (P18), and

“...the network also provided – through committees... things like leadership.” (P8)

The opportunity to network with others with common interests under a shared umbrella was also described as a key benefit:

“...on top of being exposed...to the various...PIs...I got to meet people from various places...which I wouldn't have...if it wasn't for the...network.” (P15), and
“I think the networking opportunities provided by the network are really key...” (P17)

Trainees further recognized the broad base of network nodes beyond the science bench, including policy, ethics and commercialization. The network sparked interest in the stem

Table 2 Dominant focus group themes and subthemes

Themes	Subthemes
Unique opportunities provided by the SCN	<ul style="list-style-type: none"> • Workshops • Networking • Educational opportunities beyond bench science
Desirable features of a training environment	<ul style="list-style-type: none"> • Funding • Interesting research • Mentorship
Personal considerations	<ul style="list-style-type: none"> • Family • Quality of life
Challenges associated with postdoctoral positions	<ul style="list-style-type: none"> • Low salary • Lack of human resources benefits • Limited opportunities for academic career advancement
Recommendations from trainees	<ul style="list-style-type: none"> • Bridge the gap between postdoctoral fellowship and first PI position • Advocacy for trainees

cell field as a whole and optimism for its future. As the following participants explain:

“...I was exposed to the whole stem cell research field in Canada...that...broadened my horizons towards mainly what I'm going to do in my figure...it instilled hope in me...” (P15), and

“[The Stem Cell Network] exposed me to more options for what my future might entail, and also got me in touch with people who could inform how to get there...” (P23)

Features of a Desirable Network-Based Training Environment

Trainees discussed different features that constitute a desirable training environment. They emphasized the importance of interesting work and of funding that enable them to carry out their research without struggling financially through their training. As one participant noted: “cash and science” (P03), or in other words, funding and research interest, were prominent motivators for participants. For example:

“For me, I guess the biggest factor would be my interest in the project...I find my project really interesting. That's why I'm willing to move...” (P05), and

“You look at the field where you want to go, and then you want to choose a lab that has enough money...I've worked in labs that are really poor...you just can't do anything.” (P15)

Trainees also placed high value on mentorship in the workplace and the kind of support that only a supervisor can provide. For example:

“If you're building a career in academia, you want to be able to get teaching experience...grand writing experience, and...find a PI that's going to help you do that.” (P27), and

“[My PIs] got a great reputation for training trainees... and really invest[s] the time and energy it takes to do that properly...that was...the biggest motivating factor.” (P17)

Personal Considerations Family considerations and quality of life specific to a geographic location were also prominent themes in the discourse. As the following participants describe:

“...moving cities or provinces or even countries when you have another person who you're sharing a life with, is really difficult...especially if you have kids.” (P14), and

“...working in [Location X withheld for confidentiality] and having mountains nearby is an important thing to me.” (P11)

Challenges Associated with Postdoctoral Positions Participants spoke about the tight job market and their concerns about limited opportunities available for career advancement as what one participant called “*eternal post-docum.*” (P23). They described how the perceived challenge of “*no upwards movement*” (P27), baseline salary levels established by the NCE, and limited human resource at that level creates a tension between the passion for science and day-to-day reality, leaving them to ask “*do I stay in science or do I leave?*” (P27). As the following participants explain, challenges with postdoctoral fellow salary and lack of benefits put boundaries on their personal lives and hinder achievement of scientific goals:

“...the salary is abysmal. And so no one want to do more than one single post-doc. Why would you?” (P25), and *“So we can’t claim expenses like people with a regular job. We can’t get unemployment insurance. We don’t have any sort of stability if anything happens in our life.”* This participant later went on to add: *“...some of the brightest minds probably can’t afford to be post-docs...”* (P01)

These significant challenges made participants feel particularly uncertain about their future in academia. For example:

“I think that listening to everybody’s opinions on post-docs, I’m running. I’ve been looking for jobs outside of doing research...” (P22), and *“I feel like going forward to do a postdoc with the hope of becoming a PI and having my own lab...it’s just too high risk.”* (P09)

Improving Training in Future Networks Participants offered suggestions for how the trainee experience could be improved in future networks. Deliberate and innovative action to bridge to the postdoctoral fellow-PI gap was one:

“So the senior postdocs, they’re now staring at a big, blank slate...you’re coming to the end of your postdoc, but then there seems to be ten steps...how do you get to that point? So the SCN I think can actually bridge that gap, provide the steps in order for us to progress.” (P4), and *“They did a workshop on how to write grants, but they didn’t do a workshop on how to get to the point where you would be able to write them...so that’s missing.”* (P20)

The participants also recommended that networks make trainee advocacy an integral part of the network framework. They recommended a greater focus on integrating their voices in the creation and shaping of policies that impact them. For example:

“If there’s a future organization that...is similar to the Stem Cell Network...maybe it should have some kind of funding,

lobbying arm that actually...engages post-docs and their concerns, and can relay those to policy makers...to make post-docs feel engaged as well as develop policies that would keep them in Canada...” (P23), and *“The Stem Cell Network has the influence, the voice, to speak on our behalf.”* (P4)

Discussion

Large, active research networks are designed to leverage the talents and force of interdisciplinary scientists and scholars and, through their broad scope, offer expanded opportunities for training and career growth. In this study using Canada’s SCN as a model, we found that graduate students and postdoctoral fellows trained in this network in Canada tend to stay in Canada and that they seek and value a working environment where there is stable funding, a supportive mentor, and where their research interests are nurtured. They also weigh quality of life in the geographic location they are considering, as well as family concerns, as significant variables in the decision about where to train. We discovered that most trainees became a part of this network serendipitously, and then realized the unique opportunities provided by such a structure in a dynamic way during their experience. The trainees highlighted the breadth of educational opportunities that promote marketable skill sets beyond the science bench, and the expansive professional network as particularly valuable features of the network.

The findings here parallel recommendations that call for a shift in focus towards emphasis on diversification of skills and career paths for young scientists [6–8]. At the heart of these recommendations is the extreme competition for limited positions for highly qualified personnel with narrowly focused skills. Many trainee scientists desire to pursue non-conventional academic careers, the path to which is infrequently broached in individual laboratory settings [6–8]. Networks are not only opening up this option, but also destigmatizing movement to industry and government that was once considered a second-choice career option. Such an approach is modeled in Germany, for example, where graduate training is now being advertised as a gateway not only academia but to the broader workforce [9].

Still, even in the most successful networks, enormous challenges remain. Financial stress, lack of benefits and social supports, and limited opportunities to advance in their careers plague postdoctoral fellows whose disillusionment seeps down to the graduate student level. These challenges may not only impact their career choices [8, 10, 11] but also trainee motivation, productivity, mental health and overall well-being [12–14]. In a 2013 study, 40 % of graduate students reported past or current feelings of hopelessness while 27 % reported feelings of depression during the previous year [15]. Good mentorship is a strong mitigating factor that works in favor

of stress management, career guidance and trainee confidence [11, 16]. In fact, effective mentorship was pinpointed in one US survey as the most important factor in graduate school completion [17].

Trainees in the present study reported that they have taken quality of personal life into significant consideration when deciding where to train, a finding that echoes a recent international study of stem cell scientists in the professoriate [18], and of over 8000 doctoral students conducted across universities in California [8]. Success in academia often comes with a personal price as scientists must often either move away from loved ones or find partners who are willing to move with them while they, the trainee, accumulates debt, no less [6]. The personal price is even more apparent in women trainees who feel like they must often choose between starting a family and academic success [19].

All told, centres of excellence like Canada's SCN are well positioned to sustain the dynamic, however uncertain nature of research, even in a difficult economic environment, and to attract and retain highly qualified personnel to the enterprise. While some researchers argue that change must come directly from the trainees themselves, the empowerment to change the training environment must come from the top down [20]. Indeed, participants in this study focused on stem cell science emphasized the importance of the voice of trainees in matters that affect them and for policies that impact them.

We recognize the possible self-selection bias of the participants in the focus groups, the limitations of data transferability but not generalizability, and our own possible biases as SCN investigators ourselves. Nonetheless, we find that through the ingenuity and diversity of its training programs, the SCN has provided inspiration to its trainees and hope for the future of stem cell research. Mentorship and funding have been key variables in its development and success. Even in the face of challenges experienced by virtually all sectors of academic biomedicine, the SCN has retained trainees in Canada, and promoted and enriched the multidisciplinary stem cell environment.

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Conflict of Interest The authors declare no potential conflicts of interest

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