Research Article

Cancer Epidemiology, Biomarkers & Prevention

The Role of Access to a Regular Primary Care Physician in Mediating Immigration-Based Disparities in Colorectal Screening: Application of Multiple Mediation Methods

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Abstract

Background: Colorectal cancer screening participation is lower among recent immigrants than among Canadian-born individuals. We assessed whether this screening disparity is mediated by access to regular primary care physicians (PCP).

Methods: Pooling years 2003 to 2014 of the Canadian Community Health Survey, lifetime screening in respondents aged 50 to 75 years of age who immigrated in the previous 10 years ($n = 1{,}067$) was compared with Canadian-born respondents ($N = 102{,}366$). Regression- and inverse probability weighting-based methods were used to estimate the total effect (TE) and controlled direct effect (CDE) of recent immigration on never having received either a stool- or endoscopic-based screening test. The proportion of the TE that would be eliminated if all had a PCP was computed using these estimates [proportion eliminated (PE) = (TE − CDE)/(TE − 1)]. Analyses were stratified by visible minority status and adjusted for income, rurality, age, sex, marital status, education, and exposure to a provincially organized colorectal screening program.

Results: The prevalence of never having been screened was 71% and 57% in visible minority and white recent immigrants, respectively, and 46% in white Canadian-born respondents. If all had regular PCPs, there would be no reduction in the screening inequality between white recent immigrants and Canadian-born (null PE), and the inequality between visible minority immigrants and white Canadian-born may increase by 6% to 13%.

Conclusions: Ensuring all have regular PCPs may lead to greater screening gains among Canadian-born than recent immigrants.

Impact: Improving access to PCPs may increase colorectal screening overall, but not reduce immigration-based disparities screening. Alternative interventions to reduce this disparity should be explored.

Introduction

In Canada, as in other developed nations (1, 2), immigrants are less likely than Canadian-born residents to have ever been screened for colorectal cancer (3, 4), which is currently the third most common cause of cancer death in the country (5). The gap in lifetime screening between those born in Canada and those born abroad is of approximately 10% (6). Since having never been screened is associated with later-stage at diagnosis and higher levels of colorectal cancer mortality (7), immigrants are likely to bear a disproportionate amount of the burden of colorectal cancer, in part because they are under-screened. Immigration-based screening disparities beg two questions: how do these disparities come to exist; and what interventions can be leveraged to reduce them?

Known social determinants of colorectal screening include lack of available free time (8), lack of high school graduation (4), lower income (3), rural residence (9), and not being exposed to an organized screening program (10). Beyond these determinants, one factor that is hypothesized to drive immigration-based inequalities in colorectal screening is the difficulty that many recent immigrants face in accessing primary health care services. In Canada, though immigrants granted permanent residency are entitled to universal health care coverage, linguistic, cultural and system-based barriers can make accessing health resources difficult (11, 12). For example, recent immigrants are less likely than non-immigrants to have a primary care physician (PCP; ref. 13). Because individuals without regular PCPs are less likely to be screened (3), the disparity in access to regular PCPs may explain, at least in part, this disparity in colorectal screening.

Although improving regular PCP access has been identified as a potential area of intervention to increase screening among recent immigrants, this potential mediating pathway between recent immigration and screening has yet to be formally empirically assessed. The aim of this study was therefore to assess if having a regular PCP mediates the disparity in lifetime colorectal screening between recent immigrants and non-immigrants in Canada, and if so, assess what proportion of the disparity would be eliminated if all had a regular PCP (referred to as the proportion eliminated or

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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"PE"). Because recent immigrants' cancer screening habits and beliefs, and overall interactions with the health care system, can vary across racial and ethnic identities (14, 15), we wished to assess the PE across visible minority and white sub-populations. We did so using multiple techniques to compare the stability of findings.

