The changing postdoc and key predictors of satisfaction with professional training

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Abstract

Purpose – The postdoctoral position was originally created as a short training period for PhD holders on the path to becoming university professors; however, the single-purpose paradigm of training has evolved considerably over time. The purpose of this paper is to report on the opportunities and challenges faced by postdocs as they navigate this complex training period.

Design/methodology/approach – To better understand the changes in postdoctoral training the Canadian Association of Postdoctoral Scholars – l'Association Canadienne des Stagiaires Postdoctoraux (CAPS-ACSP) conducted three professional national surveys of postdocs working in Canada and Canadian postdocs working internationally. Using the data from each survey, the authors investigated demographics, career goals and mental health and developed a theory-based path model for predicting postdoctoral training satisfaction, using structural equation modeling.

Findings – The analysis revealed that during their training postdocs face mental health symptoms, which play a role in job satisfaction. Additionally, predictors of satisfaction with career training were opportunities for skills development and encouragement from supervisors. Predictors of satisfaction with compensation were salary, skills training, mental health and encouragement from supervisors.

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Originality/value – This first in-depth analysis of mental health symptoms illuminates the postdoc experience in academia. The study highlights the need for substantive changes to address the challenges facing postdoctoral training in the current research model in North America.

Keywords Academia, Postdoctoral training, Mental health, Knowledge-based economy, Satisfaction

Paper type Research paper

Introduction

A postdoctoral fellow, scholar, researcher or trainee (i.e. a postdoc) is defined as "an individual holding a recently completed research doctoral degree or medical professional equivalent in a temporary period of mentored research or scholarly training on the road to a career as an independent researcher" (Mitchell *et al.*, 2013). They are important human capital in knowledge-based economies and are major contributors to research, innovation, arts, culture, science and policymaking throughout the world (Edge and Munro, 2015; Igami *et al.*, 2015). Postdocs contribute disproportionately more to research productivity when compared to other academics (Black and Stephan, 2010; Feldon *et al.*, 2019; Savoir, 2014; Vogel, 1999; Wallach, 2017). For example, one study showed that Canadian postdocs in the health sciences on average published more articles and have more citations when compared to professors or doctoral students (Barbosa and Larivière, 2014). In addition to contributing novel findings to their respective fields, postdocs also provide day-to-day supervision and mentorship of students and other research staff, while playing key roles in knowledge transmission and the establishment of collaborative research networks (Black and Stephan, 2010). Most importantly, postdoctoral appointments are the platform from which new researchers embark on independent careers (Davis, 2009).

Traditionally, postdoctoral appointments have been viewed as short-term positions intended to bridge the gap between completion of a PhD and employment as a university professor. In more recent years, the hypercompetitive job market has forced many trainees to engage in a series of postdoctoral appointments in pursuit of academic careers. These successive positions may span five or more years (Daniels, 2015; Jadavji *et al.*, 2016; Mitchell *et al.*, 2013; Offord *et al.*, 2017; Rockey, 2012; Stanford *et al.*, 2009; Yang and Webber, 2015) and have led to a phenomenon known as the "postdoc pile-up" (Powell, 2015). The "postdoc pile-up" refers to the growing number of postdocs stuck in the training pipeline because of a shortage in the number of academic positions available relative to the number of trainees (Grinstein and Treister, 2017). The increasing length of time spent in postdoctoral positions has been described in many countries worldwide, indicating that this is a global phenomenon (Grinstein and Treister, 2017; Helbing *et al.*, 1998; Jadavji *et al.*, 2016; Polka *et al.*, 2015; Powell, 2015). Job satisfaction is at risk during this extended time of training (Davis, 2009; Washington, 2005). Aspects of the postdoctoral experience associated with satisfaction might include both tangible factors such as salary and resources, and less-tangible factors such as support by supervisors and opportunities for skill development (Åkerlind, 2005; Davis, 2005). The idea that distinct orthogonal factors can represent job satisfaction was first introduced by Herzberg (1959) (Alshmemri *et al.*, 2017). These satisfaction factors exist along two separate continuums, representing an intrinsic and an extrinsic dimension. Motivators of intrinsic satisfaction are less tangible and, when available, lead to satisfaction, but not necessarily dissatisfaction, on the job. In contrast, tangible extrinsic factors are those that if not met, can lead to job dissatisfaction. Thus, one may not only have high intrinsic satisfaction (e.g. generous support and encouragement) but also a conflicting high extrinsic dissatisfaction (e.g. low salary). For example, postdocs working in Holland reported fairly high levels of intrinsic satisfaction, such as guidance

from supervisors, but less satisfaction with career prospects and work-life balance (van der Weijden *et al.*, 2016). With reduced satisfaction, there is a risk of these highly trained personnel leaving academia, which results in several negative consequences, including loss of personal investment. There is also a cost to the public, who has invested in training these highly trained personnel and a loss to research, as well as contributions to the knowledge-based economy. As knowledge-based economies grow, so does the understanding that structures that support mental health are critical to maintaining an optimal workforce capacity (Engelbrecht, 2012). As a critical segment of this workforce, warning signs regarding issues with postdoc mental health will need to be taken seriously. For example, Dorenkamp and Weiß (2018) found that heightened job stress among postdocs leads to greater levels of intention to leave academia (Dorenkamp and Weiß, 2018).

Previous work in the Canadian postdoc population identified key concerns of postdoctoral training including lack of benefits, low pay, increased time in position and concerns about career advancement (Helbing *et al.*, 1998). Mental health has been described in both students (Evans *et al.*, 2018; Rummell, 2015) and faculty (Boyd *et al.*, 2011), but not yet in postdocs. To better understand trends and the current state of the postdoctoral training, the Canadian Association of Postdoctoral Scholars – l'Association Canadienne des Stagiaires Postdoctoraux (CAPS-ACSP) conducted national surveys of postdocs working in Canada and Canadians working internationally in 2009 (Stanford *et al.*, 2009), 2013 (Mitchell *et al.*, 2013) and 2016 (Jadavji *et al.*, 2016). The present study reports on the trends in the postdoc population using data collected from the three professional national surveys and identifies intrinsic and extrinsic motivators of job satisfaction using the data collected in the 2016 survey (Herzberg, 1959; Herzberg *et al.*, 2011). Postdoc mental health was investigated via 11 survey items that served as indicators of mental health and a thematic qualitative analysis of *verbatim* comments surrounding the discourse of mental health and well-being. Findings report on trends in the postdoctoral landscape from 2009 to 2016 and outline two models of job satisfaction. Results point to specific actions that can be taken by stakeholders to improve the experience and outcomes of postdoctoral training. In particular, the prevalence of mental health symptoms is explored and investigated as a mediator of both intrinsic and extrinsic motivators of job satisfaction.

