Jointly published by Akadémiai Kiadó, Budapest
and Springer, Dordrecht

Scientometrics, Vol. 72, No. 2 (2007) 307–323
DOI: 10.1007/s11192-007-1731-y

Direct interactions medical school faculty members have with professionals and managers working in public and private sector organizations: A cross-sectional study

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The research questions are as follows: to what extent do Canadian medical school faculty members have person-to-person interactions with individuals working in public and private sector organizations? What are the characteristics of Canadian medical school faculty members who interact with individuals working in these work settings? Are these different network patterns complementary or substitute? The data used for this study are from a cross-sectional survey of Canadian medical school faculty members (n = 907). Structural multivariate ordered probit models were estimated to explore the characteristics of faculty members with different network patterns and to see if these network patterns are complementary or substitute. Study results suggest that the different network patterns considered in the study are not conflicting, but that some patterns correspond to different faculty member profiles.

Introduction

The call for a better relationship between university, government and industry, which is implicit in the so-called "Triple Helix" paradigm (see LEYDESDORFF & MEYER, 2006), is particularly prominent in the health care sector, as illustrated by the recent emergence of the evidence-based medicine (SACKET & HAYNES, 1995), evidence-based management (AXELSON, 1998; WALSHE & RUNDALL, 2001) and

Received October 6, 2006

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0138–9130/US $ 20.00

evidence-informed policy-making (BLACK, 2001; LAVIS et al., 2004) movements. Indeed, the importance of and challenges associated with integrating academic research into clinical practice (GRIMSHAW et al., 2001; GROL & GRIMSHAW, 2003; LENFANT, 2003), as well as into decision-making at the level of health systems (BLACK, 2001; INNVAER et al., 2002; GRAY, 2004; LAVIS et al., 2004), are widely discussed in major medical journals. Various interventions have been proposed to stimulate the utilization of health research results by health care professionals (e.g., physicians, nurses) and health managers with decision-making roles at the level of health systems. Among the various propositions, the creation and maintenance of person-to-person interactions between health researchers *and* health care professionals and managers are surely the most popular these days. The Canadian Health Services Research Foundation (CHSRF) is an innovator in this matter as its portfolio of funding programs is clearly based on a vision of linkage & exchange (see LOMAS, 2000). For example, all research programs and projects funded by CHSRF involve both faculty members *and* managers or policymakers working in the health sector as principal or co-investigators. The rationale of this funding policy is to increase the prospects of research utilization in a context where interaction between researchers and health system managers and policymakers is the factor that has been found (through systematic reviews of observational studies) to be most consistently associated with the use of research in health systems management and policymaking (INNVAER et al., 2002; LAVIS et al., 2005).

One important outcome of direct interactions is the sharing of common understanding among individuals with different personal knowledge bases. Taking the foundationalist view described in METCALFE & RAMLOGAN (2005), it can be posited that "only individuals can know and what they know depends on perceptions, introspection, memory and inference, in short, experience allied with reason" (METCALFE & RAMLOGAN, 2005: 657). Consequently, private or personal knowledge is dependent on, but never identical with, the knowledge of others (Ibid., 658). Personal knowledge is never completely shared, but groups of individuals can occasionally share common understanding on subjects or issues. This is where direct interactions bring benefits by providing: i) the channel required to connect parts of previously disconnected private knowledge, and ii) the opportunities to share common understanding. According to METCALFE & RAMLOGAN (2005), "knowledge is always tacit" and information is the "more or less imperfect representation of knowledge that can be codified in symbolic form" (Ibid., 658). These conceptual clarifications allow us to point out that many empirical studies pertaining to research use in organizations focus on the uptake of scientific information codified in research reports, papers, chapters, books, patents or licenses, while fewer empirical studies relate to the sharing of common understanding among producers and potential users of research information and knowledge.