Materials and Methods

Data and target population

Data from years 2003, 2005, 2007 to 2014 of the population-based, cross-sectional Canadian Community Health Study (CCHS) were used (16). The CCHS questionnaire was administered in English and French (with the possibility of completing the interview in an alternative language when necessary; ref. 17) via computer-assisted interviewing, either in-person or by telephone (40% and 60% of interviews, respectively; ref. 17). Response rates ranged from 80.7% in 2003 (18) to 65.6% in 2014 (17), with sampling weights adjusted for nonresponse. This study's target population was adults aged 50 to 75 years, who were either white and Canadian-born or had immigrated to Canada recently ($\leq$10 years), and had no known risk factors or symptoms of colorectal cancer (19). Excluded from this study were respondents who reported screening due to "family history of colorectal cancer," "follow-up of a problem," and "follow-up of colorectal cancer treatment" (16), as well as longer-term immigrants (>10 years). The latter were excluded given their similar overall prevalence of never having been screened for colorectal cancer (45.6%; 95% CI, 44.4%–47.1%) as Canadian-born respondents (46.3%; 95% CI, 45.8%–46.8%).

Measures

Figure 1 describes the hypothesized relations between the following measures (additional theory and literature on which are described in detail in the Supplementary eMethods 1):

Outcome measure

The CCHS questionnaire describes stool-tests and endoscopic examination (sigmoidoscopy, colonoscopy) and asks: "Have you ever had this test/either of these exams?" For immigrants, the question did not differentiate whether tests were conducted before or after arrival to Canada. Respondents were considered to have never been screened ($Y = 1$) if they reported to have never had any of these tests. We focused on lifetime screening as most Canadians have in fact never been screened in their lifetime (6) and since having never been screened is associated with later-stage cancer at diagnosis and higher risk of mortality (7).

Exposure measure

The exposure of interest (A) was recent immigration experience ($A = 1$ for those who reported immigrating to Canada in the previous 10 years). A 10-year cut-off for recent immigration was used to reflect the observed period it takes, on average, for new residents to feel a sense of familiarity in the Canadian setting, and to report similar income earnings as average Canadian residents (20). To account for the intersecting experiences of recent immigration and racialization (21), recent immigrants and non-immigrants were stratified by visible minority status (yes or no). The CCHS' derived variable for visible minority status captures whether respondents' self-reported cultural and racial background is other than "white" (22). Screening among white recent

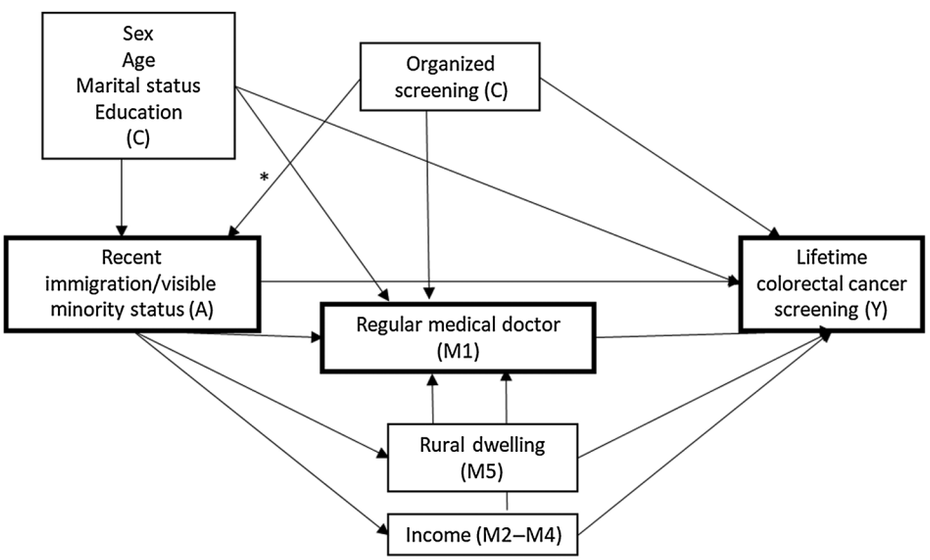

Figure 1.

Directed acyclic graph (DAG) of the assumed direction of associations between study measures. One-way arrows indicate assumed direction of associations between the exposure of the study (A, recent immigration/visible minority status), the principal mediator (M1, access to a primary care physician), the outcome (Y, lifetime colorectal cancer screening), other assumed mediators (M2–M5), and covariates (C). The asterisk (*) is used to indicate that certain assumptions underly the assumed direction of the arrow from exposure to an organized screening program to recent immigration (A). These assumptions are that (i) recent immigration entails a set of experiences, some of which are mutable and can vary according to the country of arrival's integration policies, and (ii) organized screening programs (which represent a provincial investment in health promotion and health service accessibility—or least, the promotion of service and screening awareness) could shape recent immigrants' experiences in navigating a new health system.

immigrants and visible minority recent immigrants was compared to screening among white Canadian-born respondents to isolate associations for joint exposure (visible minority status, recent immigration) and single exposure (recent immigration).