Survey methodology

The CAPS-ACSP 2009, 2013 and 2016 professional surveys covered demographic and funding details, postdoc well-being and satisfaction and career goals and outcomes. Where survey questions aligned in at least two national surveys, an examination of trends was undertaken. For more details on survey questions, please refer to individual reports 2009 (Stanford *et al.*, 2009), 2013 (Mitchell *et al.*, 2013) and 2016 (Jadavji *et al.*, 2016).

Demographics of the survey respondents for each year are presented in Table I. The population of survey respondents included Canadian citizens working in Canada and internationally, as well as permanent residents and international postdocs working in Canada.

The 2009 national survey was conducted using an online survey tool (LimeSurvey). Participants were recruited via a link on the CAPS-ACSP website. The survey was open to responses for 91 days and a total of 1,192 postdocs participated (Table I). The data analysis was performed by postdocs volunteering their time with CAPS-ACSP.

In 2013, CAPS-ACSP worked with Mitacs along with the research and survey consulting firm Academica Group to conduct the national survey. To expand the breadth of the survey, representatives from all three organizations worked on survey question development, and the US Sigma Xi postdoc survey (Davis, 2005) was also consulted. Academica Group

deployed the survey in both English and French and conducted a detailed analysis. The 2013 survey was open for 39 days and a total of 1,830 postdocs participated (Table I). At the end of the survey, respondents were given the option to enter their e-mail address for future research purposes.

In 2016, the CAPS-ACSP survey was delivered again with the assistance of the Academica Group. Input on survey questions from the Tri-Council funding agencies (Canadian Institutes of Health Research, CIHR; Natural Sciences and Engineering Research Council, NSERC; and Social Sciences and Humanities Research Council, SSHRC) was also obtained. Five new survey questions were added, one focused on mental health during training and the other four targeted toward postdocs who had completed their training. Academica Group deployed the survey in English and French and analyzed the data. The survey was open for 50 days and a total of 1,630 postdocs working in Canada participated (Table I).

To address the challenge that there is no comprehensive list of all postdocs working in Canada, e-mails containing links to the survey were sent to postdoctoral administrators working at Canadian universities with postdoctoral training programs available. The Tri-Council (CIHR, NSERC and SSHRC) funding agencies and Mitacs were asked to forward the survey to the postdocs in their databases. Institutional postdoctoral associations and the CAPS-ACSP membership were also sent e-mails with survey links.

Training satisfaction analysis

Satisfaction with postdoctoral training was queried in the 2016 survey. A path model was developed using partial least squares structural equation modeling (SEM) to examine the latent structure of satisfaction with postdoctoral training and the most salient predictors of postdoc satisfaction. The indicators and measures included in the model were derived from the 2016 survey responses. The structure of the model and composition and quality of the latent variables were analyzed using WarpPLS 6.0 (Kock, 2017).

Outcome variable. The latent outcome variable, postdoc satisfaction, was initially reflected by 11 indices of satisfaction. Survey respondents were queried regarding satisfaction with their salary, benefits, opportunities for collaboration, resources and facilities, career development and options, professional training, work environment/interaction, level of supervision/independence and work-life balance. The queries were

Demographic measurements	2009	2013	2016
Number of respondents	1,192	1,830	1,630
Length of survey (days)	91	39	50
Percentage of respondents by discipline			
Life sciences	63	46	45
Physical sciences/engineering	23	32	28
Social sciences/humanities	11	14	16
Interdisciplinary	Unknown	8	12
Percentage of respondents by gender			
Female	56	53	51
Male	44	46	48

Notes: Data is presented as a percentage of respondents. Respondents included postdocs working in Canada and Canadians working internationally

Table I.
Demographics of all survey respondents from 2009, 2013 and 2016 CAPS-ACSP national surveys

answered using a five-point Likert scale that ranged from "completely disagree" to "completely agree." In Table II, hypothesized motivators of satisfaction were categorized as either intrinsic or extrinsic in accordance with Herzberg (1959, 2005) and Herzberg *et al.* (2011). Intrinsic factors centered on professional development and recognition, whereas extrinsic are related to policies, such as wages, benefits and job security. Two additional ratings of overall satisfaction with the postdoctoral experience and the value of the training were also examined.

Predictor variables. Predictors of postdoc satisfaction were developed from queries in the 2016 survey that followed a categorical, scale or ordinal response format and indexed various aspects of the postdoctoral experience. Potential predictors (with number of representative items) of postdoctoral training satisfaction included concern with encouragement from supervisors (1 item), certainty of achieving the desired goal (1 item), quality of skills training (5 items), non-academic career preparation (3 items), time allocated to various aspects of the training (8 items), professional priorities (10 items), annual salary (1 item) and mental health (11 items). These individual predictor variables represented a broad range of factors that could influence satisfaction with the postdoctoral experience. The structural model was also designed to test the mediating influence of mental health, whereby the effects from all predictors significantly associated with mental health and the satisfaction outcomes were separately tested to determine whether their effects on satisfaction were significantly mediated by mental health. The full path model was analyzed using age, gender and location of postdoc (within or outside of Canada) as control variables.

A qualitative analysis of mental health themes was also undertaken with the QDA Miner-Lite software. Key terms were selected by the researchers as codes and text retrieval matched the discourse (respondent free text) with the thematic codes.

