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Outcomes of the Northern Ontario School of Medicine's distributed medical education programs: protocol and description of participants in a longitudinal comparative multi-cohort study

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Abstract

Introduction The Northern Ontario School of Medicine (NOSM) has a social accountability mandate to serve the health care needs and diversity of the people of Northern Ontario, Canada. A multi-year, multi-method tracking study of medical students and postgraduate residents is being conducted by the Centre for Rural and Northern Health Research (CRaNHR) in conjunction with NOSM starting in 2005 when NOSM first enrolled students. The objective is to understand how NOSM's selection criteria and medical education programs set in rural and northern communities affect early career decision-making by physicians with respect to their choice of medical discipline, practice location, medical services and procedures, inclusion of medically underserved patient populations and practice structure.

Methods and Analysis: This prospective comparative longitudinal study follows multiple cohorts from entry into medical education programs at the undergraduate (UG) level (56-64 students per year at NOSM) or postgraduate (PG) level (40-60 residents per year at NOSM and 30-40 NOSM UGs who go to other schools for their residency training) and continues into independent practice.

The study compares learners who experience NOSM UG and NOSM PG education to those who experience NOSM UG education alone or NOSM PG education alone. Within these groups, the study also compares learners in family medicine to those in other specialties. Data will be analysed using descriptive statistics, chi-square tests, logistic regression, and hierarchical loglinear models.

Ethics and Dissemination

Ethical approval was granted by the Research Ethics Boards of Laurentian and Lakehead Universities. Results will be published in peer reviewed scientific journals, presented at one or more scientific conferences, and shared with policy and decision-makers and the public through 4-page research summaries and by social media.

Strengths and limitations of this study

- NOSM is one of a few medical schools in the world with an explicit social accountability mandate employing a distributed medical education model
- Study started with the opening of the medical school and includes all cohorts as they complete NOSM's UG or PG medical education programs.
- Longitudinal tracking allows learners' educational experience to be matched with intended and actual behaviours (e.g., intended versus actual medical discipline).
- Natural comparison groups are used to investigate the effect of NOSM admission criteria and educational experience.
- Because NOSM selects medical students with rural backgrounds, remaining variation in this attribute may be insufficient to predict outcomes. However, the study will assess the influence of other factors.
- Low response rates to surveys in some cohorts and groups, though data from overlapping surveys and administrative data will cover most gaps.
- Unknown confounders—a common limitation of any observational study.

Introduction

The Northern Ontario School of Medicine (NOSM) is a key initiative in the physician human resources plan of the Province of Ontario, Canada[1] and is an important strategy[2] to overcome the long running shortage of medical doctors (MDs) in Northern Ontario.[3,4,5] NOSM's mission statement includes a mandate to be socially "accountable to the needs and the diversity of the populations of Northern Ontario" and to actively involve the "Aboriginal, Francophone, remote, rural and underserviced communities" of Northern Ontario.[6] NOSM seeks to increase "the number of physicians and health professionals with the leadership, knowledge and skills to practice in Northern Ontario".

NOSM's approach is based on evidence that if medical schools select learners who have lived in underserved areas such as rural and Northern Ontario and train them in a positive manner in similar environments, then these learners are more likely to practice in these areas. This evidence comes from Canada,[7] Ontario,[8] Northern Ontario,[9,10] and systematic reviews.[11,12,13,14]

Northern Ontarians have poorer access to and lower use of medical care services than the rest of Ontario.[5,15,16] Northern Ontario has over 800,000 km^2 and a population density that averages 1 person/km^2 with approximately 56% of the population clustered in and around five urban areas ranging in size from 43,000 to 161,000 people.[17] The population includes two cultural-linguistic minority groups: Francophones represent 18% of Northern Ontarians versus 5% in the province and Aboriginal people represent 14% versus 2%, respectively.[18,19] People in Northern Ontario also have poorer health status than the rest of Ontario and the health status of Francophone and Aboriginal people is worse.[20,21,22,23]

The Centre for Rural and Northern Health Research (CRaNHR) in conjunction with NOSM and funded by the Ontario Ministry of Health and Long-Term Care (MOHLTC) has tracked learners since 2005, the year in which NOSM admitted its first cohort of undergraduate (UG) medical students.[24] The study's

objective is to understand how NOSM's socially accountable admission criteria and medical education programs set in rural and Northern Ontario communities affect choice of medical discipline, practice location, medical services and procedures, inclusion of medically underserved patient populations and practice structure (e.g., solo, interprofessional team).

This tracking study is unique as NOSM is one of a few medical schools in the world with an explicit social accountability mandate[25] and with medical education provided in communities away from large cities and regional hospitals.[24] There is emerging global interest in how well NOSM and similar schools can fulfil their mandates.[26,27] A second unique aspect is that the study started with the opening of the medical school and includes all cohorts as they complete NOSM's UG or PG medical education programs. Third, longitudinal tracking allows learners' educational experience to be matched with intended and actual behaviours (e.g., intended versus actual medical discipline). This is important as previous and ongoing research demonstrate the utility of longitudinal tracking studies.[28,29] A fourth unique aspect is the use of natural comparison groups to investigate the effect of NOSM admission criteria and educational experience. Groups are defined on three dimensions: (1) learners' medical school (i.e., NOSM versus other medical schools); (2) medical education level (i.e., UG versus PG); and (3) medical discipline (i.e., family medicine versus other specialties). Finally, in the absence of randomized trials, longitudinal cohort studies can gather evidence linking admission criteria, medical education and other factors to outcomes. This paper describes methods and compares study participants to non-participants for cohorts admitted in 2005–2013 to NOSM's UG program or in 2009–2013 to NOSM's PG program.

Methods and Analysis

Study Design, Participant Recruitment and Data Collection

This prospective comparative longitudinal study follows multiple cohorts from entry into NOSM's UG or PG programs and up to 5 years into independent practice. A purposive sampling strategy invites all NOSM UG and PG medical learners to participate. Every year, 56 undergraduate students are recruited (64 since 2010) and followed throughout their undergraduate education as well as into postgraduate residency, when they are joined by an additional 40-60 postgraduate residents who are new to NOSM. NOSM UG students are asked to participate at the first year orientation, end of second year and end of fourth year (**Figure 1**). NOSM PG residents are invited to participate during orientation and just prior to completion. NOSM UG students who go elsewhere for their PG residency training (30-40 residents per year go to other medical schools, already counted with NOSM UGs) are invited to continue their participation at entry and completion of residency. To summarize, the study tracks learners who finish their UG education and PG training at NOSM, only their UG at NOSM or only their PG at NOSM. These three groups are followed for residents who become family physicians or other specialists (combined) to yield six comparison groups.

CRaNHR researchers invite NOSM medical students, but not NOSM personnel, to a CRaNHR-sponsored meal, to explain the study and distribute the survey in paper or electronic format or by a web page link. Wherever possible, a similar event is organized for PG residents at NOSM. NOSM UGs who go elsewhere for their residency training are invited by email or mail to start or continue their participation in the study. All subsequent contact with participants is by email or mail. A modified tailored design method [30] is used for all surveys with at least two reminders, excepting those who have opted out. Each UG survey round lasts until all learners have responded or for 3 months, whichever comes first. PG

survey rounds last up to 4 months and are initiated throughout the year because of staggered starts and exits due to parental leave or extra training requirements for internationally trained doctors. As well as, contact information for residents at other medical schools can be difficult to obtain and so we send an invitation whenever we have updated contact information. Participants can complete an on-line questionnaire, electronic MS Word document or paper form. For each survey round, a draw is held for a $50 gift card from a national retail store as an incentive to participate.

During the UG entry survey, students are also invited to participate in short duration semi-structured interviews in their first year and again in their fourth year. Interviews are conducted face-to-face, by telephone or by Skype™, depending primarily on learner preference. All interviews are digitally recorded with the interviewee's permission and conducted by Dr. Hoi Cheu (CRaNHR Faculty Investigator) using a six question interview guide, with prompting questions as needed. Questions are shared at least one day prior to the interview. Interviewees are given an honorarium of a $25 gift card from a national retail store.

Data are extracted from administrative databases (e.g., medical school admissions data, medical licencing agencies registration data) for those outcomes not covered by survey or interview questions or to independently verify selected outcomes.