Mediator measures

The principal mediator of interest was access to a regular PCP. Respondents were considered to not have a regular PCP if they answered "No" to the question "Do you have a regular medical doctor?" And, as it is convention to consider other potential mediating factors in the analysis of direct and indirect effects (23), we identified two factors in the literature to be treated as additional potential mediators in the analyses: household income and area of residence. These factors were excluded from TE analyses and included as potential confounders of the mediator-outcome association in CDE analyses. Household income was categorized as quartile groupings (highest income [Quartile 4] as reference). Since missing income data were not imputed in the CCHS before 2005, income for CCHS 2003 was imputed based on individuals' age, sex, education, marital status, immigration status, and sampling weight, using hot deck imputation in Stata 14 (*hotdeckvar*; ref. 24). Area of residence was dichotomized (urban vs. rural). Urban classification in the CCHS is based on census population concentration ($n \geq 1{,}000$ inhabitants) and density ($n \geq 400/\text{km}^2$). It includes urban core, urban fringe, secondary urban core, and suburban areas (22).

Covariate measures

Covariates included were sex, age (50–59 years; 60–75 years), marital status (single; divorced, widowed, or separated; married or in a common-law relationship), educational attainment, and exposure to a provincially organized colorectal screening program. Because lack of high school graduation is an important predictor of non-recent screening participation across white and visible minority groups at other cancer sites (9) and has previously been associated with lower likelihood of colorectal screening (with nondifferential effect sizes for higher education groups, i.e., high school graduates, postsecondary attendees; ref. 25), those who had not completed high school were compared with those who had a high school diploma or more formal education (including college attendance). Residents of Manitoba from 2007, Ontario from 2008, Saskatchewan from 2009, Nova Scotia from 2009, and New Brunswick from 2014 were considered exposed to a mail-out based organized colorectal screening program (26), designed to promote screening. Exposure to these programs was included as a confounder (i.e., as a potential determinant of having a regular PCP, screening likelihood, and how immigration is experienced) and effect modifier (i.e., as a moderating factor of the associations between immigration experience and having a regular PCP, and between PCP access and screening).

Analysis

Estimating the proportion of the disparity would be eliminated if all had a regular PCP (the "PE"), requires an estimation of (i) the total adjusted association (referred to as the total effect or "TE") between recent immigration experience and lifetime colorectal screening, and (ii) the direct association between recent immigration and lifetime colorectal screening if all had a PCP (referred to as the controlled direct effect "CDE"). In a counterfactual framework (27), if we assume having measured all mediator-outcome confounders, the CDE can be defined as the remaining immigration-based disparity in lifetime screening prevalence had

Table 1. Summary of models required for the estimation of the controlled direct effect and total effect in the three methods used in the study