Results

Trend analysis of 2009, 2013 and 2016 surveys

The postdoc population is aging. The results from 2009, 2013 and 2016 surveys suggest a shift in the age distribution of postdocs working Canada and Canadians working internationally. The percentage of postdocs in the two younger categories, 25-29 and 30-34 years of age, has decreased since 2009 (Figure 1). Meanwhile, in 2016, 31 per cent of current postdocs were 35+ years of age; the proportion of postdocs in this age group has increased eight percentage points since 2009.

Index of satisfaction	Intrinsic or extrinsic motivation
Salary	Extrinsic
Benefits	Extrinsic
Opportunities for research collaboration	Intrinsic
Resources and facilities	Extrinsic
Funds for research and travel	Extrinsic
Career development	Intrinsic
Professional training opportunities	Intrinsic
Work environment/peer interaction	Intrinsic
Level of supervision/independence	Intrinsic
Work-life balance	Both extrinsic and intrinsic

Note: [a]Categorization of intrinsic versus extrinsic motivation is based on work by Herzberg (1959, 2005) and Herzberg *et al.* (2011)

Table II. Hypothesized intrinsic and extrinsic motivators of satisfaction[a]

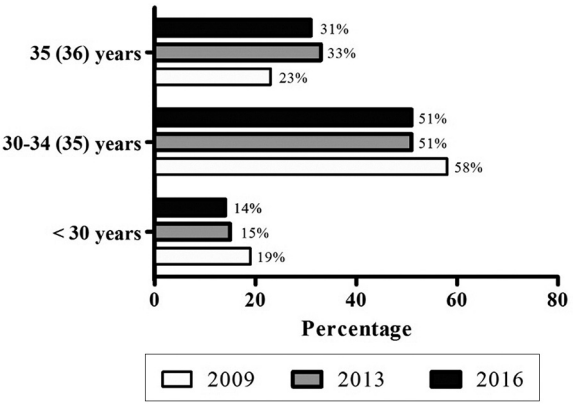


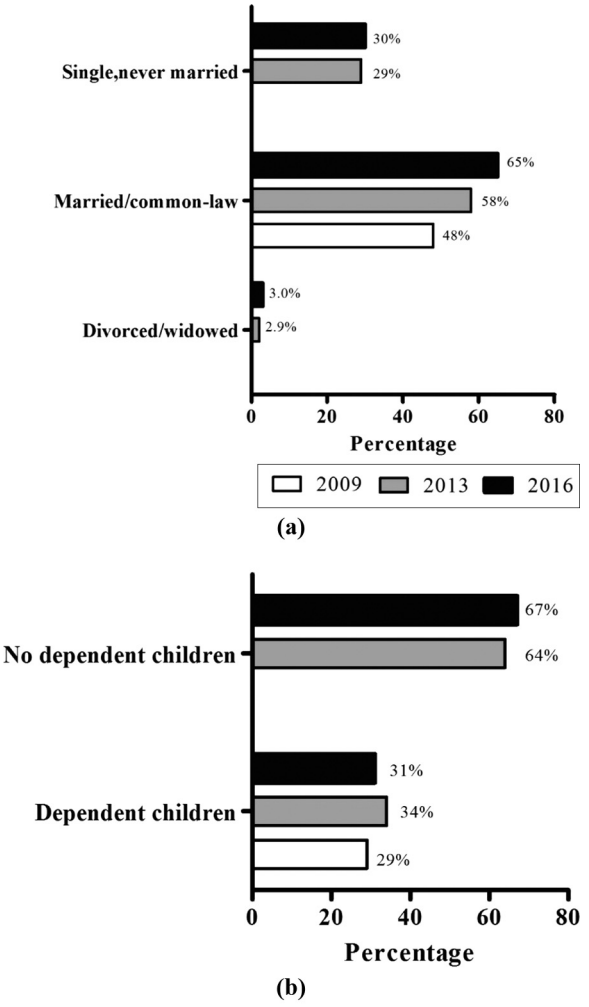
Figure 1.
Age of postdocs working in Canada and Canadian postdocs working internationally in 2009, 2013 and 2016

Notes: Data collected from 2009, 2013 and 2016 CAPS-ACSP Canadian National Postdoctoral Surveys. In 2009, the two middle age categories were 30 to 35 years, and 36 to 40 years as indicated by the values in brackets. In 2016, 5 per cent of survey respondents preferred to not report their age. In the 2009 and 2013 survey's there was no option to not report age of respondent

In Figure 2(a), the number of married postdocs in 2016 increased from 2009. No data on the number of single, never married or divorced/widowed postdocs was collected in the 2009 survey. There were more postdocs with children in 2016 as compared to 2009 [Figure 2(b)]. Our analysis shows that there was a concomitant increase (15.6-19.0 per cent) in the need for paid parental leave from 2013 to 2016. In 2016, the percentage of past postdocs with dependents was 47 per cent, as compared to current postdocs (31 per cent). A comparison of desired benefits from the 2013 and 2016 surveys also suggests a maturing cohort, with needs that reflect typical family-related concerns. For example, there was an increase in the desire for paid parental leave from 16 per cent (2013) to 19 per cent (2016).

Career goals of postdocs. The 2013 and 2016 surveys examined the career goals of postdocs before beginning their postdoctoral appointment. In Figure 3, the tenure-track position was, and is, the primary initial career goal for more than 70 per cent of postdocs. However, there is a trend from 2013 to 2016 for fewer postdocs (approximately 5 per cent) to begin with a tenure-track career goal. In 2016 more postdocs selected other career options such as industry and private sector research, public service and consulting or non-government organization as their primary career goal.

Gender representation among postdocs. A clear trend across the three surveys was the increasing proportion of female postdocs [Figure 4(a)]. While there remain slightly more men than women in postdoctoral positions, the gap has closed by 2016. More importantly, there were no gender differences in salary between male (C$47,847.34) and female postdocs (C $47,751.76). Despite the increasing number of female postdocs and similarly reported earnings between genders, there was a pattern of lower satisfaction with career options for women that persisted from the 2013 survey [Figure 4(b)]. Post hoc analysis of the association of gender to the number of postdoctoral appointments found no significant relationship in the present study.