Sociological and psychological theories provide other explanations of the benefits of direct interactions between individuals. These theories suggest that the motivational foundation of social networks is two-fold (see KADUSHIN, 2002; BURT, 1987). First, one of the primary human activities is to seek out others in search of security, that is, individuals seek to interact with others to satisfy basic needs. Second, there is the quest for effectiveness that makes individuals seek out others to access resources or manipulate the flow of these resources in order to gain a competitive advantage (see BURT, 1992). Both situations, namely the search for security and the search for effectiveness, are "inherent human motivations and present in all social networks […]" (KADUSHIN, 2002: 84). Turning more specifically to faculty members, multiple reasons might motivate them to interact directly with professionals and managers working in non-academic settings. Gaining access to new ideas that could prove useful in developing research projects and scientific papers *and* securing extra funding are the most obvious payoffs, but others might also exist, such as gaining experience, acquiring additional confirmation of evaluation of a problem, and stimulating cross-fertilization (see LEE & BOZEMAN, 2005: 676 for a brief literature review of motives for collaboration).[1] The point is that faculty members are constantly under pressure to bring funding to their university or faculty and to present and publish scientific papers at conferences and in scholarly journals. Therefore, creating and maintaining direct interactions with professionals and managers working in non-academic settings might be justified for both professional security and effectiveness reasons. On the other hand, investing time and energy in interacting with professionals and managers could provide some disadvantages such as a reduction of time spent on research and on the scientific productivity level. These possible disadvantages are not negligible in a context where promotions within medical schools largely depend on research outputs.

Summing up, the direct interactions faculty members have with individuals working in non-academic organizations:

- have been proved effective in increasing the use of research knowledge in clinical practice, health systems' management and policy-making;
- provide opportunities to connect previously independent personal knowledge and to share common understanding; and
- are potentially positive contributors to faculty members' professional security and effectiveness.

[1] In interacting with health professionals and managers, faculty members can also access various kinds of information and knowledge. If codified knowledge (i.e., information) is partly accessible via information and communication technologies, personal knowledge such as skills or abilities to perform specific tasks (*know-how*) (see LUNDVALL & JOHNSON, 1994) is less likely to be codified, so an effective way for faculty members to acquire such knowledge is through person-to-person interactions with professionals and managers. These person-to-person interactions might also generate a strategic kind of knowledge (*know-who*), that is, knowledge involving information about who knows what and who knows what to do (see JOHNSON et al., 2002: 251).

An important contribution would therefore be to study the correlates of these interactions. Considering that there are different organizational environments in the health sector (i.e., ministries, regional health authorities, NGOs, hospitals, private firms), the question of what are the characteristics of faculty members who interact with these different environments is an interesting (but still unanswered) question. Furthermore, person-to-person interactions with people working in each of these organizational environments correspond to specific network patterns that could be either complementary or substitute. For example, faculty members who interact with people working in health ministries may or may not tend to interact with people working in pharmaceutical firms.

This exploratory study aims to address the following three questions: 1) to what extent do Canadian medical school faculty members have person-to-person interactions with individuals working in government departments, regional health authorities, hospitals, community-based health care organizations and private firms in the health sector? 2) What are the characteristics of Canadian medical school faculty members who interact with individuals working in these work settings? 3) Are these different interaction patterns complementary or substitute? To date, no empirical study has provided answers to these questions. This exploratory study aims to provide a first series of answers to these questions by reporting the results of a structural multivariate ordered probit model estimated using data from a cross-sectional survey of more than 900 Canadian medical school faculty members.

Data and methods

Participants and survey instrument

The study population consists of full, associate and assistant professors working in Canadian medical schools. Names and addresses were collected during the summer of 2000 from provincial registries of health researchers and from the websites of all Canadian medical schools. A random sample was selected, with stratification designed to ensure a regional distribution in line with the distribution of the Canadian population and the distribution of Canadian medical school revenues for biomedical and health care research. From the 1 727 faculty members that were contacted and included in the final sample, 10 asked to be interviewed later but were never reached again, 23 ended the call before the questionnaire had been completed, and 596 refused to participate (after a recall). The overall net response rate was 63.58%. The lowest response rate was in the province of Alberta (60.34%), while the highest was in Ontario (65.21%). Overall, the regional distribution of respondents is very close to what was originally targeted in the sampling strategy. The responses from the 120 Alberta researchers who were over-sampled and who were not medical school faculty members as well as the responses from the 71 participants who did not specify their professional status (full, associate and assistant professor) and their work setting were excluded from the analyses. As a consequence, responses from 907 faculty members were used in the analyses.