Method	Controlled direct effect (CDE)		Total effect (TE)
(1) Generalized Product Method	**Outcome model**		**Outcome model**
	$\log(E[Y\|a,m\ c] = \theta_0 + \theta_1 A_i + \theta_2 M1 + \theta_3 AM1 + \theta' M_i + \theta' c$		$\log(E[Y\|a,m\ c] = \theta_0 + \theta_1 A_i + \theta' M_i + \theta' c$[a]
	CDE indicated by $(\theta_1 + \theta_3 m)$, where m was set to $m = 1$; all have physicians		TE indicated by (θ_1)
(2) Inverse probability weighting (IPW) Marginal Structural Model approach	**Propensity score models**		**Propensity score models**
	Logistic model for A = 1 ~ 1 (p_A)		Logistic model for A = 1 ~ 1 (p_A)
	Logistic model for A = 1 with C_i (p_A1)		Logistic model for A = 1 with C_i (p_A1)
	Logistic model for M1 = 1 with A (p_M)		
	Logistic model for M1 = 1 with A, C_i, all M_i (p_M1)		
	Weights for A	**Weights for M1**	**Weights for A**
	If A = 1: p_A/p_A1	If M1 = 1: p_M/p_M1	If A = 1: p_A/p_A1
	If A = 0: p_A/(1-p_A1)	If M1 = 0: p_M/(1-p_M1)	If A=0: p_A/(1-p_A1)
	Outcome model		**Outcome model**
	Where all are weighted using product of weights for A and for M1: $\log(E[Y\|a,m\ c] = \theta_0 + \theta_1 A_i + \theta_2 M1 + \theta_3 AM1 + \theta' M_i + \theta' c$		Where all are weighted using weights for A:
	CDE indicated by $(\theta_1 + \theta_3 m)$, where m was set to $m = 1$; all have physicians		$\log(E[Y\|a,m\ c] = \theta_0 + \theta_1 A_i + \theta' M_i + \theta' c$ TE indicated by (θ_1)
(3) Inverse probability weighted (IPW) Average Marginal Effect approach	**Propensity score models**		**Propensity score model**
	Logistic model for A = 1 with C_i (p_A1)		Logistic model for A = 1 with C_i
	Logistic model for M1 = 1 with A, C_i, all M_i (p_M1)		
	Weights for A	**Weights for M1**	**Weights for A**
	If A = 1: 1 /p_A1	If M1 = 1: 1/p_M1	If A = 1: 1/p_A1
	If A = 0: 1/(1 − p_A1)	If M1 = 0: 1/(1 − p_M1)	If A = 0: 1/(1-p_A1)
	Estimation		**Estimation**
	CDE is estimated by the ratio of weighted (using product of weights for A and M1) screening prevalence in those with A = 1 and M1 = 1 over those with A = 0 and M1 = 1:		TE is estimated by the ratio of weighted screening prevalence in those with A = 1 over those with A = 0:
	$Y_{A=1,\ M1=1,\ \text{weighted}} / Y_{A=0,\ M1=1,\ \text{weighted}}$		$Y_{A=1,\ \text{weighted}} / Y_{A=0,\ \text{weighted}}$

[a]A = exposure (recent immigration). M1 = mediator (not having a primary care physician). M_i describes the additional mediators, here M2-M4 are quartile groupings 1,2,3 of household income, and M5 stands for rural residence. C_i represent covariates, which include sex, age, marital status, education, and exposure to an organized screening program.

all individuals been assigned (possibly counterfactually) a regular PCP (28, 29). Measuring the CDE is particularly relevant when interested in assessing how a potential intervention on the mediator (here, assigning all a PCP) could influence a known inequality (28, 29). If the inequality in access to regular PCPs according to immigration status does explain, at least in part, immigration-based inequalities in screening, we would expect to see a proportion of the inequality eliminated.

Multiple approaches have been proposed to estimate the TE and CDE. Some use regression modeling (30, 31), whereas others combine regression modeling with inverse probability weighting techniques (32), or use a purely inverse probability weighting approach (23). The aim of using inverse probability weights is to create synthetic populations that are balanced in terms of the measured covariates, through which contrasts in average outcomes can be estimated (23). In this study, we applied three methods [summarized in detail in other texts (23, 31, 32) and in Table 1]—which, taken together, enable an assessment of the robustness of the findings. We describe the three methods here:

First, we used a regression-based product method (also referred to as the generalized product method; ref. 29) proposed by VanderWeele and Vansteelandt (31), which extends Baron and Kenny's product method (30) to allow for effect estimation in the presence of exposure-mediator interaction [Method 1]. This method requires the specification of two Poisson regression models for the screening outcome—one with, the other without, the mediator measure and its product term with the exposure (these are the CDE, and TE models, respectively). Second, we used an inverse probability-weighted marginal structural model approach [Method 2], described by VanderWeele (32), in which TE and CDE models (as in Method 1) are weighted using inverse probability weights for the exposure and mediator. These weights are constructed using propensity scores (predicted probabilities) for the exposure and mediator, given covariates and other mediator values, which are estimated using logistic models (details in Table 1 and the Supplement's eMethod 2). Finally, we used an inverse probability weighted approach for marginal effect estimation [Method 3], described by VanderWeele (23), in which screening prevalence is weighted (as in Method 2), and simple ratios of the average screening prevalence between the exposed and unexposed (for TE estimation), and between the exposed with a PCP and unexposed with a PCP (for CDE estimation) are computed. Inverse probability weights used in this method are also constructed using propensity scores for the exposure and mediator, estimated using logistic models (details in Table 1 and Supplement's eMethod 2). Estimates from IPW methods 2 and 3 can be interpreted as the average associations in the population, whereas method 1 associations are conditional on the strata of the variables in the models. With the TE and CDE, the proportion of the total effect explained by having a regular PCP (PE) was estimated on an excess relative risk scale [using prevalence ratio (PR) estimates] as follows: $(PR^{TE} - PR^{CDE)}/(PR^{TE} - 1)$ (23). Confidence intervals (95%) for CDE, TE, and PE were estimated using the bootstrap method (500 replications; ref. 23). Analyses were conducted in R (version 3.4.1; ref. 33).