Exposure

NOSM's UG and PG admissions criteria and medical education programs comprise the exposure. NOSM serves as the Faculty of Medicine of Laurentian University in Sudbury (census metropolitan area population 161,000) and of Lakehead University in Thunder Bay (census metropolitan area population 122,000)—located 1,000 km apart by road. NOSM selects medical school applicants with a grade point average of ≥3.0/4.0 in science and non-science university degrees and does not require the Medical

College Admission Test® (MCAT®).[31] Preference is given to students from northern, rural, remote, Aboriginal or Francophone backgrounds so as to reflect Northern Ontario demographics. Learners must also have a strong interest in, understanding of and aptitude for practising medicine in Northern Ontario. NOSM provides medical learners with educational and clinical experiences in different health service settings in over 70 rural, remote and northern communities.[32] For instance, all first and second year medical students undertake an one month Integrated Community Experience in Northern Ontario Aboriginal and rural or remote communities. In the third year, all medical students complete an eight month Longitudinal Integrated Clerkship, based in family practice, and located in one of fifteen large rural or small urban communities in Northern Ontario, away from Sudbury or Thunder Bay. Similarly, NOSM's postgraduate residency programs combine learning at the regional hospitals in Sudbury and Thunder Bay with clinical rotations throughout rural and Northern Ontario. NOSM offers PG residency training in family medicine programs and in eight additional specialist programs.[33] All of this is designed to select learners from rural areas or who are aware of the health care needs of the rural underserved and have them learn from and be mentored by physicians who have chosen to live and practice in Northern Ontario so as to prepare learners for practices with fewer resources than in major population centres.

Research Questions, Study Outcomes and Explanatory Variables

Main research questions and key variables were derived from the literature with limited input from the funder (Ontario Ministry of Health and Long-Term Care). Questions and variables were outlined in a research framework adopted by the advisory committee, updated annually and critically reviewed in the 5th and 9th study year. The main research outcomes (**Table 1**) include:

- Clinical and organizational practice characteristics: medical discipline, medical services and procedures, patient population, practice organization (e.g., solo, interdisciplinary care team)

- Practice location: categorized by geographic region, population size/density and rural-urban continuum

Explanatory variables include:

- Learner traits: selected socio-economic and education demographic characteristics including rural or northern background and language/culture/ethnicity.
- Medical education: level (i.e., UG or PG), medical school (i.e., NOSM or other school)
- Influential factors: opportunity, personal, familial and societal imperatives that affect decision-making around the main outcomes.

Many study outcomes are collected first as intention and then as actual outcome (e.g., intended and actual medical discipline). Intended influential factors are those considered by the respondent as important prior to decision making and actual influential factors are those that respondents report in hindsight as having affected their decision.

Development and Assessment of Study Tools

Questionnaires were developed as the charter class progressed through their medical education: UG entry questionnaire and interview guide were developed in academic year 2005/2006; UG midway questionnaire in 2006/2007; and the UG exit questionnaire and interview guide in 2008/2009. The PG entry and exit surveys were developed in 2011/2012.

Operationalization of outcomes, linkages among independent and dependent variables as well as questions wording were based on the literature available when the study began,[11] informed by a workshop to evaluate the impact of medical education initiatives in Canada,[43] and updated with literature published as the study progressed.[12,13,14] To provide additional content validation and facilitate comparisons with other medical educational programs, most questions were based on similar

CRaNHR studies.[44,45,46] Other questions were based on the literature, including a block of questions to measure student attitudes on working and living in rural areas,[47] modified to the Canadian context and used with permission (Adams ME, Dollard J, Hollins J, Petkov J. 2005, personal communications). Questions from earlier studies were revised to reflect choices available to NOSM learners. NOSM undergraduate medical students, postgraduate residents and practising MDs (two of each and all located in Sudbury, Ontario) reviewed surveys. Interview questions inquired about selected key outcomes and related decision-making in greater detail.

Multiple data sources (e.g., surveys, interviews or administrative data) for several outcomes improved content validity and allowed checking of response consistency. Test-retest reliability of the questionnaires was not assessed because the research team judged that the likelihood of respondents remembering their answers would be too high over the short term and that answers to many questions would be expected to change in as little as a few months as respondents became immersed in NOSM's distributed medical education programs.

Dealing with Potential Bias in Surveys and Interviews

To reduce social desirability bias, CRaNHR researchers ensure that NOSM faculty or staff are absent during surveys or interviews. Learners are told that their responses would not affect their academic standing and that only aggregate data would be published or shared with NOSM and other stakeholders. Researchers seek to reduce non-response bias by providing multiple mediums (i.e., paper, electronic, or online surveys) for up to 3–6 months to facilitate participation at the learners' convenience. Recall bias may be an issue only for selected questions about the geographic location of where respondents or their spouses have lived previously. Researchers use administrative data to assess non-response and recall bias for selected demographic information.

Analytical Approach

Data comprise multiple measurements on individual learners generated from an (in)complete census of each cohort and therefore descriptive statistics or randomization tests are used to determine associations or group differences.[48,49] Chi-square tests, logistic regression, and hierarchical loglinear models will be the most frequently used statistical methods. Cohorts are stratified by medical school (i.e., NOSM vs other), education level (i.e., UG vs PG)and medical specialty (i.e., family medicine vs other specialties). The use of multiple imputation techniques to handle missing data will be considered in the context of the specific analytical method or research question. Every effort will be made to contact non-respondents, provided they have not explicitly declined to participate. Administrative data may be used to fill data gaps, as appropriate.

Interview transcripts and responses to open-ended questions are analysed using an iterative analytical and inductive approach to group findings within each question.[50] Transcripts and electronic recordings are re-examined to ensure that context is preserved and that confirmatory and contradictory findings are noted. Researchers' interpretations are distinguished from key informants' statements,[51] while anonymized quotes illustrate the scope and depth of groupings plus any exception.

Ethics and Dissemination

Ethical approval was granted by the Research Ethics Boards of Laurentian and Lakehead Universities commencing in 2005 and has been renewed annually or as new tools were produced. All data are stored on a secure server hosted by Laurentian University with access to individual-level data restricted to CRaNHR researchers directly involved in the study. CRaNHR shares only aggregated data (cell size >5) and follows other Statistics Canada guidelines to reduce identity, attribute or residual disclosure.[52]

Results will be published in peer reviewed scientific journals and presented at one or more scientific conferences. Research highlights will also be shared with policy and decision-makers and the public through 4-page reader-friendly summaries of research results ($^{\text{Research In}}$ FOCUS $_{\text{On Research}}$) and by social media.

Discussion

Response Rates

As of January 2014, complete surveys were received from 93% (500/537 students in 9 UG cohorts) 77% (310/405 students in 7 cohorts) and 82% (227/276 students in 5 cohorts) for the UG entry survey, midway and exit surveys were respectively. Response rates for 3 cohorts of PG residents were 62% (165/268) at entry survey and 34% (55/160) at exit. In January 2014 there were only 4 physician who had completed residency programs in other specialties and so the response rate at exit was determined by family practitioners.

Researchers conducted entry and exit interviews with 22% (61/281) and 12% (34/275), respectively, of NOSM's medical students from the first 5 cohorts. Twenty-seven respondents completed both UG interviews. Interviews lasted 6–58 minutes with a mean and median of 21 minutes.

Representativeness

Demographic characteristics of NOSM UG entry survey respondents were not significantly different ($p>0.07$) from non-respondents (**Table 2**). There were no significant differences between respondents and non-respondents for the midway or exit surveys ($p\geq0.06$, see Tables A and B in additional file). More entry interviewees than non-interviewees were Francophone ($p=0.05$, **Table 3**). At exit, interviewees were 2.1 years older than non-interviewees ($p=0.03$, see Table C in additional file).

A higher percentage of NOSM PG entry survey respondents than non-respondents were female (70% versus 60%, p=0.03) and married or partnered (66% versus 45%, p<0.01), while a lower percentage completed their UG medical degree at NOSM (56% versus 68%, p=0.01) (**Table 4**). At PG exit, more survey respondents than non-respondents completed their UG education at NOSM (75% versus 54%, p=0.02) (see Table D in additional file), opposite to what was detected for the PG entry survey. Overall, survey respondents and interviewees were largely representative of NOSM learners for UG cohorts, but with some differences for PG cohorts.

Limits and strengths of the approach

One limitation arises with assessing the exposure because NOSM selects medical students with rural or Northern Ontario backgrounds. Given that these characteristics are strongly associated with practice in rural areas, [7,8,11-14] there may not be much variation remaining among NOSM medical students to predict outcomes. However, the evidence for the influence of other factors, such as language/culture, on practice location is variable [13] and so the study will assess these influences. In addition, the tracking study is able to isolate the influence of different medical schools (i.e., NOSM vs. other) at different levels (i.e., UG vs PG) and for different medical disciplines (i.e., family medicine vs other specialties).