A questionnaire comprising close-ended questions was developed for this study. The questionnaire was adapted from an existing survey of Canadian social scientists (LANDRY et al., 2001). An advisory committee comprising health researchers, health care professionals, and health system managers and policymakers reviewed preliminary drafts of the questionnaire in order to ensure its comprehensibility. The survey was pre-tested and administered by telephone from December 2000 to February 2001 by a survey firm that uses computer-assisted telephone interviewing (CATI) technology, which allows for simultaneous data entry and data coding.

Data coding

There are five outcome variables considered in this study. These outcome variables capture the perceived frequency with which respondents had person-to-person interactions with professionals and managers working in government departments (1), regional health authorities (2), community-based health organizations (3), hospitals (4), and private firms in the health sector (5). These five ordinal variables were measured on 5-point adjectival scales, where 1 = *never*, 2 = *rarely*, 3 = *sometimes*, 4 = *often*, and 5 = *very often*. *Does not apply* answers were coded as *never* as we were mainly interested in whether and to what extent respondents interact with professionals and managers working in different non-academic work settings.

The exogenous variables considered in this exploratory study capture (1) different attributes of the research knowledge produced by the respondents (i.e., research focusing on improvements of services to patients, research focusing on cost reduction, applied research), (2) respondents' preferences for different types of research outputs (i.e., literature reviews, clinical guidelines, patents), (3) funding sources (i.e., government agencies, research councils, private firms or own organization), (4) organizational context (i.e., unit size, work setting(s) where research activities are conducted), and (5) individual attributes and activities (scientific productivity, involvement in clinical practice, academic rank, time spent on research and gender). The operational definition and descriptive statistics of these exogenous variables are presented in Table 1.

Table 1. Operational definitions and descriptive statistics for exogenous variables

Exogenous variables: Operational definition	Percentage	Mean (SD)
Attributes of the research knowledge produced		
• *Research focusing on improvements of services to patients*: 1 if the respondents were *agreed* or *strongly agreed* with the following proposition: The application of my research into the development of new or improved health services would improve services to patients (Likert scale: *strongly disagree, disagree, neither agree nor disagree, agree, strongly agree*)	65.9	
• *Research focusing on cost reductions:* 1 if the respondents were *agreed* or *strongly agreed* with the following proposition: The application of my research into the development of new or improved health services would allow health care organizations to reduce costs or labor (Likert scale: *strongly disagree, disagree, neither agree nor disagree, agree, strongly agree*)	41.3	
• *Applied research*: 1 if currently active in at least one of the following research domains: clinical research, health services research, health policy research, and/or population health research and 0 if currently active only in basic biomedical research and/or basic research in other disciplines	76.5	
Preferences for different types of research outputs: 1 if the respondents answered from *somewhat important* to *extremely important* to the following question: In terms of your professional satisfaction, what is the importance of… (adjectival scale: *does not apply, not important at all, somewhat important, moderately important, very important, extremely important*)		
• Literature reviews (including meta-analyses)	81.1	
• Clinical guidelines	43.1	
• Patents	45.0	
Funding source: 1 if the following sources were judged from *somewhat important* to *extremely important* for the successful completion of the respondents' projects in the last five years, and 0 if they were judged as *not important at all* (adjectival scale: *does not apply, not important at all, somewhat important, moderately important, very important, extremely important*)		
• *Internal (i.e., from within own organization)*	61.2	
• *Private firms*	49.6	
• *Governments*	55.6	
• *Research councils*	87.4	
Organizational context		
• *Conducting research in hospitals*: 1 if research was conducted in a hospital (solely or as well as in a university) and 0 if research was conducted solely in a university	35.3	
• *Unit size:* Current number of research personnel supported by the research grants and contracts in own unit		6.94 (10.31)
Individual attributes and activities		
• *Research productivity*: Total number of peer-reviewed books, book chapters and articles published over a five-year period		19.25 (16.45)
• *Practicing clinically*: 1 if at least one percent of time spent doing clinical practice and 0 otherwise	29.8	
• *Time spent on research*: Percentage of time spent on research		55.25 (24.24)
• *Associate professor*	34.4	
• *Assistant professor*	16.4	
• *Gender:* Female = 1, male = 0	20.6	