Notes: Data collected from 2009, 2013 and 2016 CAPS-ACSP Canadian National Postdoctoral Surveys. In 2009, only data on married/common-law status and the percentage of postdocs that had dependents was collected

Figure 2.
The marital status of postdocs (a) and percentage with dependents (b)

Postdoc mental health

In our analysis, we considered postdoc mental health as a separate predictor of job satisfaction, and a potential mediator of effects from intrinsic and extrinsic satisfaction motivators. As knowledge-based economies grow, so does the understanding that structures that support mental health are critical to maintaining an optimal workforce capacity (Engelbrecht, 2012).

As shown in our hypothesized path model (Figure 5), postdoc mental health was posited as a potential mediator of effects from the number of postdoctoral appointments held, the postdoc

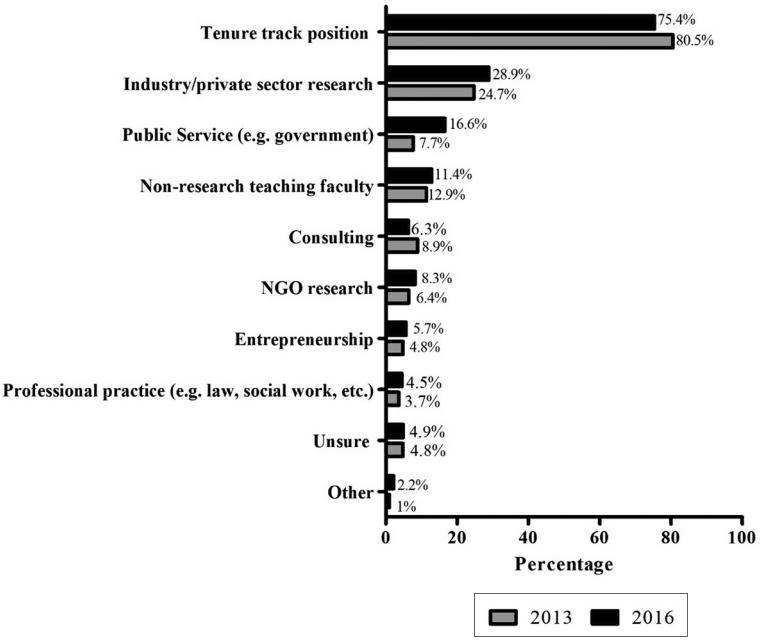


Figure 3.
Career goals of PhD holders before starting a postdoctoral position

Note: Data was only collected from 2013 and 2016 CAPS-ACSP Canadian National Postdoctoral Surveys

pile-up effect and both intrinsic and extrinsic motivators of satisfaction and was, therefore, examined in detail. About 75 per cent of respondents indicated experiencing serious thoughts, feelings or conditions related to their mental health during their postdoctoral appointment. Approximately 75 per cent of respondents who reported negative symptoms also reported multiple symptoms, with the majority of these respondents indicating three or more symptoms. In Figure 6, the most commonly reported experiences (lasting for a month or more) were feeling overwhelmed by tasks, feelings of hopelessness and loneliness, and anxiety or panic attacks. About one-quarter reported experiencing depression and insomnia, and one-fifth reporting feeling extreme sadness. Of imminent concern are the 7 per cent of postdocs who report thoughts of self-harm or self-loathing. A Pearson correlation analysis found that scores on the overall satisfaction: survey item correlated significantly with the number of negative mental health symptoms experienced by respondents ($r = -0.27$, $p < 0.001$). Thus, as negative symptoms increased overall satisfaction decreased.

To investigate the effect of the length of time spent in the postdoctoral pipeline on mental health, we examined the relationship between each mental health item and the number of appointments postdocs held. Chi-square (χ^2) analyses were conducted for the presence of each mental health with the number of postdoctoral appointments held. Self-reported depression was significantly associated with the number of appointments, such that the relative occurrence of reports of depression increased as the number of appointments increased ($X^2(3) = 9.45$, $p = 0.024$).

Comments from survey respondents to the 2016 survey were examined for themes pertaining to mental health and well-being. This qualitative analysis pointed to

Note For the survey item pertaining to satisfaction with career options, data was only collected from 2013 and 2016 CAPS-ACSP Canadian National Postdoctoral Surveys

Figure 4.
The percentage of female and male respondents for 2009, 2013 and 2016 surveys (a) satisfaction of postdocs with career options by gender for all respondents (b)

relationships with supervisors as a pivotal factor in postdoc stress. Some postdocs reported having excellent relationships with their supervisor; this giving way to overall better postdoc experiences. In other cases, troublesome interactions with supervisors were described using terms that reflect harassment, bullying and lack of support. Some postdocs reported feeling as though they are "at the mercy" of their supervisor. Only two-fifths of postdocs indicated that they had access to extended health benefits, the point of access for mental health services.

Postdoc satisfaction with training, career and compensation

In regard to overall satisfaction with postdoctoral training, the 2016 survey indicated that about half the respondents were at least somewhat satisfied. However, more postdocs were either ambivalent or dissatisfied as compared to the number of completely satisfied postdocs. The results of the 2016 survey items pertaining to satisfaction with various