Assumptions and sensitivity analyses

The analyses described above rely on two assumptions, the validity of which will be tested using sensitivity analyses. First, the validity of the CDE estimates (and consequently, of the PE estimates) relies on the assumption of controlled confounding for the mediator–outcome relationship (34). We apply formulas derived by VanderWeele (2015; ref. 35) to test the sensitivity of observed CDE estimates to unmeasured confounding of the mediator-outcome relationship. This approach estimates how large associations would have to be between an unmeasured factor and both the mediator and outcome for the true CDE estimates to be null (PR = 1) despite non-null estimates, or to be equivalent or smaller to the observed TEs (yielding null or positive PEs).

Second, estimating CDE requires both theoretical positivity of the mediator (i.e., that all respondents have a non-null probability of having a regular PCP) and—when using inverse probability weighting—practical positivity for the exposure and

Table 2. Prevalence of having never been screened and not having a primary care physician across demographic, social, and economic population characteristics among respondents 50 to 75 years of age to the 2003 to 2014 waves of the Canadian Community Health Survey ($n = 659$ visible minority recent-immigrants, $n = 408$ white recent-immigrants, $n = 102{,}366$ white Canadian-born respondents)

Characteristics	Overall	% Without a primary care physician (95% CI)	% Never screened (95% CI)
	100	9.3	47.0
Recent immigration			
No	99.2	9.0 (8.7, 9.4)	46.3 (45.8, 46.8)
Yes	0.9	18.2 (13.8, 23.7)	67.9 (62.6, 72.7)
Visible minority status			
No	93.6	9.0 (8.7, 9.3)	46.3 (45.7, 46.8)
Yes	6.4	14.4 (12.0. 17.2)	57.6 (54.7, 60.5)
Immigration/visible minority			
Recent immigrant, visible minority ($n = 659$)	0.61	18.4 (13.0, 25.4)	71.0 (65.0, 76.3)
Recent immigrant, white ($n = 408$)	0.38	17.6 (13.0, 23.4)	56.8 (46.5, 66.4)
Canadian-born, visible minority ($n = 5{,}241$)	4.82	11.7 (10.4, 13.2)	48.9 (46.0, 51.7)
Canadian-born, white ($n = 102{,}366$)	94.20	8.9 (8.6, 9.3)	46.2 (45.7, 46.7)
Primary care physician			
Yes	90.7		44.7 (44.1, 45.2)
No	9.3		69.8 (67.9, 71.6)
Sex			
Men	49.9	11.1 (10.5, 11.6)	47.1 (46.2, 47.9)
Women	50.1	7.6 (7.2, 8.0)	46.9 (46.2, 47.6)
Age (years)			
50–59	52.8	11.3 (10.5, 12.0)	54.9 (54.0, 55.8)
60–75	47.2	7.2 (6.8, 7.6)	38.1 (37.5, 38.8)
Marital status			
Married/common law	73.6	7.8 (7.4, 8.2)	45.4 (44.7, 46.0)
Divorced/widowed/ separated	18.6	11.3 (10.5, 12.0)	49.5 (48.3, 50.8)
Single	7.8	19.8 (18.4, 21.3)	47.0 (46.5, 47.6)
Education			
≥High school	80.5	9.1 (8.0, 9.5)	45.8 (45.2, 46.5)
<High school	19.5	10.2 (9.6, 10.9)	51.9 (50.8, 53.0)
Organized screening			
Yes	39.6	7.4 (6.9, 8.0)	35.2 (34.2, 36.1)
No	60.4	10.6 (10.2, 11.1)	55.8 (54.1, 55.4)
Income quartiles			
Quartile 1	19.0	12.0 (11.2, 12.8)	51.6 (50.6, 52.7)
Quartile 2	20.4	9.6 (8.9, 10.4)	45.0 (43.9, 46.1)
Quartile 3	30.4	9.1 (8.4, 9.8)	46.3 (45.2, 47.5)
Quartile 4	30.2	7.7 (7.2, 8.3)	46.1 (45.0, 47.2)
Rural			
Yes	25.9	9.3 (8.8, 9.9)	49.2 (45.6, 46.9)
No	74.1	9.3 (8.9, 9.8)	46.3 (45.6, 46.9)