Analytical plan

The analytical plan contains three stages. Firstly, we calculated correlations among ordinal outcome variables to explore if interacting with people working in a specific organizational setting (i.e., a governmental department, a regional health authority, a hospital, etc.) is complementary to or substitute for interacting with people working in other settings. Secondly, we simultaneously estimated five ordered probit equations (i.e., by using Mplus 3.13, a structural equation-modeling package, see MUTHÉN & MUTHÉN, 1998–2004) to explore the correlates of the five interaction patterns considered in the study. We used the weighted least squares mean and variance adjusted (WLSMV) estimator[2] as it out-performed the more standard ADF-WLS estimator for small and medium samples (FLORA & CURRAN, 2004; GOLOB, 2003).[3] Each outcome variable, which corresponds to a specific interaction pattern (*INTER*), was measured by a 5-point ordinal variable. Therefore, all five equations correspond to ordered probit regressions:

$INTER^*_i = \beta x_i + \varepsilon_i$

where x_i is the vector of K explanatory variables for faculty member i and β is the vector of parameters to be estimated that indicate the effect of the K explanatory variables on $INTER^*$. ε_i is the error term for faculty member i assumed to be normally distributed with mean and variance normalized to 0 and 1 respectively. $INTER^*_i$ is a latent continuous variable underlying the ordered observed variable y_i where,

$y_i = 0$ if $INTER^*_i \le \tau_0$

$y_i = 1$ if $\tau_0 < INTER^*_i \le \tau_1$

$y_i = 2$ if $\tau_1 < INTER^*_i \le \tau_2$

$y_i = 3$ if $\tau_2 < INTER^*_i \le \tau_3$

where $\tau_{[0,1,2,3)}$ are 'threshold' parameters that provide information on the distribution of the ordinal variable y_i and are estimated altogether with the β parameters. An intercept

[2] For the cases where at least one outcome variable is categorical, the asymptotic covariance matrix for the vector of sample statistics S is estimated using the limited information likelihood approach of MUTHÉN (1984) and the weighted matrix W, which is formed as an estimate of S, is a diagonal matrix using the estimated variances of the S elements (see MUTHÉN et al., 1997). More technical details about the WLSMV estimator are provided in MUTHÉN (1998–2004: 17–20).

[3] A literature review of the different approaches that can be used to estimate multivariate probit models can be found in GOLOB (2003) and GOLOB & REGAN (2001). GOLOB & REGAN (2001) used the standard ADF-WLS estimator implemented in the LISREL package. We used the WLSMV estimator implemented in Mplus rather than the ADF-WLS estimator, because of the size of our sample. Simulation studies show than the WLSMV estimator yields robust and reliable estimates (MUTHÉN et al., 1997).

term is not needed because of the threshold parameters $\tau_{[0,1,2,3]}$ (see MUTHÉN, 1998–2004). The model is thus similar to univariate ordered probit models, except that it applies to five simultaneously estimated ordered probit equations with free error-term covariances.

Thirdly, the same model was estimated, but by fixing insignificant regression coefficients (i.e., those with P > 0.10, two-tailed) at 0. Unlike the first model, the second one can be assessed for model fit.[4] GOLOB & REGAN (2002: 217) recommend fixing insignificant parameters, as "saturated models are difficult to interpret, because statistically significant effects can be diminished due to multicolinearity with insignificant effects".

Results

Sample characteristics

Of the 907 respondents, 20.6% are female. About one half of the respondents were full professors (49.2%), while 34.4% and 16.4% of them were associate and assistant professors, respectively. Slightly more than one third of the respondents were conducting research in hospitals (35.3%) as opposed to conducting research exclusively on university campuses. Slightly less than one third of the respondents were practicing clinically (29.8%). On average, respondents were spending more than half of their time doing research (55.25%; SD 24.24%) and about seven research personnel (6.94; SD 10.31) were supported by their research grants and contracts. Of the 907 respondents, nearly three quarters (72.8%) were currently active in basic biomedical research. However, 76.5% of the respondents were engaged in applied research (as opposed to being solely engaged in basic biomedical and/or in other types of basic research). The respondents scored a median score of 4 (i.e., *agree*) on a 5-point Likert scale capturing their level of agreement with the statement suggesting that the application of their research results into new or improved health services would improve services to patients. The median score was also 4 (i.e., *agree*) for the statement suggesting that the application of their research results into new or improved health services would allow health care organizations to reduce costs or labour. As for respondents' preferences regarding certain types of research products, their median score was 3 (i.e., *moderately important*) on a five-point adjectival scale capturing the importance they granted to literature reviews (including meta-analyses), while this median score was 1 (i.e., *not important at all*) for both clinical guidelines and patents.