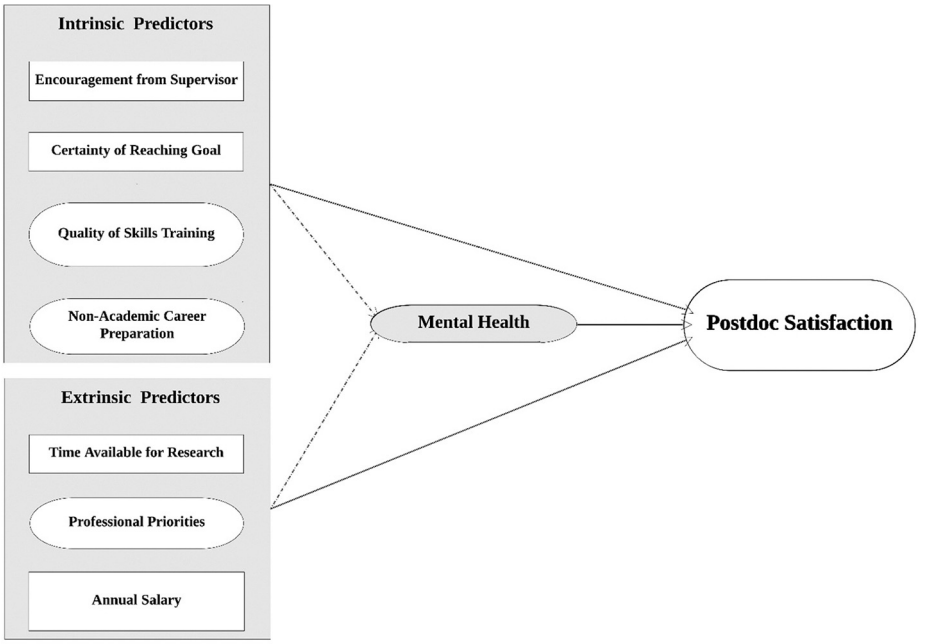


Figure 5.
Hypothesized path model for predictors of postdoc satisfaction

Note: Dashed arrows from predictors to mental health indicate that mediating effects from predictors to satisfaction factors, via the mental health factor were also examined

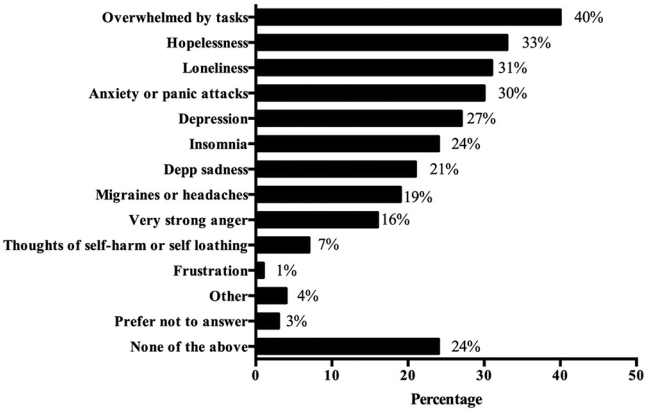


Figure 6.
Mental health symptoms experienced by 2016 survey respondents during their postdoctoral training

Note: These symptoms were experienced for greater than one month

elements of the postdoc experience are shown in Figure 7. The highest satisfaction ratings were found for workplace characteristics such as supervision level and independence, resources, peer interaction and collaboration opportunities. Satisfaction levels were relatively low for factors associated with work and life balance, extra funding for travel, career development and training. The lowest satisfaction was noted for salary and benefits.

In Figure 5, the structural path model for determining predictors of postdoc satisfaction was originally constructed as a variety of factors directly predicting one latent postdoc satisfaction outcome variable. In accord with the survey items, some predictors were represented as latent constructs (e.g. professional priorities, quality of skills training, mental health and non-academic career preparation), and others as single indicators (e.g. number of appointments, annual salary, encouragement from supervisor, certainty of reaching goal and time available for research). All control variables were represented as single-indicator variables (not shown in path diagram).

Measurement model testing

Before examining the structural relationships between variables in the SEM, measurement model analysis using confirmatory factor analysis was completed for each latent variable in the SEM. As per convention, when loadings were significant and in the expected direction, they were retained for the final outer measurement models, see Figure 8 for the structure of each predictor variable (Kline, 2005). With respect to the satisfaction outcome variable, we found that two latent satisfaction constructs, rather than a single factor, better represented the concept of satisfaction. Each of these two satisfaction constructs fell along the lines of either extrinsic (e.g. compensation) or intrinsic (e.g. training and career) factors (Table II). An initial analysis of the loadings from all 11 items of satisfaction on one factor found that three key factors loaded poorly (less than 0.5). When the two-factor structure was tested the

Notes: Satisfaction levels range from high (left side of bars) to low (right side of bars). data was only collected from 2016 CAPS-ACSP Canadian National Postdoctoral Survey

Figure 7. Percentage of satisfaction across various elements of the postdoctoral training