Small sample size limits some analyses given that there are 56 new UG students each year (64 since 2010) and lower numbers in PG programs, especially individual RCPSC specialties. Cohorts or groups will be combined to achieve adequate sample size, albeit at the loss of some detail, and confounded by low response rates.

While response rates for UG students are high, averaging 77–93% across UG surveys, average rates for PG residents drop from 62% at entry to 34% at exit. NOSM UGs who go to another medical school for residency training, particularly those who leave the province, may always have lower response rates as

they are more difficult to contact. To improve response rates, surveys have been streamlined to obtain information that is not otherwise available from administrative databases.

High response rates for UG students in conjunction with a lack of statistically significant differences for demographic characteristics between participants and non-participants suggest that results will be representative of NOSM's UG population. Differences in demographic characteristics between PG respondents and non-respondents combined with lower response rates, particularly as they exit the program, suggest that generalizability of findings will need to be examined carefully for the specific context. Nonetheless, response rates of residents at completion of residency (34%) exceed the response rate of the National Physician Survey (NPS) of Canadian residents (19%).[53]

Choice of outcome measures derived from medical care needs of Northern Ontario and situated in the political context may be interpreted as a limitation as well as a strength. Perhaps a more important limitation is that study outcomes (i.e., practice location and scope of practice) are proxies of the ultimate outcome—the health of Northern Ontarians. However, choice of proxy outcomes is reasonable given that NOSM is an important step in ensuring that there are sufficient numbers of skilled and locally trained MDs in Northern Ontario.[1,2] The expectation is that improved access to MDs will help improve the health of Northern Ontarians.

Other limitations include delays and gaps in execution of surveys. UG surveys and interviews have been on schedule since early 2006 (a 0.5 year delay), while PG surveys have been on schedule since 2012 (2 prior cohorts had incomplete coverage). Fortunately, missed PG entry surveys had near-temporal equivalents in the UG exit survey and so gaps exist only for PGs new to NOSM in 2009 and 2010. Changes in questions or response options create challenges for temporal continuity that is addressed by a detailed codebook that facilitates appropriate comparisons and provisos.

Study tools and methods are reviewed in-house, which increases internal utility, but may reduce external validity. Although there is no third-party review, many of the indicators and outcomes are copied or derived from the international literature. In addition, several advisory committee members are experts in rural or distributed medical education in Canada, USA and Australia and the study benefits accordingly.

Future Study

The tracking study will be integrated within a broader research program assessing the medical, social and economic impact of NOSM on Northern Ontario communities, building on previous research.[54] Detailed individual-level data allows for investigations into the relationship between specific aspects of NOSM's programs and medical education outcomes or socio-economic impacts. For instance, practice characteristics (e.g., medical discipline, geographic location) of medical students with science backgrounds could be compared to students with non-science backgrounds.[55] Other examples would be to compare performance and practice characteristics of students who had their third year clerkship in larger versus smaller communities (Ellaway RH, Graves L, personal communication, 2011) or to assess the effect of cultural safety training (Jacklin K, Maar M, personal communication, 2012). The integrated study will include investigations into NOSM's admission criteria and processes.

Conclusions

This paper describes a prospective comparative multi-cohort longitudinal study of NOSM undergraduate and postgraduate medical learners that tracks learners as they progress through medical education system beginning at admission into NOSM and up to five years after completion of residency training. The tracking study also serves as a platform upon which other research can improve understanding of the role of learner background and medical education experience on outcomes germane to the health

and well-being of people living in sparsely populated and medically underserved areas such as in Northern Ontario.

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Figure Caption

Figure 1. Flow of medical learners at the Northern Ontario School of Medicine (NOSM) and study participation.

Tables and Captions

Table 1. Primary Research Questions, Study Outcomes and Explanatory Variables

Research Question	**Outcome / Variable** [i]	**Categories (if any) & Definition**	**Data Sources**
Practice Characteristics Outcome Group			
Do NOSM medical learners practice in family medicine, generalist specialties such as paediatrics, general surgery, and internal medicine or other medical/surgical specialties or subspecialties?	Medical discipline or specialty	CFPC or RCPSC certification [ii, iii] Specialty within RCPSC (e.g., paediatrics) Specialties as defined by CFPC or RCPSC.	CRaNHR survey of medical learners/practitioners Medical regulatory agencies [iv]
What types of medical services and procedures will learners offer to their patients? (i.e., what will be their scope of practice?)	Types of services or procedures	CFPC certified MDs: 65 Procedure skills [34,35] 99 Priority Topics and Key Features for Assessment in Family Medicine [34]	Survey of MDs
		RCPSC certified MDs: Skills and procedures identified in "objectives of training" documentation for each Royal College specialty [36]	CRaNHR surveys

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
Will learners provide services to special populations such as Aboriginal and Francophone peoples or the Elderly?	Practice Languages	MD is able to practice medicine in specified language. Learners' cultural/linguistic background as proxy: Aboriginal learners [37]	CRaNHR surveys Medical regulatory agencies
		Francophone learners [38]	
	Cultural group or ethnicity of patient population	Adapted from criteria for learners	CRaNHR surveys Medical regulatory agencies OHIP or similar provincial health insurance plan data

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
	Age profile of patients	Actual age of patients	CRaNHR surveys Medical regulatory agencies OHIP or similar provincial health insurance plan data
How will learners organize their practices?	Practice administrative type	Solo, group practice, etc.	CRaNHR surveys Medical regulatory agencies
	Practice operational type	Independent practice, multidisciplinary practice, interdisciplinary practice, other	CRaNHR surveys Medical regulatory agencies
	Hospital privileges, on-call duties, emergency department (ED) coverage, etc.	Name and location of hospital at which the MD has privileges, provides on-call coverage, ED coverage, etc.	CRaNHR surveys Medical regulatory agencies

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
Practice Location Outcome Group			
Will learners practice in medically underserved regions such as those in rural and Northern Ontario?	Practice location – region	Geographic region Northern Ontario defined the 2003 boundaries of the 3 District Health Councils of Northern Ontario).[39] This area is 0.5% larger and has 7.5% more people than the 2015 provincial definition of Northern Ontario. The older definition represents NOSM's service area. Southern Ontario defined as other location in Ontario. Northern Canada defined by ministry of health of applicable province or territory.	CRaNHR surveys Medical regulatory agencies (or derived source such as CIHI's HHR database, Scott's medical database, etc.)

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
Will learners practice in the smaller communities?	Practice location – rural-urban continuum	Measures of rurality/medical underservice: Rural-urban classes based on Government classifications of population size, distance/commuter flow to urban centres, etc. [40,41] Rural Index of Ontario score [42]	CRaNHR surveys Medical regulatory agencies (or derived source such as CIHI's HHR database, Scott's medical database, etc.)
Explanatory Variables			
What is the effect of the selected demographic characteristics on outcomes listed above?	Socio-economic and demographic characteristics	Rural or northern background, culture/ethnicity, other demographic characteristics	MD surveys / interviews Medical school data
What is the effect of the medical education experience on outcomes listed above?	Educational experience	UG and PG medical education at NOSM or other medical school	MD surveys / interviews Medical school data

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
What are some of the other factors that influence the decisions listed above?	Influential factors	Factors such as, opportunity, personal, familial, and societal imperatives.	MD surveys / interviews

[i] The study measures intended and actual outcome/influential factor.

[ii] CFPC=College of Family Physicians of Canada specialty.

[iii] RCPSC=Royal College of Physicians and Surgeons of Canada specialty.

[iv] To the extent that such data are collected by this and other agencies

Table 2. Northern Ontario School of Medicine undergraduate study entry survey respondents compared to non-respondents.

For: 2005–2013 cohorts, N=537	**Respondents, n=500**	**Non-Respondents, n=37**	**Test for difference** [i]
Age at UG Entry: mean (standard deviation)	26.0 years (5.19) n=499	26.7 years (4.60) n=37	t=0.81, df=534, p=0.42
Female	68.7%, 343/499	54.1%, 20/37	X^2=3.40, p=0.07
Aboriginal [ii]	6.8%, 34/500	13.5%, 5/37	X^2=2.31, p=0.18
Francophone [ii]	21.2%, 106/500	24.3%, 9/37	X^2=0.20, p=0.68
From Northern Ontario [ii]	91.0%, 454/500	83.8%, 31/37	X^2=2.07, p=0.24
From Rural community in Northern Ontario [ii]	30.3%, 151/498	27.0%, 10/37	X^2=0.18, p=0.72
From rural community in other regions [ii]	8.8%, 41/466	11.1%, 4/36	X^2=0.22, p=0.76

[i] Study participants are compared to non-participating NOSM undergraduates at entry. Differences in age are analysed with a t-test and other characteristics are compared with Chi-squared (X^2) tests (df=1).