[4] Fixing parameters (i.e., insignificant parameters found in the first model) allows estimating the model with degrees of freedom. Saturated models like the one estimated in the first stage always fit perfectly as they typically have 0 degree of freedom. In other words, the fit of these models cannot be assessed.

Respondents produced an average of 19.25 (SD 16.45) publications over a five-year period. The two most productive faculty members had 100 publications. Of the 907 respondents, 29 had no publication and 25 had only one publication over a five-year period. Respondents produced an average of 16.07 articles (SD 14.25), 2.57 (SD 3.88) book chapters and 0.61 (SD 2.25) books. A large majority of the respondents (78.7%) had published no book at all.

Research councils constitute a particularly important source of funds for most participants. Indeed, their median score was 4 (i.e., *very important*) on a five-point adjectival scale capturing the perceived importance of funding from research councils for the successful completion of their projects in the last five years. However, their median score was 2 (i.e., *somewhat important*) on the five-point adjectival scales capturing their perceived importance of funding from their own organization, funding from ministries and government agencies, and funding from private firms.

Interactions with professionals and managers

The perceived frequency with which respondents had person-to-person interactions with professionals and managers was relatively low. From the five ordinal variables that were used to capture person-to-person interactions with professionals and managers working in different types of organizations, the following four had a median of 2 (i.e., *rarely*) on the 5-point adjectival scale: 1) professionals and managers working in government departments, 2) regional health authorities, 3) community-based health organizations, and 4) private firms in the health sector. For its part, the ordinal variable, corresponding to the perceived frequency with which respondents had person-to-person contacts with professionals and managers in hospitals, had a median of 3 (i.e., *sometimes*) on the 5-point adjectival scale.

Correlations among interaction patterns

Before estimating the structural multivariate ordered probit models, we calculated the correlations among the ordinal variables capturing person-to-person interactions with professionals and managers working in different settings.[5] As can be seen from Table 2, all interaction patterns are significantly and positively correlated, indicating that none of these patterns substitute for one another. However, some correlations are higher than others, suggesting the presence of bundles of interaction patterns. One

[5] As pointed out by XIE (1989: 330), JÖRESBORG & SÖRBOM (1984, 1986) recommend replacing Pearson moment correlations with polychoric correlations when testing the association between two ordinal variables. Mplus 3.13 estimates polychoric correlations by using the two-stage approach described by OLSSON (1979). The polychoric correlations listed in Table 2 are directly comparable measures of association between the frequency probabilities for pairs of interaction types.

bundle of interaction type is comprised of (1) government departments, (2) regional health authorities and (3) community-based health organizations, with the link between government departments and community-based organizations being the weakest. The high correlations for each pair of these interaction types indicate that if a faculty member interacts frequently with professionals and managers working in one type of organization, he or she typically interacts frequently with individuals working in all three types of organizations. Another bundle is comprised of (1) regional health authorities and (2) hospitals. Other correlations are from moderate to low, with the correlation between regional health authorities and private firms being the weakest. While being all statistically significant, the correlations involving interactions with individuals working in private firms are generally weak, with the correlation between interactions with individuals working in private firms and interactions with individuals working in hospitals being the strongest.

Table 2. Estimated polychoric correlations among interaction patterns (T statistics in parentheses)

	(1)	(2)	(3)	(4)
(1) Government departments				
(2) Regional health authorities	0.498•••			
	(19.971)			
(3) Hospitals	0.265•••	0.420•••		
	(8.421)	(14.542)		
(4) Community-based health	0.453•••	0.531•••	0.371•••	
organizations	(16.413)	(21.533)	(13.091)	
(5) Private firms	0.223•••	0.144•••	0.270•••	0.179•••
	(6.739)	(4.110)	(8.550)	(5.203)

• $p \leq 0.1$, •• $p \leq 0.05$, ••• $p \leq 0.01$, two-tailed.