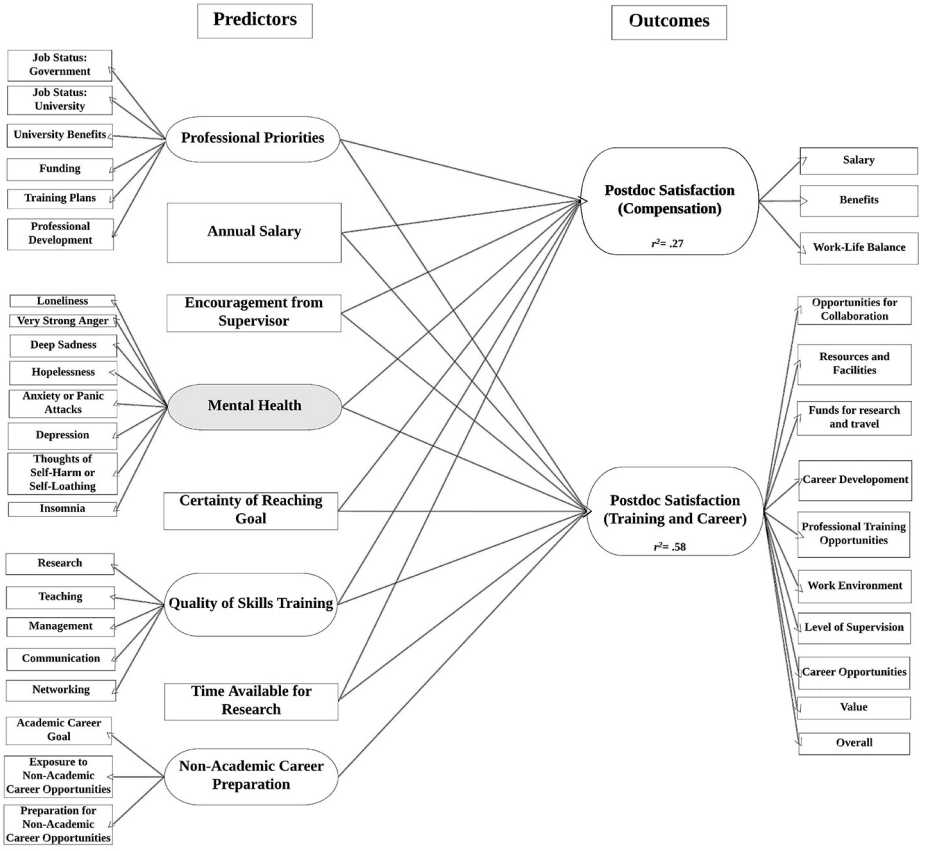


Figure 8.
Structural equation model with significant predictors of postdoctoral training satisfaction

Notes: Latent constructs are oval-shaped, while directly measured single-indicator constructs are indicated by rectangle-shaped variables. Only the indicators with significant loadings (0.60 or greater) were retained for each final measurement model. not shown are the direct and mediating paths from predictors to the mental health construct; however, as indicated by figure 5, these mediating effects were tested for all predictors

cross-loadings between the indicators and the other construct were low (less than 1), thus validating the use of two latent satisfaction constructs (Table III).

In Figure 8, the first satisfaction construct was composed primarily of intrinsic factors pertaining to training and career-related activities (e.g. resources such as funds for research and travel), collaboration and work environment and supervisory factors. Extrinsic satisfaction (compensation factor) was reflected by salary, benefits and work-life balance.

Also, shown in Figure 8 are the indicators found to significantly reflect each of professional priorities (six items), mental health (eight items), the quality of a variety of skills training (five items) and non-academic career preparation (three items). These tests resulted in measurement models with high to moderate quality indices such as average variance extracted (>0.5) and model reliability (>0.7).

Satisfaction factor	Indicator	Loading	Cross-loading	Factor quality coefficients
Compensation	Salary	0.782	−0.04	Cronbach's $\alpha = 0.541$
	Benefits	0.738	−0.072	Composite reliability = 0.766
	Work/life balance	0.645	0.131	AVE = 0.523
Training and career	Opportunities for research collaboration	0.683	−0.159	Cronbach's $\alpha = 0.863$
	Resources and facilities	0.563	0.108	Composite reliability = 0.892
	Funds for research and travel	0.511	0.199	AVE = 0.458
	Career development	0.768	0.04	
	Professional training opportunities	0.695	0.037	
	Work environment/peer interaction	0.691	−0.085	
	Level of supervision/ independence	0.691	−0.127	
	Satisfaction with career options	0.84	0.004	
	Satisfaction with value	0.77	−0.011	
	Overall satisfaction	0.461	0.092	

Notes: Quality coefficients index reliability, such that indicators are shown to reflect the latent construct. Ideally Cronbach's α and composite reliability > 0.6 and average variance extracted (AVE) > 0.5

Table III.
Loading values of each satisfaction indicator with its respective latent construct

Structural model results

Most predictors in the model had small to medium effects on the satisfaction constructs (Table IV). In Figure 8, when an arrow from a predictor to either of the satisfaction factors is not present, this indicates the lack of a significant relationship between a predictor and an outcome variable. For example, the non-academic career preparation factor was associated with satisfaction with training and career issues but was not significantly linked to satisfaction with compensation. The relative predictive strength for each significant predictor variable for the two satisfaction constructs and the mental health construct is illustrated in Figure 9. As is often found in SEMs with large sample sizes, links between constructs may be statistically significant but offer little in the way of explained variance of

Predictors	Path coefficients Training and career satisfaction	Compensation satisfaction	Mental health issues
Annual salary	0.075	0.286	
Time available for research	0.073	0.04 (ns)	
Professional priorities	−0.069	−0.109	
Mental health issues	−0.137	−0.166	
Encouragement from supervisor	0.181	0.121	−0.129
Certainty of reaching goal	0.122	0.055	−0.161
Variety of skills training	0.484	0.155	−0.114
Non-academic career development	0.121	0.102 (ns)	−0.102

Note: All path coefficients are significant at $p < 0.05$ unless otherwise indicated

Table IV.
Beta path coefficients from predictors to outcome variables

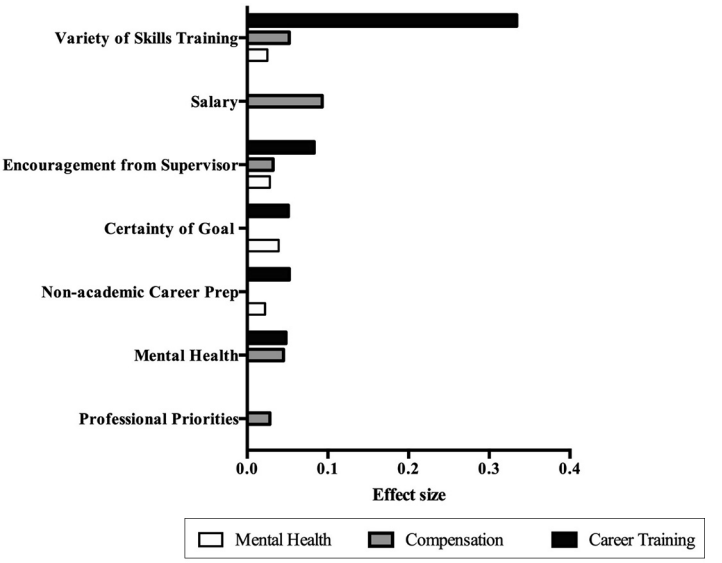


Figure 9.
Relative effects (Cohen's f^2) of predictors of postdoc satisfaction

Note: Bars indicate the strength of the relationship of the predictors on *y*-axis with the two satisfaction constructs, compensation and career training, and with mental health

the outcome variables. Thus, effects less than 0.02 were removed from Figure 9 because of their practical insignificance in explaining the outcome factors (Cohen, 1988).