[ii] Refer to Table 1 for definitions.

Table 3. Northern Ontario School of Medicine undergraduate study entry interview participants compared to non-participants.

For: 2005–2013 cohorts, N=281	**Interviewees, n=61**	**Non-Interviewees, n=220**	**Test for difference** [i]
Age at UG Entry: mean (standard deviation)	26.9 years (5.43) n=61	26.6 years (5.51) n=219	t=0.33, df=278, p=0.74
Female	78.7%, 48/61	65.3%, 143/219	X^2=3.95, p=0.06
Aboriginal [ii]	4.9%, 3/61	7.7%, 17/220	X^2=0.57, p=0.58
Francophone [ii]	31.1%, 19/61	19.1%, 42/220	X^2=4.09, p=0.05
From Northern Ontario [ii]	90.2%, 55/61	88.1%, 193/219	X^2=0.20, p=0.82
From Rural community in Northern Ontario [ii]	32.8%, 20/61	30.1%, 66/219	X^2=0.16, p=0.75
From rural community in other regions [ii]	8.2%, 5/61	11.9%, 26/218	X^2=0.67, p=0.50

[i] Study participants are compared to non-participating NOSM undergraduates at entry. Differences in age are analysed with a t-test and other characteristics are compared with Chi-squared (X^2) tests (df=1).

[ii] Refer to Table 1 for definitions.

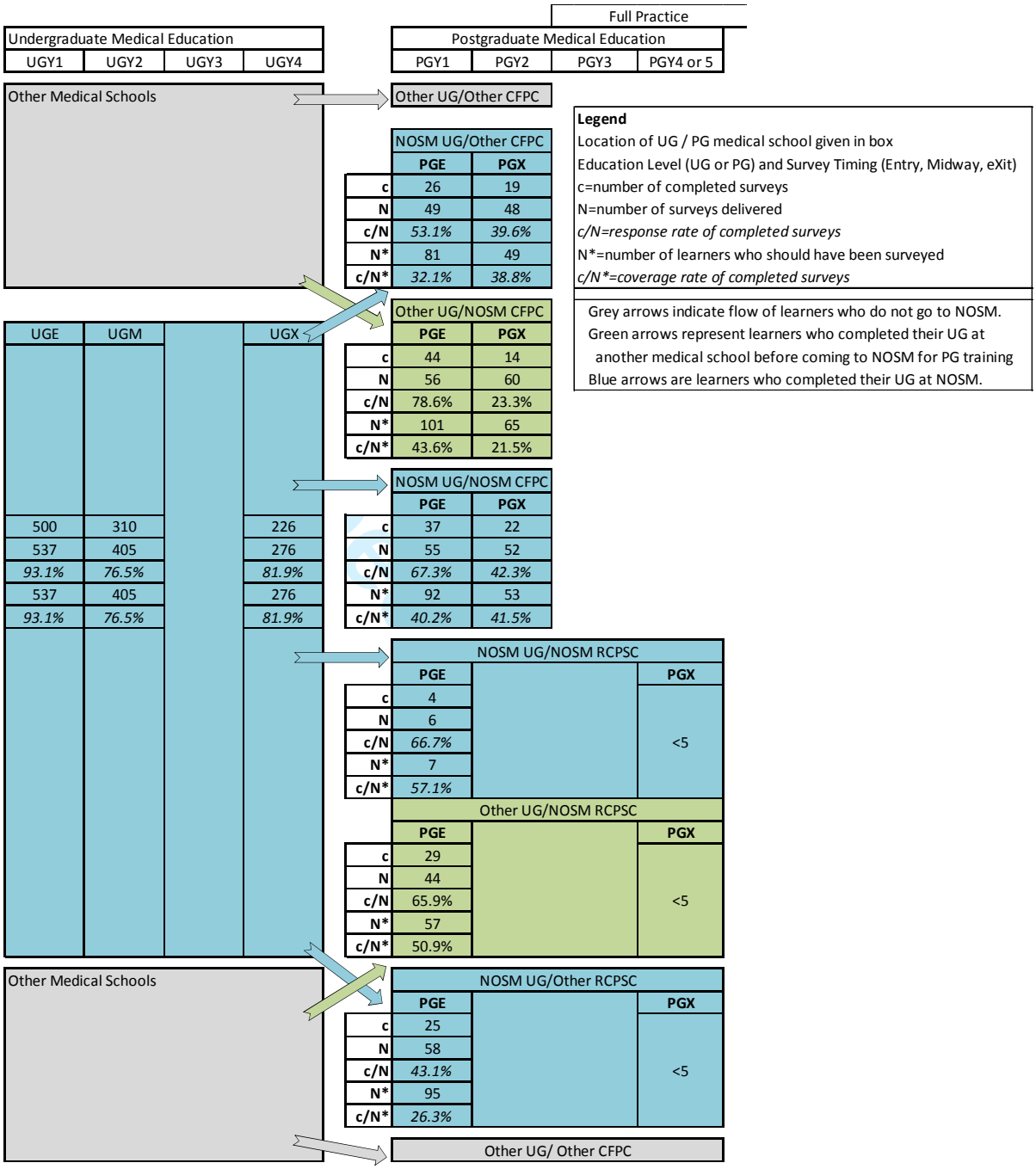
Table 4. Northern Ontario School of Medicine postgraduate entry survey respondents compared to non-respondents.

For 2009–2013 cohorts, N=433	Respondents, n=165	Non-respondents, n=268 [i]	Statistical Tests [ii]
Age at PG Entry: mean (standard deviation) [iii]	30.8 years (6.31) n=165	31.0 years (5.88) n=268	t=0.41, df=431, p=0.68
Female	69.7%, 115/165	59.7%, 154/258	X^2=4.35, p=0.04
Married / Partnered	66.1%, 109/165	45.3%, 115/254	X^2=17.37, p<0.01
Aboriginal background	6.7%, 11/165	9.5%, 18/189	X^2=0.96, p=0.34
Fluent in French	30.5%, 50/164	23.4%, 50/214	X^2=2.42, p=0.13
Canadian Citizen	94.5%, 156/165	97.8%, 262/268	X^2=3.16, p=0.10
NOSM UG	55.8%, 92/165	68.3%, 183/268	X^2=6.91, p=0.01
CFPC	64.8%, 107/165	62.3%, 167/268	X^2=0.28, p=0.61

[i] Non-respondents include 165 residents who did not receive a PG entry survey.

[ii] Study participants are compared to non-respondent postgraduates at entry. Differences in age are analysed with a t-test and other characteristics are compared with Chi-squared (X^2) tests (df=1).

[iii] Attributes are self-reported on surveys, medical school databases or regulatory agencies databases.



NOSM TS Methods paper-additional files

Additional files to accompany "Outcomes of the Northern Ontario School of Medicine's distributed medical education programs: protocol and description of participants in a longitudinal comparative multi-cohort study."

Table A. Northern Ontario School of Medicine undergraduate study midway survey participants compared with non-participants.

2005-2011 cohorts (N=405) [1]	**Survey Respondents (n=310)**	**Survey Non-Respondents (n=95)**	**Test for difference** [2]
Age at UG Entry: mean (standard deviation)	26.0 years (5.03) n=310	27.1 years (5.96) n=94	t=1.77, df=402, p=0.08
Female	66.8%, 207/310	70.2%, 66/94	X^2=0.39, p=0.62
Indigenous [3]	6.1%, 19/310	9.5%, 9/95	X^2=1.26, p=0.35
Francophone [3]	20.6%, 64/310	22.1%, 21/95	X^2=0.09, p=0.77
From Northern Ontario [3]	90.3%, 280/310	83.0%, 78/94	X^2=3.86, p=0.06
From rural community in Northern Ontario [3]	31.3%, 97/310	27.7%, 26/94	X^2=0.45, p=0.53
From rural community in other regions [3]	8.7%, 27/310	12.9%, 12/93	X^2=1.44, p=0.32

[1] Excludes 4 students who dropped out of medical school.

[2] Study participants are compared with non-participating NOSM undergraduates. Differences in age are analyzed with a t-test and other characteristics are analyzed with Chi-squared (X^2) tests (df=1).

[3] Refer to Table 1 for definitions.

Table B. Northern Ontario School of Medicine undergraduate study exit survey participants compared with non-participants.