Overall model fit, R-squares and error-term covariances

As mentioned in the previous section, the saturated structural multivariate ordered probit model estimated in the first stage could not be assessed for model fit as it typically has zero degree of freedom. We therefore only present the fit of the final model, which excludes the insignificant parameters found in the saturated model estimated in stage 1.[6] The final unsaturated multivariate ordered probit model had 31 degrees of freedom and an insignificant Chi-Square statistic of 24.731 (p = 0.779). The insignificant Chi-Square indicates that the final model has an excellent fit.

[6] It should be noted that an interesting aspect of the robust WLSMV estimator implemented in Mplus "is that the value for the model degrees of freedom is estimated from the empirical data…rather than being determined directly from the specification of the model" (FLORA & CURRAN, 2004: 470), as is the case with the more standard ADF-WLS method.

Table 3. Percent variance accounted for by different models

Endogenous variable	Estimated R^2	
	Final model	Saturated model
Government departments	0.178	0.176
Regional health authorities	0.211	0.233
Hospitals	0.317	0.325
Community-based health organizations	0.173	0.181
Private firms	0.189	0.203

The R^2 estimates are listed in Table 3 for both the saturated and the final multivariate ordered probit models. These R-squares refer to explained variance proportion in underlying continuous latent response variables. The differences in R^2 values between the final and the saturated model describe the reduction or the gain in explanatory power that comes from eliminating all exogenous variable effects that are not statistically significant (see GOLOB & REGAN, 2002). As can be seen, direct interactions with professionals and managers working in hospitals are the type of interaction that is the most effectively explained in both models.

The estimates of the error-term covariances of the final unsaturated structural model are listed in Table 4. All of the error-term covariances are significant at the $p = 0.05$ level.[7] The results listed in Table 4 indicate that the unexplained frequencies of all types of interactions are positively correlated with one another. The error-term covariances are all lower than the polychoric correlations listed in Table 2, which indicates that the final structural model explains a relatively good proportion of the relationships between interaction types (see GOLOB & REGAN, 2002). However, the model does a relatively poor job of explaining the relationships between (a) interactions with professionals and managers working in private firms and interactions with professionals and managers in regional health authorities, and between (b) interactions with professionals and managers working in private firms and interactions with professionals and managers in community-based health organizations.

Effects of the faculty members' characteristics

The estimated regression coefficients of the final model are presented in Table 5.[8] It can be seen that faculty members who believe that the application of their research

[7] We estimated the model by using the WLS estimator instead of the WLSMV estimator (that was used to get model estimates) in order to explore the contribution to model fit of estimating error-term covariances. When fixing the error-term covariances at 0, the model does not fit as the Chi-Square is significant at the 1% level (473.01; $p = 0.000$), while freeing the error-term covariances makes the model fit very well (40.99; $p = 0.471$). This result suggests that freeing error-term covariances better reflects the data.

[8] It must be recalled that these estimates were calculated through the use of the diagonally weighted least square (WLSMV) estimator implemented in Mplus 3.13 and that regression coefficients that were found to be insignificant in the saturated model were fixed at 0 in the final model. It must also be recalled that the estimates listed in Table 5 are similar to coefficients of univariate ordered probit models, except that they apply to five simultaneously estimated ordered probit models with free error-term covariances.

results into new or improved health services would allow health care organizations to reduce costs or labour are not more or less likely to have person-to-person interactions with professionals and managers working in any of the five types of organizations.

Table 4. Estimated error-term covariances for the final model (T statistics in parentheses)

	(1)	(2)	(3)	(4)
(1) Government departments				
(2) Regional health authorities	0.402•••			
	(14.243)			
(3) Hospitals	0.175•••	0.304•••		
	(5.176)	(9.025)		
(4) Community-based health	0.360•••	0.421•••	0.267•••	
organizations	(11.555)	(14.466)	(8.365)	
(5) Private firms	0.166•••	0.100•••	0.202•••	0.161•••
	(4.810)	(2.646)	(5.982)	(4.610)

• $p \leq 0.1$, •• $p \leq 0.05$, ••• $p \leq 0.01$, two-tailed.