mediator [i.e., that propensity scores for these factors are neither 0 nor 1 (0% or 100% probability); ref. 36]. To assess this, we performed stratified, descriptive analyses of propensity scores for the exposure and mediator (23).

The study protocol was approved by the Ethical Review Board of the Centre de Recherche du Centre Hospitalier de l'Université de Montréal.

Results

Sample characteristics

Of the total sample (102,366 of whom were white Canadian-born respondents, 659 were recent-immigrants of visible minorities, and 408 of whom were white recent-immigrants), 47% had never been screened in their lifetime and 9% did not have a regular PCP. The prevalence of never having been screened was 71% and 57% in visible minority and white recent immigrants, respectively, and 46% in white Canadian-born respondents (Table 2). Approximately 9% of white Canadian-born respondents did not have a regular PCP, compared with 18% among both visible minority and white recent immigrants, respectively (Table 2). Overall, the proportion of those who had never been screened was higher among those who were younger than 60 years, not partnered, had lower income (quartiles 1 and 2), had not obtained a high school diploma, did not have a PCP, resided in rural settings, and were not exposed to a provincial organized screening program (Table 2).

Associations between exposure, mediator, and outcome

Overall, associations were observed between recent immigration, having a regular PCP, and screening. Adjusting for all factors, recent immigrants were less likely to have a PCP (Table 3) and more likely to have never been screened (Table 4). However, associations between having a regular PCP and screening were heterogeneous across strata of immigration status. Expressed as prevalence differences (PD), the adjusted difference in screening between those with and without a PCP was larger among white Canadian-born respondents [PD = 19% (95% CI, 17%–20%), i.e. prevalence of approximately 44% among those with a PCP, 68% among those without] than among white immigrants [PD = 4% (95% CI, 15%–24%), i.e. prevalence of approximately 54% among those with a regular PCP, 58% among those without] or among visible minority immigrants [PD = 8% (95% CI, 10%–27%), i.e., prevalence of approximately 71% among those with a PCP, 79% among those without; data not in table].

TE, CDE, and PE estimates

The TE, CDE, and PE estimates were largely consistent across all three mediation methods (Table 5). Large CDE estimates (between PR = 1.56 and 1.60 for visible minority recent immigrants, and between PR = 1.24 to 1.27 for white recent immigrants, depending on the method used) suggest that even if inequalities in access to a regular PCP were eliminated, a large disparity in lifetime screening would remain for recent immigrants across visible minority status. Most CDE estimates were

Table 3. Covariate-adjusted models for recent immigration (A) and not having a primary care physician (M1), stratified by visible minority status ($n = 659$ visible minority, $n = 408$ white), with white Canadian-born respondents ($n = 102{,}366$) as reference category, in the Canadian Community Health Survey 2003 to 2014