2005-2009 cohorts, N=276 [1]	**Respondents, n=226**	**Non-Respondents, n=50**	**Test for difference** [2]
Age at UG Entry: mean (standard deviation)	26.4 years (5.25) n=226	27.4 years (6.24) n=49	t=1.12, df=273, p=0.26
Female	69.5%, 157/226	67.3%, 33/49	X^2=0.09, p=0.87
Indigenous [3]	6.2%, 14/226	12.0%, 6/50	X^2=2.05, p=0.22
Francophone [3]	23.0%, 52/226	14.0%, 7/50	X^2=1.98, p=0.19
From Northern Ontario [3]	89.8%, 203/226	81.6%, 40/49	X^2=2.63, p=0.14
From rural community in Northern Ontario [3]	31.4%, 71/226	32.7%, 16/49	X^2=0.03, p=1.00
From rural community in other regions [3]	11.1%, 25/226	12.5%, 6/48	X^2=0.08, p=0.80

[1] Excludes 4 students who dropped out of medical school.

[2] Study participants are compared with non-participating NOSM undergraduates. Differences in age are analyzed with a t-test and other characteristics are analyzed with Chi-squared (X^2) tests (df=1).

[3] Refer to Table 1 for definitions.

Table C. Northern Ontario School of Medicine undergraduate study exit survey Interviewees compared with non-interviewees.

2005-2009 cohorts, N=276	**Interviewees, n=34**	**Non-Interviewees, n=242**	**Test for difference [2]**
Age at UG Entry: mean (standard deviation)	28.5 years (6.85) n=34	26.4 years (5.18) n=240	t=2.14, df=272, p=0.03
Female	64.7%, 22/34	70.0%, 168/240	X^2=0.39, p=0.55
Indigenous [1]	0.0%, 0/34	8.3%, 20/241	X^2=3.04, p=0.15
Francophone [1]	17.6%, 6/34	21.6%, 52/241	X^2=0.28, p=0.66
From Northern Ontario [1]	97.1%, 33/34	87.1%, 209/240	X^2=2.87, p=0.15
From rural community in Northern Ontario [1]	35.3%, 12/34	30.8%, 74/240	X^2=0.28, p=0.69
From rural community in other regions [1]	2.9%, 1/34	12.6%, 30/239	X^2=2.73, p=0.15

[1] Refer to Table 1 for definitions.

[2] Study participants are compared with non-participating NOSM undergraduates. Differences in age are analyzed with a t-test and other characteristics are analyzed with Chi-squared (X^2) tests (df=1).

Table D. Northern Ontario School of Medicine CFPC postgraduate exit survey respondents compared with non-respondents.

For 2009–2011 PG cohorts (N=167)	Exit Survey Respondents (n=55)	Exit Survey Non-respondents (n=112)	Statistical Tests [1]
Age at PG Entry: mean (standard deviation) [2]	32.5 years (6.54) n=55	32.0 years (6.38) n=112	t=0.48, df=165, p=0.63
Female	63.6%, 35/55	56.8%, 63/111	X^2=0.72, p=0.41
Married / Partnered	58.2%, 32/55	55.0%, 60/109	X^2=0.15, p=0.74
Aboriginal background	9.1%, 5/55	13.8%, 9/ 65	X^2=0.65, p=0.57
Fluent in French	23.6%, 13/55	20.4%, 19/ 93	X^2=0.21, p=0.68
Canadian Citizen	96.4%, 53/55	96.4%, 108/112	X^2=0.00, p=1.00
NOSM UG	74.5%, 41/55	54.5%, 61/112	X^2=6.26, p=0.02

[1] Survey respondents are compared with non-respondent postgraduates. Differences in age are analyzed with a t-test and other characteristics are analyzed with Chi-squared (X^2) tests (df=1).

[2] Most attributes are self-reported on surveys or in databases held by medical schools or medical regulatory agencies.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8 Table 1
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	Not applicable as this is a census
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8 Table 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, explain how loss to follow-up was addressed	10
		(*e*) Describe any sensitivity analyses	pending

Section/Topic	Item #	Recommendation	Reported on page #
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Figure 1
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 2-4 Figure 1 shows different exposure groups
		(b) Indicate number of participants with missing data for each variable of interest	Table 2-4 Figure 1
		(c) Summarise follow-up time (eg, average and total amount)	5
Outcome data	15*	Report numbers of outcome events or summary measures over time	Not applicable for a protocol, pending
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pending
		(*b*) Report category boundaries when continuous variables were categorized	Pending
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Pending
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Pending
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12 & Pending
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Outcomes of the Northern Ontario School of Medicine's distributed medical education programs: protocol for a longitudinal comparative multi-cohort study

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ABSTRACT

Introduction The Northern Ontario School of Medicine (NOSM) has a social accountability mandate to serve the health care needs of the people of Northern Ontario, Canada. A multi-year, multi-method tracking study of medical students and postgraduate residents is being conducted by the Centre for Rural and Northern Health Research (CRaNHR) in conjunction with NOSM starting in 2005 when NOSM first enrolled students. The objective is to understand how NOSM's selection criteria and medical education programs set in rural and northern communities affect early career decision-making by physicians with respect to their choice of medical discipline, practice location, medical services and procedures, inclusion of medically underserved patient populations and practice structure.

Methods and Analysis: This prospective comparative longitudinal study follows multiple cohorts from entry into medical education programs at the undergraduate (UG) level (56-64 students per year at NOSM) or postgraduate (PG) level (40-60 residents per year at NOSM, including UGs from other medical schools and 30-40 NOSM UGs who go to other schools for their residency training) and continues at least 5 years into independent practice.

The study compares learners who experience NOSM UG and NOSM PG education to those who experience NOSM UG education alone or NOSM PG education alone. Within these groups, the study also compares learners in family medicine with those in other specialties. Data will be analysed using descriptive statistics, chi-square tests, logistic regression, and hierarchical loglinear models.

Ethics and Dissemination

Ethical approval was granted by the Research Ethics Boards of Laurentian University (REB #2010-08-03 and #2012-01-09) and Lakehead University (REB #031 11-12 Romeo File #1462056). Results will be published in peer reviewed scientific journals, presented at one or more scientific conferences, and

shared with policy and decision-makers and the public through 4-page research summaries and social media such as Twitter (@CRaNHR) or Facebook.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- NOSM is one of a few medical schools in the world with an explicit social accountability mandate employing a distributed medical education model
- Study started with the opening of the medical school in 2005 and includes all cohorts as they participate in NOSM's UG or PG medical education programs.
- Longitudinal tracking allows learners' educational experience to be matched with intended and actual behaviours (e.g., intended versus actual medical discipline) for at least 5 years into independent practice.
- Natural comparison groups are used to investigate the effect of NOSM admission criteria and educational experience.
- Because NOSM selects UG medical students with rural backgrounds, remaining variation in this attribute may be insufficient to predict outcomes. However, the study will assess the influence of other factors on UGs. However, PG learners have more varied background to enable analysis.
- Data from overlapping surveys and administrative data will cover most gaps arising from missed surveys or low survey response rates.
- Unknown confounders—a common limitation of any observational study.

INTRODUCTION

The Northern Ontario School of Medicine (NOSM), which first enrolled medical students in 2005, is a key initiative in the physician human resources plan of the Province of Ontario, Canada[1] and is an important strategy[2] to overcome the long running shortage of medical doctors (MDs) in Northern Ontario.[3-5] NOSM's mission statement includes a mandate to be socially "accountable to the needs and the diversity of the populations of Northern Ontario" and to actively involve the "Aboriginal, Francophone, remote, rural and underserviced communities" of Northern Ontario.[6] NOSM seeks to increase "the number of physicians and health professionals with the leadership, knowledge and skills to practice in Northern Ontario".

NOSM's approach is based on evidence that if medical schools select learners who have lived in underserved areas such as rural and Northern Ontario and train them in a positive manner in similar environments, then these learners are more likely to practice in these areas. This evidence comes from Canada,[7] Ontario,[8] Northern Ontario,[9,10] and is synthesized at the international level in several systematic reviews.[11-14]

Northern Ontario has over 800,000 km^2, an area larger than France, and a population density that averages 1 person/km^2 with approximately 56% of the population clustered in and around five of the larger urban areas (Timmins, North Bay, Sault Ste. Marie, Thunder Bay and Greater Sudbury), which range in size from 43,000 to 161,000 people.[15] Northern Ontario includes a larger proportion of two cultural-linguistic minority groups than the province as a whole. Francophones represent 18% of Northern Ontarians versus 5% in the province and Aboriginal people represent 14% versus 2%, respectively.[16,17] Northern Ontarians have poorer access to and lower use of medical care services than the rest of Ontario.[5,18,19] People in Northern Ontario also have poorer health status than the rest of Ontario and the health status of Francophone and Aboriginal people is worse.[20-23]

The Centre for Rural and Northern Health Research (CRaNHR) in conjunction with NOSM and funded by the Ontario Ministry of Health and Long-Term Care (MOHLTC) has tracked learners since 2005, the year in which NOSM admitted its first cohort of undergraduate (UG) medical students.[24] The study's objective is to understand how NOSM's socially accountable admission criteria and medical education programs set in rural and Northern Ontario communities affect choice of medical discipline, practice location, medical services and procedures, inclusion of medically underserved patient populations and practice structure (e.g., solo, interprofessional team).