The variable "focused on cost reduction" was therefore excluded from the final structural model presented in Table 5. Scientific productivity and funding from research councils are the two other variables that were found to have insignificant effects on all types of person-to-person interactions, so they were excluded from the final structural model as well.

Predictors of person-to-person interactions with professionals and managers working in *government departments* are: (a) conducting at least some applied research, (b) granting at least some importance to clinical guidelines, (c) receiving funding from government ministries or agencies (excluding research councils), (d) higher number of research personnel supported by research grants and contracts in own unit (unit size), and (e) lower proportion of time faculty spent on research.

Propensity to have person-to-person interactions with professionals and managers working in *regional health authorities* is predicted by: (a) the perception of faculty members that the application of their research results into new or improved health services would lead to improvements of services to patients, (b) conducting at least some applied research, (c) granting at least some importance to clinical guidelines and (d) to literature reviews (including meta-analyses), (e) granting no importance at all to patents, (f) receiving funding from government ministries or agencies (excluding research councils), and (g) lower proportion of time spent on research. It is interesting to note that direct interactions with professionals and managers working in *community-based health organizations* (NGOs) are predicted by exactly the same factors as the ones predicting interactions with professionals and managers in regional health authorities.

Table 5. Estimated effects of the medical school faculty members' characteristics

Exogenous variables	Interaction patterns				
	Government departments	Regional health authorities	Hospitals	Community-based health organizations	Private firms
Attributes of the knowledge produced					
Focused on improvements of services to patients		0.223 (2.366)••	0.198 (2.270)••	0.179 (1.981)••	
Focused on cost reduction*					
Applied research	0.460 (4.423)•••	0.288 (2.679)•••	0.440 (4.391)•••	0.454 (4.379)•••	0.228 (2.162)••
Preferences for different types of research outputs					
Literature reviews (including meta-analyses)		0.486 (4.715)•••		0.374 (3.627)•••	
Clinical guidelines	0.263 (2.978)•••	0.310 (3.325)•••	0.312 (3.311)•••	0.173 (1.924)••	0.161 (1.741)•
Patents		–0.322 (–3.875)•••		–0.220 (–2.630)•••	0.273 (3.371)•••
Funding sources					
Research councils*					
Governments	0.517 (6.482)•••	0.238 (2.923)•••		0.326 (4.045)•••	
Internal			0.204 (2.529)••		
Private firms					0.657 (8.090)•••
Organizational context					
Conducting research in hospitals			0.568 (5.997)•••		
Unit size‡	0.095 (3.413)•••				0.071 (2.408)••
Individual attributes & activities					
Scientific productivity‡*					
Practicing clinically			0.480 (4.340)•••		
Time spent on research	–0.006 (–3.331)•••	–0.009 (–5.017)•••	–0.003 (–1.789)•	–0.007 (–3.604)•••	
Associate professor					–0.177 (–2.108)••
Assistant professor					–0.088 (-0.780)
Gender (Female)					–0.221 (–2.206)••

Notes: T statistics are in parentheses. • $p \leq 0.1$, •• $p \leq 0.05$, ••• $p \leq 0.01$, two-tailed. Nonparametric Spearman correlations among exogenous variables were computed in order to identify potential collinearity problems. The highest correlation was between the variables *clinical guidelines* and *practicing clinically* (i.e., 0.451).
‡ = variables normalized by using a square root transformation.
* = variable excluded in step 2 as it was found to have an insignificant effect on the five types of interactions in the saturated structural multivariate ordered probit model estimated in step 1.

Direct interactions with professionals and managers working in *hospitals* are more frequent among faculty members who (a) believe that the application of their research results into new or improved health services would lead to improvements of services to patients, (b) conduct at least some applied research, (c) grant at least some importance to clinical guidelines, (d) receive funding from their own organization (i.e., internal funding), (e) conduct at least some of their research in a hospital, (f) practice clinically, and (g) spend less time on research.

Finally, medical school faculty members' interactions with professionals and managers working in *private firms* tend to (a) conduct at least some applied research, (b) grant at least some importance to clinical guidelines and (c) to patents, (d) receive funding from private firms, (e) to work in larger research units, (f) be full rather than associate professors, and (g) be male.