	Stratified, covariate-adjusted models for recent immigration (A)		Stratified, covariate-adjusted models for not having a primary care physician (M1)	
Characteristics	Visible minority recent immigrants vs. white Canadian-born Recent immigration PR[b] (95% CI)	White recent immigrants vs. white Canadian-born Recent immigration PR[b] (95% CI)	Visible minority recent immigrants vs. white Canadian-born Not having a primary care physician PR[b] (95% CI)	White recent immigrants vs. white Canadian-born Not having a primary care physician PR[b] (95% CI)
Recent immigration[a]				
Yes			1.40 (1.14, 1.82)	2.86 (2.22, 3.63)
No			1	1
Sex				
Men	1.16 (1.07, 1.26)	0.91 (0.82, 1.00)	1.58 (1.54, 1.61)	1.57 (1.54, 1.61)
Women	1	1	1	1
Age				
50–59	2.15 (1.98, 2.32)	1.52 (1.38, 1.69)	1.65 (1.61, 1.68)	1.65 (1.61, 1.68)
60–75	1	1	1	1
Marital status[a]				
Mar./Com. Law	1	1	1	1
Div./Widow.	0.63 (0.57, 0.70)	0.63 (0.55, 0.72)	1.55 (1.51, 1.60)	1.56 (1.50, 1.60)
Single	0.41 (0.35, 0.49)	0.40 (0.32, 0.50)	2.41 (2.34, 2.49)	2.42 (2.36, 2.47)
Education				
≥High school	1	1	1	1
<High school	1.06 (0.97, 1.17)	0.25 (0.20, 0.30)	1.13 (1.10, 1.15)	1.13 (1.10, 1.16)
Organized screening				
Yes	1	1	1	1
No	1.23 (1.13, 1.33)	0.88 (0.79, 0.97)	1.25 (1.22, 1.28)	1.25 (1.22, 1.28)
Income quartiles				
Quartile 1			1.13 (1.09, 1.17)	1.13 (1.09, 1.17)
Quartile 2			1.02 (0.99, 1.05)	1.02 (0.99, 1.05)
Quartile 3			1.01 (0.97, 1.04)	1.01 (0.98, 1.04)
Quartile 4 (highest)			1	1
Rural				
Yes			1.19 (1.17, 1.22)	1.19 (1.17, 1.22)
No			1	1

[a]"Mar" indicates married; "Com. Law" indicates Common law relationship status; "Div." indicates divorced, "Widow." indicates widowed.

[b]Stratified PR values represent stratified prevalence risk ratios estimated via Poisson log-linear regression models. Models were adjusted for age, sex, marital status, educational attainment, exposure to a provincial organized screening program, income quartile, and rural residence.

Table 4. Covariate-adjusted models for having never been screened (Y), stratified by visible minority status ($n = 659$ visible minority, $n = 408$ white), with white Canadian-born respondents ($n = 102{,}366$) as reference category, in the Canadian Community Health Survey 2003 to 2014

	Stratified, covariate-adjusted models for having never been screened (Y)	
	Visible minority recent immigrants vs. white Canadian-born	**White recent immigrants vs. white Canadian-born**
Characteristics	Having never been screened PR_{11}[a] (95% CI)	Having never been screened PR_{10}[a] (95% CI)
Recent immigration (A)[b]		
Yes	1.16 (0.92, 1.41)	1.01 (0.75, 1.27)
No	1	1
Primary care physician (M1)		
Yes	1	1
No	1.41 (1.36, 1.44)	1.42 (1.36, 1.47)
Product terms		
A*M1	1.33 (1.07, 1.60)	1.23 (0.93, 1.53)
Sex		
Men	1.02 (1.00, 1.04)	1.02 (1.00, 1.04)
Women	1	1
Age		
50–59	1.40 (1.39, 1.42)	1.41 (1.39, 1.42)
60–75	1	1
Marital status[b]		
Mar./Com. Law	1	1
Div./Widow.	1.08 (1.06, 1.11)	1.08 (1.06, 1.11)
Single	1.12 (1.09, 1.15)	1.12 (1.09, 1.15)
Education		
≥High school	1	1
<High school	1.13 (1.11, 1.15)	1.13 (1.11, 1.15)
Organized screening		
Yes	1	1
No	1.66 (1.64, 1.68)	1.66 (1.64, 1.68)
Income quartiles		
Quartile 1	1.04 (1.02, 1.07)	1.04 (1.02, 1.07)
Quartile 2	0.96 (0.93, 0.98)	0.96 (0.93, 0.99)
Quartile 3	0.94 (0.92, 0.97)	0.94 (0.91, 0.97)
Quartile 4 (highest)	1	1
Rural		
Yes	1.03 (1.01, 1.05)	1.03 (1.01, 1.05)
No	1	1

[a]"Mar" indicates married; "Com. Law" indicates Common law relationship status; "Div." indicates divorced; "Widow." indicates widowed.

[b]PR values represent stratified prevalence ratios estimated via Poisson log-linear regression models. Models were adjusted for age, sex, marital status, educational attainment, exposure to a provincial organized screening program, income quartile, rural residence, and product terms.

larger than TE estimates, yielding null PE estimates for white recent immigrants, and negative PE estimates (i.e., exacerbated inequalities under mediator intervention) for visible minority recent immigrants (between −6% and −13%, depending on the method used; Table 2).