This tracking study is unique as NOSM is one of a few medical schools in the world with an explicit social accountability mandate[25] and with medical education provided in communities away from large cities and regional hospitals.[24] There is emerging global interest in how well NOSM and similar schools can fulfil their mandates.[26,27] For example, the Training for Health Equity Network (THEnet) is a worldwide movement of schools committed to improving health equity by transforming education of health professionals.[26] Eleven schools in nine countries are committed to measuring how well they match educational outcomes to the needs of the areas they serve.[28] A second unique aspect is that the study started with the opening of the medical school and includes all cohorts as they participate in NOSM's UG or postgraduate (PG) medical education programs. Third, longitudinal tracking allows learners' educational experience to be matched with intended and actual behaviours (e.g., intended versus actual medical discipline) as learners are tracked from the time of their arrival at NOSM and continuing for at least 5 years into independent practice. This is important as previous and ongoing research demonstrate the utility of longitudinal tracking studies linking admission criteria, medical education and other factors to outcomes.[29,30] A strength of the study resides in the use of natural comparison groups to investigate the effect of NOSM admission criteria and educational experience. Six groups are defined on three dimensions: (1) learners' medical school (i.e., NOSM versus other medical schools); (2) medical

education level (i.e., UG versus PG); and (3) medical discipline (i.e., family medicine versus other specialties). This paper describes methods developed since the study started in 2005.

METHODS AND ANALYSIS

Study Design, Participant Recruitment and Data Collection

All learners are tracked through administrative databases (e.g., medical school admissions and educational programs databases, medical licencing agencies registration databases), which provide basic demographic data (e.g., **Table 1**), details of the learners educational experience at NOSM and selected information on outcomes (e.g., provincial health insurance (billing) databases). Additional demographic data as well as the learner's perspective on factors that influence key outcomes plus detailed information on the outcomes are obtained by surveys or interviews.

This prospective comparative longitudinal study follows multiple cohorts from entry into NOSM's UG or PG programs and at least 5 years into independent (fully qualified) practice. A purposive sampling strategy invites all NOSM UG and PG medical learners to voluntarily participate in surveys or interviews. Every year, 56 undergraduate students (64 since 2010) are tracked throughout their undergraduate education as well as into postgraduate residency, when they are joined by an additional 40-60 postgraduate residents who are new to NOSM. NOSM UG students are asked to participate in surveys and interviews at the first year orientation, end of second year and end of fourth year (**Figure 1**). NOSM PG residents are invited to participate in surveys during orientation and just prior to completion. NOSM UG students who go elsewhere for their PG residency training (30-40 residents per year go to other medical schools for PG training, included in the count of NOSM UGs) are invited to continue their participation in surveys at entry and completion of their residency. To summarize, the study tracks learners who finish (1) their UG education and PG training at NOSM, (2) only their UG at NOSM and go to other schools to complete their PG training or (3) only their PG at NOSM having completed their UG

medical education at other schools. These three groups are followed for residents who become family physicians or other specialists (combined) to yield six groups for comparison.

CRaNHR researchers invite NOSM medical students, but not NOSM personnel, to a CRaNHR-sponsored meal, to explain the study and distribute the survey in paper or electronic format or by a web page link. Wherever possible, a similar event is organized for PG residents at NOSM. NOSM UGs who go elsewhere for their residency training are invited by email or mail to start or continue their participation in the study. All subsequent contact with participants is by email or mail. A modified tailored design method [31] is used for all surveys with at least two reminders, excepting those who have opted out. Each UG survey round lasts until all learners have responded or for 3 months, whichever comes first. PG survey rounds last up to 4 months and are initiated throughout the year because of staggered starts and exits due to parental leave or extra training requirements for internationally trained medical graduates. As well as, contact information for residents at other medical schools can be difficult to obtain and so we send an invitation whenever we have updated contact information. Participants can complete an on-line questionnaire, electronic MS Word document or paper form. For each survey round, a draw is held for a $50 CAD gift card from a national retail store as an incentive to participate.

During the UG entry survey, students in the first 5 years were also invited to participate in short duration semi-structured interviews in their first year and again in their fourth year. Interviews were conducted face-to-face, by telephone or by Skype™, depending primarily on learner preference. All interviews were digitally recorded with the interviewee's permission and conducted by Dr. Hoi Cheu (CRaNHR Faculty Investigator) using a six question interview guide, with prompting questions as needed. Questions were shared at least one day prior to the interview. Interviewees were given an honorarium of a $25 CAD gift card from a national retail store.

Exposure

NOSM's UG and PG admissions criteria and medical education programs comprise the exposure. NOSM serves as the Faculty of Medicine of Laurentian University in Sudbury (2011 census metropolitan area population 161,000) and of Lakehead University in Thunder Bay (2011 census metropolitan area population 122,000)—located 1,000 km apart by road. NOSM selects medical school (undergraduate) applicants with a grade point average (GPA) of ≥3.0 out of 4.0 in science and non-science university degrees and does not require the Medical College Admission Test® (MCAT®).[32] Mean GPA was 3.8 for NOSM students starting in 2015 and this falls within the 3.7 – 3.9 range for all other Canadian medical schools.[33] Preference is given to students from northern, rural, remote, Aboriginal or Francophone backgrounds so as to reflect Northern Ontario demographics. Learners must also have a strong interest in, understanding of and aptitude for practising medicine in Northern Ontario. NOSM provides medical learners with educational and clinical experiences in different health service settings in over 90 rural, remote and northern communities.[34,35] For instance, all first and second year medical students undertake a one month Integrated Community Experience in Northern Ontario Aboriginal and rural or remote communities. In third year, all medical students complete an eight month Longitudinal Integrated Clerkship, based in family practice, and located in one of fifteen large rural or small urban communities in Northern Ontario, away from Sudbury or Thunder Bay. Similarly, NOSM's postgraduate residency programs combine learning at the regional hospitals in Sudbury and Thunder Bay with clinical rotations throughout rural and Northern Ontario. NOSM offers PG residency training in family medicine and in eight additional specialist programs.[36] All of this is designed to select learners from rural areas or who are aware of the health care needs of the rural underserved and enable learners to be trained and mentored by physicians who have chosen to live and practice in Northern Ontario so as to prepare learners for practices with fewer resources than in major population centres.

Research Questions, Study Outcomes and Explanatory Variables

Main research questions and key variables were derived from the literature with selected input from the funder (Ontario Ministry of Health and Long-Term Care). Questions and variables were outlined in a research framework adopted by the advisory committee, updated annually and critically reviewed in the 5th and 9th study year. All tools and methods are being reviewed in 2015—the 11th study year. The main research outcomes (**Table 2**) include:

- Clinical and organizational practice characteristics: medical discipline, medical services and procedures, patient population, practice organization (e.g., solo, interprofessional care team)
- Practice location: categorized by geographic region, population size/density and rural-urban continuum

Explanatory variables include:

- Learner traits: selected socio-economic and education demographic characteristics including rural or northern background and language/culture/ethnicity.
- Medical education: level (i.e., UG or PG) and medical school (i.e., NOSM or other school)
- Influential factors: opportunity, personal, familial and societal imperatives that affect decision-making around the main outcomes.

Many study outcomes are collected first as intention and then as actual outcome (e.g., intended and actual medical discipline). Intended influential factors are those considered by the respondent as important prior to decision making and actual influential factors are those that respondents report in hindsight as having affected their decision.

Development and Assessment of Study Tools

Tools to extract administrative data, questionnaires and interview guides were developed as the charter class progressed through their medical education: UG entry questionnaire and interview guide were

developed in academic year 2005/2006; UG midway questionnaire in 2006/2007; and the UG exit questionnaire and interview guide in 2008/2009. PG residents were tracked since 2009 using administrative data. However, funding delays meant that the PG entry and exit surveys were not developed until 2011/2012. Measures to fill this data gap are described in the section on limits and strengths.