Discussion and conclusion

In this paper, we present a structural multivariate ordered probit model of person-to-person interactions that medical school faculty members have with professionals and managers working in different work settings. Data for the model were drawn from a 2000–2001 cross-sectional survey of more than 900 faculty members operating in Canadian medical schools.

The model predicts the perceived frequency with which faculty members with different characteristics have person-to-person interactions with different types of professionals and managers. The study results first suggest that medical school faculty members tend to have infrequent interactions with all types of professionals and managers considered in the study. The results also suggest that none of the network patterns considered in the study substitute for one another. Four network patterns were found to be relatively complementary, that is, interactions with professionals and managers in government departments, regional health authorities, hospitals and community-based health organizations, while person-to-person interactions with professionals and managers in private firms were found to be less complementary to, but not substitutes for, the other network patterns.

Other findings suggest that two characteristics are positively associated with all types of interaction patterns considered in this study: (1) not solely conducting basic research and (2) granting at least some importance to clinical practice guidelines. The second finding seems to converge with the results of a cross-sectional survey showing that clinical guidelines are not solely relevant for health care professionals working in health care facilities such as physicians and nurses, but also for health care managers working in other work settings (OUIMET et al., 2006). Study findings also suggest the existence of a negative association between the time faculty members invest in research and their propensity to have person-to-person interactions with professionals and managers working in government departments and agencies, regional health authorities, hospitals and community-based health organizations. However, the time invested in research does not seem to affect the propensity to network with professionals and managers working in private firms. It is also interesting to note that no statistical evidence was found regarding the potential conflict between the number of publications and the propensity to network with professionals and managers working in the five types of work settings. In other words, it was found that research productivity neither decreases nor increases the propensity to network with non-researchers.

Finally, study results suggest the existence of different faculty members' profiles. Faculty members with frequent person-to-person interactions with professionals and managers working in regional health authorities and faculty members with frequent person-to-person interactions with professionals and managers in community-based organizations seem to share the same overall characteristics. However, while sharing some characteristics with others, faculty members with frequent person-to-person interactions with professionals and managers working in private firms seem to have unique characteristics such as being male, being more experienced (i.e., full professor), being funded by private firms and granting importance to patents.

The main strengths of the study are how the complementarities among different network patterns and how the profiles of faculty members with these different network patterns were examined explicitly. The study's main weaknesses are its cross-sectional survey design and the fact that it did not control for all possible confounding variables (which preclude any statements about causality). Another limitation of this study is the 5-point relative frequency scales that were used to measure interactions respondents had with different health organizations. Using *absolute* frequency scales (e.g., *never*, *less than once a year*, *sometimes every year*, *at least once a month*, *at least once a week*, *at least once a day*) rather than *relative* ones (e.g., *never*, *rarely*, *sometimes, often, very often*) would have provided us with more precise information. Given that this study represents the first attempt to explore the complementarities among different networking strategies adopted by medical school faculty members, the findings cannot be put in the context of other research.

Further cross-sectional surveys of medical school faculty members are needed in order to multiply the number of observations so that systematic reviews or meta-analyses can be conducted on this subject. Research funders should also consider the feasibility of funding prospective or retrospective cohort studies of faculty members in which person-to-person interactions that medical school faculty members have with different non-academic audiences would be measured, along with other important features such as scientific productivity. Clearly, further research is needed to design and evaluate interventions that research councils and medical schools can employ to stimulate linkages and exchanges between medical school faculty members and professionals and managers working outside the scholarly community. Ultimately, all these interventions should be accompanied by rigorous experimental or quasi-experimental evaluation protocols aiming at measuring intervention effects on the creation and maintenance of linkage and exchange relationships.

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Mathieu Ouimet received financial support from the Agence de la santé et des services sociaux de la Montérégie (Longueuil, QC, Canada) as an non-tenure employee, and from the Canadian Health Services Research Foundation (CHSRF) and the Canadian Institutes of Health Research (CIHR) as a postdoctoral fellow conducting research on knowledge transfer and innovation. Réjean Landry receives salary support from the Canadian Health Services Research Foundation (CHSRF) and the Canadian Institutes of Health Research (CIHR) as the CHSRF-CIHR Chair on Knowledge Transfer and Innovation. John Lavis receives salary support as the Canada Research Chair in Knowledge Transfer and Exchange.

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