More than half the variance (r^2 = 0.58) of the intrinsic job satisfaction factor was predicted by the model (Figure 8). In Figure 9, quality ratings for a variety of skills training was the strongest predictor of intrinsic satisfaction. The remaining variance in intrinsic satisfaction was predicted similarly by encouragement from supervisors, non-academic preparation certainty of reaching the goal and mental health symptoms.

Extrinsic job satisfaction was less well-predicted (r^2 = 0.27), with the majority of variance predicted by salary, and the remaining similarly predicted by mental health symptoms, skills training, concern over professional priorities and encouragement from supervisors. Further *post hoc* analysis of annual salary and satisfaction was undertaken to explore how income might affect compensation-related motivators of satisfaction. The average salary of postdocs working in Canada in 2016 was just under C$48,000.00. A positive linear relationship of salary to satisfaction with compensation was found, accounting for just under half the variance. It should be noted that a substantial increment in salary (from about C$25,000.00-85,000.00) resulted in only a minor average increase in satisfaction (1.5 points on the five-point scale). In the final model, the number of appointments held by postdocs did not significantly predict either satisfaction factor directly or did it predict mental health.

Mediation of effects by mental health

Mediation effects were tested individually with simple three-variable models (predictor → mental health → satisfaction construct). For all predictors that correlated significantly with mental health (Figure 9), we tested for the mediation of effects from these predictors on the

satisfaction constructs via mental health. For example, as listed in Table V, effects from skills training on career and training *and* compensation satisfaction factors were significantly mediated by mental health. Similarly, small but significant effects from encouragement from the supervisor, non-academic career preparation, and certainty of reaching career goals on career and training satisfaction were mediated by mental health. In sum, mental health had relatively large effects on both aspects of satisfaction, and mediated effects from a suite of other predictors of satisfaction. The majority of the role of mental health as a mediator of satisfaction came from the intrinsic factors associated with career preparation, the certainty of future career goals and day to day motivation from supervisors.

Discussion

Recent data has suggested that the postdoctoral training is changing, in Canada (Helbing *et al.*, 1998; Jadavji *et al.*, 2016; Mitchell *et al.*, 2013; Stanford *et al.*, 2009) and worldwide (Daniels, 2015; Offord *et al.*, 2017; Rockey, 2012; Yachnin *et al.*, 2015). The aim of this study was to examine the trends and the factors affecting satisfaction with training in the postdoc population working in Canada and Canadian postdocs working internationally. Our analysis revealed that the demographics of the average postdoc are changing, as we observed an increase in the average age of postdocs, as well as those married and with dependents. Our study is the first to describe mental health in the postdoc population. In terms of training satisfaction, quality of skills training, encouragement from supervisors and prior knowledge of career prospects were the three strongest predictors of satisfaction. The importance of supervisor-postdoc relationships was supported by the qualitative analysis of *verbatim* text. Open comments from postdocs indicated that while positive relationships added to the quality of the workplace, negative relationships (including lack of appreciation or bullying) could severely affect the postdoctoral experience. Our results resonate with other international research findings, which indicate that action is needed if countries wish to continue to attract and retain high-quality postdocs (Ahmed *et al.*, 2015; Daniels, 2015; Helbing *et al.*, 1998; Offord *et al.*, 2017), these trends are discussed in more detail below.

Understanding the factors that contribute to postdoc satisfaction with training and compensation can inform strategies designed to improve the training experience, positively influence training outcomes and attract high-quality PhDs to postdoctoral programs. In our study, when asked about a variety of aspects of the postdoctoral experience, ratings of "complete satisfaction" ranged from about 10-40 per cent. For most items, respondents were more likely to be "somewhat satisfied." Results of the CAPS-ASCP 2016 survey are less positive than those from a survey of US postdocs where 70 per cent of respondents indicated overall satisfaction with the postdoctoral training (Davis, 2005). The present findings reflect those of a study of Dutch postdocs, which also indicated lower levels of satisfaction with career prospects and work-life balance when compared to their satisfaction with contact with

Experiences	Career and training	Compensation
Variety of skills training	0.02	0.02
Encouragement from supervisor	0.03	<0.02
Certainty of reaching goal	0.03	<0.02
Non-academic career preparation	0.03	<0.02

Notes: Values are effect sizes, similar to Cohen's f^2, $p < 0.01$. For example, in a simple three-factor model, mental health mediated a significant portion of the variety of skills training effects on the career and training satisfaction factor

Table V. Mediated effects from predictors of satisfaction via mental health construct (simple mediation models)

colleagues, workplace conditions and supervisor guidance (van der Weijden *et al.*, 2016). Furthermore, there is concern over the possibility that satisfaction with the training may erode across multiple postdoctoral appointments. The desired permanent faculty position, including job security and academic freedom, are a major motivator for postdocs to stay in these temporary and low paid positions (Andalib *et al.*, 2018; Stephan, 2013). The addition of more funding for postdocs, especially in the biomedical field, has enabled postdocs to stay in positions longer, while they wait for the desired tenure track position (Hur *et al.*, 2015). A Canadian study documented seven postdocs as they moved through their training, and reported that a nurturing research environment, including supervisors support and networking, resulted in a smooth training period (Chen *et al.*, 2015). However, many felt that they needed to make sacrifices and personal compromises in their personal life to have a successful career (Chen *et al.*, 2015). Longer postdoc appointments and reduced satisfaction have been reported prior to our study in the Canadian population (Helbing *et al.*, 1998). This decrease in satisfaction over time was noted by van der Weijden *et al.* (2016), wherein greater numbers of appointments were associated with less satisfaction. Similarly, Vandenberg and Lance (1992) found that job satisfaction for young professionals was a result of organizational commitment, where greater commitment leads to increases in experienced job satisfaction (Vandenberg and Lance, 1992). Thus, as postdocs experience decreasing levels of commitment with their position, which may occur when the likelihood of obtaining the permanent faculty appointment appears to dwindle, satisfaction with postdoctoral positions may also wane.