Operationalization of outcomes, linkages among independent and dependent variables as well as question wording were based on the literature available when the study began,[11] informed by a workshop to evaluate the impact of medical education initiatives in Canada,[46] and updated with literature published as the study progressed.[12-14] To provide additional content validation and facilitate comparisons with other medical educational programs, most questions were based on similar CRaNHR studies.[47-49] Other questions were based on the literature, including a block of questions to measure student attitudes on working and living in rural areas,[50] modified to the Canadian context and used with permission (Adams ME, Dollard J, Hollins J, Petkov J. 2005, personal communications). Questions from earlier studies were revised to reflect choices available to NOSM learners. NOSM undergraduate medical students, postgraduate residents and practising MDs (two of each and all located in Sudbury, Ontario) reviewed surveys for content validity and readability. Interview questions inquire about selected key outcomes and related decision-making in greater detail.

Multiple data sources (e.g., surveys, interviews or administrative data) for several outcomes improved content validity and allowed checking of response consistency. Test-retest reliability of the questionnaires was not assessed because the research team judged that the likelihood of respondents remembering their answers would be too high over the short term and that answers to many questions would be expected to change in as little as a few months as respondents became immersed in NOSM's distributed medical education programs.

Dealing with Potential Bias in Surveys and Interviews

To reduce social desirability bias, CRaNHR researchers ensure that NOSM faculty or staff are absent during surveys or interviews. Learners are told that their responses would not affect their academic standing and that only aggregate data would be published or shared with NOSM and other stakeholders. Researchers seek to reduce non-response bias by providing multiple mediums (i.e., paper, electronic, or online surveys) for up to 3–6 months to facilitate participation at the learners' convenience. Recall bias may be an issue only for selected questions about the geographic location of where respondents or their spouses have lived previously. Researchers use administrative data to assess non-response and recall bias for selected information on demographics and outcomes.

Analytical Approach

Data comprise multiple measurements on individual learners generated from an (in)complete census of each cohort and therefore descriptive statistics or randomization tests will be used to determine associations or group differences.[51,52] Chi-square tests, logistic regression, and hierarchical loglinear models will be the most frequently used statistical methods. Cohorts are stratified by medical school (i.e., NOSM vs other), education level (i.e., UG vs PG) and medical specialty (i.e., family medicine vs other specialties). The use of multiple imputation techniques to handle missing data will be considered in the context of the specific analytical method or research question. Every effort will be made to contact non-respondents, provided they have not explicitly declined to participate. Administrative data are used to track learners, obtain basic demographic information, details of the learners' NOSM education experience as well as selected outcomes, while surveys and interviews allow for collection of more detailed data.

Interview transcripts and responses to open-ended questions were analysed using an iterative analytical and inductive approach to group findings within each question.[53] Transcripts and electronic recordings

were re-examined to ensure that context is preserved and that confirmatory and contradictory findings were noted. Researchers' interpretations were distinguished from key informants' statements,[54] while anonymized quotes illustrated the scope and depth of groupings plus exceptions, if any.

Ethics and Dissemination

Ethical approval was granted by the Research Ethics Boards of Laurentian University (REB #2010-08-03 and #2012-01-09) and Lakehead University (REB #031 11-12 Romeo File #1462056) commencing in 2005 and has been renewed annually or as new tools were produced. All data are stored on a secure server hosted by Laurentian University with access to individual-level data restricted to CRaNHR researchers directly involved in the study. CRaNHR shares only aggregated data (cell size >5) with NOSM personnel or other stakeholder and researchers, and follows other Statistics Canada guidelines to reduce identity, attribute or residual disclosure.[55]

Results will be published in peer reviewed scientific journals and presented at one or more scientific conferences. Research highlights will also be shared with policy and decision-makers and the public through 4-page reader-friendly summaries of research results (Research In FOCUS On Research) and by social media such as Facebook (www.facebook.com/cranhr) and Twitter (@CRaNHR and researchers' accounts).

Limits and strengths of the approach

One limitation arises in assessing the exposure because NOSM selects undergraduate medical students (but not necessarily postgraduate learners) with rural or northern Canada backgrounds. Given that rural background is strongly associated with practice in rural areas, [7,8,11-14]there may not be much variation remaining among NOSM medical students to predict outcomes such as rural practice location. However, the evidence for the influence of other factors, such as northern Canada background, language/culture, gender or marital/partnership status, on outcomes such as medical discipline and practice location

varies among contemporary studies[11-14] and may be evolving over time and so the study will assess these influences. In addition, the tracking study is able to isolate the influence of different medical schools (i.e., NOSM vs. other) at different levels (i.e., UG vs PG) and for different medical disciplines (i.e., family medicine vs other specialties).

Small population size may limit some analyses given that there are 56 new UG students each year (64 since 2010) and lower numbers in some PG programs, especially specialties other than family medicine. Groups may be combined to achieve adequate numbers for analysis, albeit at the loss of some detail.

Choice of outcome measures derived from medical care needs of Northern Ontario and situated in the political context may be interpreted as a limitation as well as a strength. Perhaps a more important limitation is that study outcomes (i.e., practice location and scope of practice) are proxies of the ultimate outcome—the health of Northern Ontarians. However, choice of proxy outcomes is reasonable given that NOSM is an important step in ensuring that there are sufficient numbers of skilled and locally trained MDs in Northern Ontario.[1,2] The expectation is that improved access to MDs will help improve the health of Northern Ontarians.

Other limitations include delays and gaps in execution of surveys. UG surveys and interviews have been on schedule since early 2006 (a 6 month delay), while PG surveys have been on schedule since 2012 (2 prior cohorts had incomplete coverage). Fortunately, administrative data is available from NOSM and missed PG entry surveys had near-temporal equivalents in the UG exit survey and so gaps in survey coverage exist only for PGs new to NOSM in 2009 and 2010. Changes in the wording of questions or response options create challenges for temporal continuity that are addressed by a detailed codebook that facilitates appropriate comparisons and provisos.

Study tools and methods are reviewed in-house, which increases internal utility, but may reduce external validity. Although there is no third-party review, many of the indicators and outcomes are

copied or derived from the international literature. In addition, several advisory committee members are experts in rural or distributed medical education in Canada, USA and Australia and the study benefits accordingly.

Future Study

The tracking study will be integrated within a broader research program assessing the medical, social and economic impact of NOSM on Northern Ontario communities, building on previous research.[56] Detailed individual-level data allows for investigations into the relationship between specific aspects of NOSM's programs and medical education outcomes or socio-economic impacts. For instance, practice characteristics (e.g., medical discipline, geographic location) of medical students with science backgrounds could be compared to students with non-science backgrounds.[57] Other examples would be to compare performance and practice characteristics of students who had their third year clerkship in larger versus smaller communities (Ellaway RH, Graves L, personal communication, 2011) or to assess the effect of cultural safety training (Jacklin K, Maar M, personal communication, 2012). The integrated study will include investigations into NOSM's admission criteria and processes.

CONCLUSION

This paper describes a prospective comparative multi-cohort longitudinal study of NOSM undergraduate and postgraduate medical learners that tracks learners as they progress through medical education system beginning at admission into NOSM and at least five years into independent practice. The tracking study also serves as a platform upon which other research can improve understanding of the role of learner background and medical education experience on outcomes germane to the health and well-being of people living in sparsely populated and medically underserved areas such as Northern Ontario.

Table 1. Demographic characteristics of Northern Ontario School of Medicine undergraduate medical students and postgraduate residents.

Characteristic [i]	**2005–2013 UG cohorts**	**2009–2013 PG cohorts** [ii]
Age at Entry: mean (standard deviation)	26.0 years (5.15) n=537	30.9 (6.04), n=433
Female	67.6%, 363/537	63.6%, 269/423
Aboriginal	7.3%, 39/537	8.2%, 29/355
Francophone	21.6%, 116/537	26.5%, 100/378
From Northern Ontario	90.5%, 486/537	
From Rural community in Northern Ontario	30.0%, 162/537	
From Rural community in other regions	8.6%, 46/537	
Married Partnered		53.2%, 223/419
Canadian Citizen		96.5%, 418/433
NOSM UG		63.7%, 276/433
Family Medicine		63.0%, 273/433

[i] Refer to Table 2 for definitions. Data reported above are based on NOSM's administrative records.

[ii] Includes learners who completed their UG at NOSM or at other medical schools.