Work-related mental health issues (e.g. work-related stress) impose a significant health and economic burden on the employee, the employing organization and the country of work more generally (Van Gordon *et al.*, 2014). As a critical segment of this workforce, warning signs regarding issues with postdoc mental health will need to be taken seriously. For example, Dorenkamp and Weiß (2018) found that heightened job stress among postdocs leads to greater levels of intention to leave academia (Dorenkamp and Weiß, 2018). The 2016 survey indicated that three-quarters of the respondents experienced one or more persistent negative mental health symptoms such as feeling overwhelmed by tasks, hopelessness, loneliness, anxiety and depression. We also found that the postdoc pile-up may be contributing to depressive symptoms, whereby greater numbers of appointments held by postdocs lead to increases in the proportion of postdocs with self-reported depression. To better understand the depth of this problem one can examine the prevalence of these symptoms in the 30-something population. For those in the "millennial" age range, as are most postdocs, women and low-income are the most likely to experience mental health issues (Ipsos, 2018). Also, for this age range, suicide is the third leading cause of death (Government of Canada, 2016). Although universities were traditionally regarded as low stress environments, occupational stress among academics indicates that it is alarmingly widespread and, on the rise (Boyd *et al.*, 2011). Studies suggest that stress is more prevalent in younger academics such as postdocs, who face high levels of job insecurity in a competitive and fast paced environment (Levecque *et al.*, 2017; Müller, 2019). The relationship between mental health and academic performance was robust in a variety of analysis (Hysenbegasi *et al.*, 2005).

We found that respondents reporting negative symptoms tended to experience multiple persistent symptoms, on average, three symptoms. It is critical that postdocs have access to extended health benefits to connect with mental health services when needed. Over half of the 2016 survey respondents also indicated that they expect to be a postdoc for three years or more, making persistent chronic stress a possibility. Chronic stress is known to have negative effects on health, including physical and mental well-being (Schetter and Dolbier, 2011). In a 20-year review, Ganster and Rosen (2013) discuss critical end points of workplace stress that include diabetes, cardiovascular disease and depression, which result from the

cortisol dysregulation brought about by sustained stressful environments (Ganster and Rosen, 2013). The central role of mental health was found in our study, with mental health mediating effects from four predictors of postdoc satisfaction. Thus, long-term postdocs in stressful environments may be vulnerable to both compromised health, including issues that can impact health across the lifespan, such as diabetes and other chronic diseases.

Results of the modeling revealed that postdoc satisfaction could be appropriately characterized according to the theory of intrinsic and extrinsic dimensions of satisfaction as described by Herzberg (1959, 2005) and Herzberg *et al.* (2011). Over half the variance in the intrinsic satisfaction factor was explained, with most of this predicted by the variety in skills training and encouragement by supervisors. However, this general satisfaction factor was also similarly predicted by non-academic goal preparation, the certainty of reaching the goal and mental health issues. By far, the best predictor of the outcome satisfaction construct for skills and training was the latent construct comprising quality ratings for research, teaching, management, communication and networking skills training. Davis (2009) found that two factors best explained satisfaction with the postdoctoral tenure: formal oversight and professional development, with structured oversight showing the most potential for improving postdoc satisfaction (Davis, 2009). While encouragement from supervisors predicted both the intrinsic and extrinsic factors, in our 2016 study, the quality of the training was the stronger predictor of job satisfaction.

Comparatively, just over a quarter of the variance in the extrinsic factor was explained, with predictors more equally spread across five variables. These results show that satisfaction with compensation was supported by more than the tangible predictors such as salary and benefits, but was also positively influenced by mental health issues, the variety of skills training, encouragement by supervisors and concern with professional issues. Support for this notion is also shown in our measurement model for the compensation satisfaction factor, where the work-life balance was found to associate with the satisfaction construct just as strongly as salary and benefits. Of concern in our findings is that according to Herzberg's (1959) dual-factor theory of job satisfaction, the low levels of satisfaction for compensation factors we observed could represent significant dissatisfaction with the postdoctoral training experience. In a study of German postdocs that investigated intention to abandon career goals, an effort-to-reward imbalance was shown to directly influence their intention of leaving academia and their profession (Dorenkamp and Weiß, 2018). In addition, as postdocs reported greater incongruence between their compensation and their work efforts there was a concomitant increase in work strain and a decrease in work satisfaction.

Conclusion

The results from our analysis suggest adjustments of guidelines for postdoctoral training are critically needed. With limited faculty positions, it may be prudent to encourage postdocs to use their skills in careers outside academia (e.g. government and industry). From our analysis, we suggest the following, recruit postdocs for careers supported by market demands so that postdocs can transition easily into the labor force once their training is complete. Similarly, stakeholders must encourage postdocs to pursue careers outside of academia through increased exposure to these career options during training. Increased support for current postdocs, for example, addressing the needs of the aging postdoc population by defining employment status, so that social support programs can be accessed, including 12-month parental leave. Countries should adopt a competitive salary scale including increases to accommodate inflation, and experience, similar to those in the UK and the USA. Our results indicate that managing expectations and mental health during postdoctoral tenures may bolster satisfaction with the postdoctoral training. The need to

manage the mental health of postdocs is exemplified by the link it provides between motivation and support from supervisors, career preparation and expectations, and certainty in reaching their career goal with satisfaction with career and training.

Worldwide, postdocs are an essential component of knowledge-based economies and drivers of research advancement and innovation. The lengthening of time in postdoctoral positions means that people are spending up to 10 years, and on average 6-8 years, in postdoctoral positions, making them not transitional jobs but positions in which it is relevant to examine job satisfaction and quality of life. The financial and work-life challenges faced by many postdocs limit the success of otherwise talented individuals. Thus, diversity in our future researchers is threatened, as shown by the many industries struggling to attract and retain a diverse workforce. Our study highlights the need for stakeholders such as university administrators and funders, to engage constructively with postdoc unions or other representatives to promote substantial improvements to the factors most affecting mental health, which include improving supervisor relationships and training and preparation for both industry and academic careers.

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