Table 2. Primary Research Questions, Study Outcomes and Explanatory Variables

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
Practice Characteristics Outcome Group			
Do NOSM medical learners practice in family medicine, generalist specialties such as paediatrics, general surgery, and internal medicine or other medical/surgical specialties or subspecialties?	Medical discipline or specialty	College of Family Physicians of Canada (CFPC) or Royal College of Physicians and Surgeons of Canada (RCPSC) certification Specialty within RCPSC (e.g., paediatrics) Specialties as defined by CFPC or RCPSC.	[ii, iii, iv]
What types of medical services and procedures will learners offer to their patients? (i.e., what will be their scope of practice?)	Types of services or procedures	CFPC certified MDs: 65 Procedure skills [37,38] 99 Priority Topics and Key Features for Assessment in Family Medicine [37]	[ii, iv, v]

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
		RCPSC certified MDs: Skills and procedures identified in "objectives of training" documentation for each Royal College specialty [39]	ii, iv
Will learners provide services to special populations such as Aboriginal and Francophone peoples or the Elderly?	Practice Languages	MD is able to practice medicine in specified language. Learners' cultural/linguistic background as proxy: Aboriginal learners [40] Francophone learners [41]	ii, iv
	Cultural group or ethnicity of patient population	Adapted from criteria for learners	ii, iv, v
	Age profile of patients	Actual age of patients	ii, iv, v
How will learners organize their practices?	Practice administrative type	Solo, group practice, etc.	ii, iv

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
	Practice operational type	Independent practice, interprofessional care teams, other	[ii, iv]
	Hospital privileges, on-call duties, emergency department (ED) coverage, etc.	Name and location of hospital at which the MD has privileges, provides on-call coverage, ED coverage, etc.	[ii, iv]
Practice Location Outcome Group			

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
Will learners practice in medically underserved regions such as those in rural and Northern Ontario?	Practice location – region	Geographic region Northern Ontario defined the 2003 boundaries of the 3 District Health Councils of Northern Ontario).[42] This area is 0.5% larger and has 7.5% more people than the 2015 provincial definition of Northern Ontario. The older definition represents NOSM's service area. Southern Ontario defined as other location in Ontario. Northern Canada defined by ministry of health of applicable province or territory.	[ii, iv, v]

Research Question	Outcome / Variable [i]	Categories (if any) & Definition	Data Sources
Will learners practice in the smaller communities?	Practice location – rural-urban continuum	Measures of rurality or medical underservice: Rural-urban classes based on Government classifications of population size, distance/commuter flow to urban centres, etc. [43,44] Rural Index of Ontario score [45]	ii, iii, iv, v
Explanatory Variables			
What is the effect of the selected demographic characteristics on outcomes listed above?	Socio-economic and demographic characteristics	Rural or northern background, culture/ethnicity, other demographic characteristics	ii, iii, iv, v
What is the effect of the medical education experience on outcomes listed above?	Educational experience	UG and PG medical education at NOSM or other medical school	ii, iii, iv, v
What are some of the other factors that influence the decisions listed above?	Influential factors	Factors such as, opportunity, personal, familial, and societal imperatives.	ii

[i] The study measures intended and actual outcome/influential factor.

[ii] Data source= CRaNHR survey/interviews with learners/physicians

[iii] Data source=Medical schools or medical education agencies

[iv] Data source=Medical licensing or regulatory bodies

[v] Data source=Provincial Health Insurance Plans (billing data)

CONTRIBUTORS

JCH: Design of study and tools, study administration, collection, analysis and interpretation of data, plus writing the paper. MGF: Design of tools, data collection and editorial review. PT: Design of study and tools, data collection, interpretation and editorial review. RPS: Project leadership, contribution to study design and tools, data interpretation and editorial review. DH: Advice on study design and tools, data interpretation and editorial review. RWP: Project leadership, design of study and tools, data interpretation and editorial review.

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COMPETING INTERESTS

JCH is employed part time, DH was formerly, while RS is currently employed full time by the Northern Ontario School of Medicine. JCH, PT and MGF receive partial salary support from the provincial government grants.

DATA SHARING PROTOCOL

Conditions of our ethical approvals permit the Centre for Rural and Northern Health Research to share only aggregated data with NOSM personnel, stakeholders or other researchers.

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FIGURE CAPTION

Figure 1. Flow of medical learners through the Northern Ontario School of Medicine (NOSM) as of January 2014.

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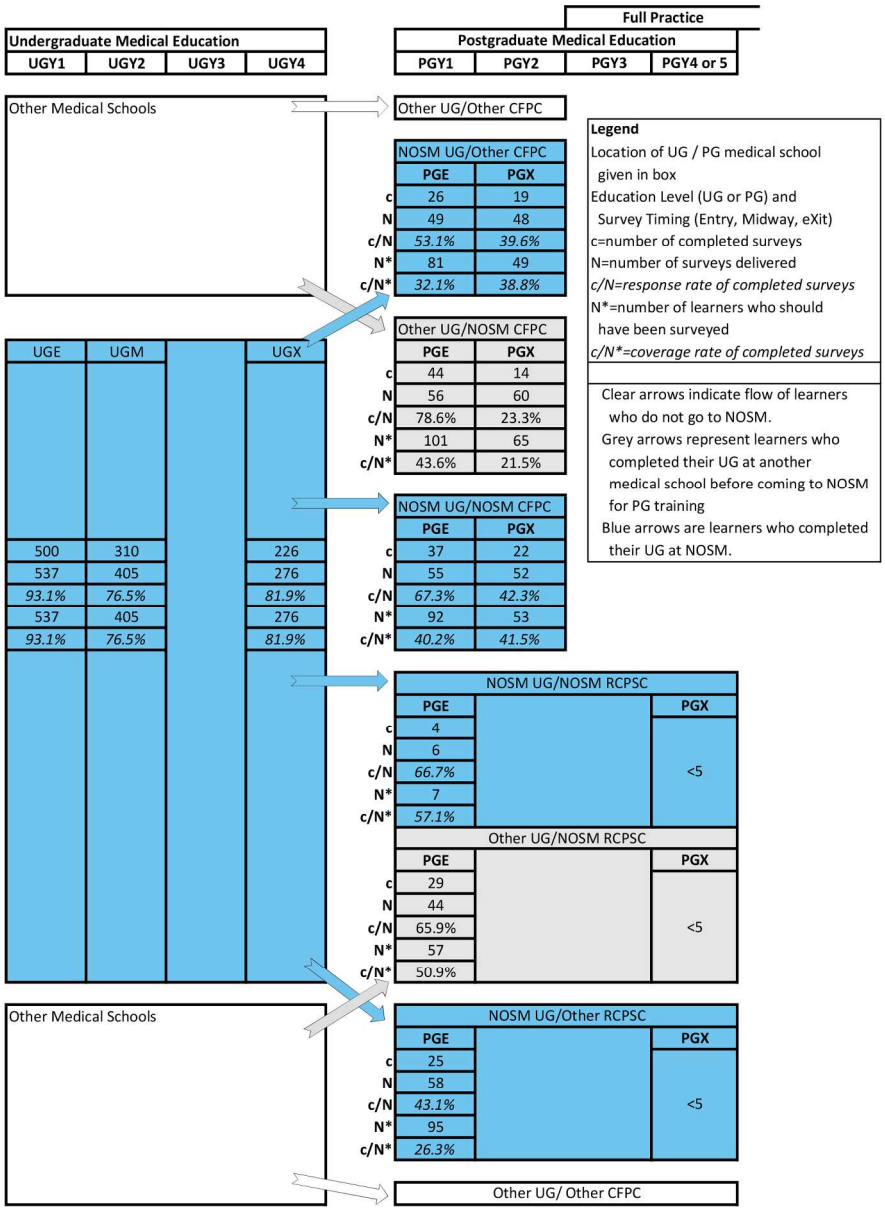

Flow of medical learners through the Northern Ontario School of Medicine (NOSM) as of January 2014.
162x222mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8 Table 1
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	Not applicable as this is a census
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8 Table 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, explain how loss to follow-up was addressed	10
		(*e*) Describe any sensitivity analyses	pending

Section/Topic	Item #	Recommendation	Reported on page #
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Figure 1
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 2-4 Figure 1 shows different exposure groups
		(b) Indicate number of participants with missing data for each variable of interest	Table 2-4 Figure 1
		(c) Summarise follow-up time (eg, average and total amount)	5
Outcome data	15*	Report numbers of outcome events or summary measures over time	Not applicable for a protocol, pending
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pending
		(*b*) Report category boundaries when continuous variables were categorized	Pending
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Pending
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Pending
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12 & Pending
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.