Results of sensitivity analyses

First, we found that the associations between the unmeasured factor and both the mediator and outcome would have to be at minimum PR = 2.5 for visible minority recent immigrants, and PR = 1.8 for white recent immigrants for the true CDE estimates to be null (PR = 1) despite non-null estimates; and would have to be at minimum PR = 1.3 and PR = 1.1 for visible minority and white recent immigrants, respectively, for true CDE estimates to be equivalent or smaller than observed TE estimates (yielding null or positive PE values; Supplementary Table S1 and S2). These are larger estimates than those observed for low education and not being exposed to an organized screening program (Tables 2 and 3). Nonetheless, the potential for unmeasured confounding remains. Second, analyses of propensity scores indicate good covariate balance between exposed and unexposed respondents after weighting, and of practical positivity for regular PCP access (Supplementary Table S3 and S4). However, the requirement of practical positivity for recent immigration may be violated (i.e., propensity scores—even when truncated at the 10th percentile—were close to 0). Lack of practical positivity may lead to potential instability of the weighting methods. Finally, results were largely consistent when accounting for effect modification by exposure to an organized screening program, with slightly attenuated direct effects (Supplementary Table S5).

Discussion

The aim of this study was to assess whether having a regular PCP mediates the disparity in lifetime colorectal screening between recent immigrants and non-immigrants in Canada. In this sample, in which nearly half (47%) have never been screened, we observed large controlled direct effects between recent immigration and screening, as well as proportions eliminated that were either null or negative—indicating that improving access to regular PCPs may not reduce observed immigration-based screening inequalities. As the screening disparity between those with and without a regular PCP is larger among white Canadian-born respondents (PD = 19%) than among recent immigrants (PD = 8% and 4% among visible and white minority recent immigrants, respectively), having a PCP lead to larger increases in screening among Canadian-born individuals than among recent immigrants, thereby leaving the disparity untouched or exacerbated.

The observed associations between recent immigration and lifetime screening are consistent with those observed previously in Canada and North America (1). These associations may be explained by recent immigrants' more limited knowledge of and trust in the efficacy of the screening tests and the medical system, discomfort with the test itself, or lower perceived susceptibility to cancer (1, 37). Differences in effect sizes between white and visible minority recent immigrants may be explained by differences in ethno-cultural feelings of fatalism and helplessness with regards to colorectal cancer diagnosis and mortality (8) or in the acceptability of screening tests (15). On a more distal level, systemic discrimination (38), barriers to health care, and social stressors such as inadequate housing and precarious employment (39) are thought to explain, in part, why persons who immigrate to Canada —who, upon arrival are disproportionately healthy—see their health experience a decline in health over time, eventually converging with Canadian-born residents their age (11). These distal factors may also explain why such strong associations are observed between immigration experience and screening. However, it should be noted that Canada's immigrant and visible minority populations are highly heterogenous, and explanations for the observed findings may not hold across all subgroups.

Although having a regular PCP is an important enabling determinant of screening participation overall (1), our findings suggest increasing access to PCPs may lead to greater gains in screening for Canadian-born individuals than for recent immigrants. Several factors may explain this observation. First,

Table 5. Estimated total effect of recent immigration (exposure) on lifetime screening, and controlled direct effect when access to a primary care physician (mediator) is held fixed, stratified by visible minority status ($n = 659$ visible minority, $n = 408$ white), with white Canadian-born respondents ($n = 102{,}366$) as reference category, in the Canadian Community Health Survey 2003 to 2014

Population strata	Approach	Total effect (TE) PR (95% CI)	Controlled direct effect (CDE) PR (95% CI)	Proportion eliminated (PE) $(PR^{TE} - PR^{CDE}) / (PR^{TE} - 1)$% (95% CI)
Visible minority recent immigrants vs. white Canadian-born	(1) Generalized product method approach[a]	1.51 (1.28, 1.65)	1.56 (1.48, 1.63)	−9% (−15%, −4%)
	(2) IPW marginal structural model approach[b]	1.54 (1.41, 1.69)	1.58 (1.50, 1.68)	−6% (−12%, −2%)
	(3) IPW Average Marginal Effect approach[c]	1.53 (1.44, 1.61)	1.60 (1.51, 1.70)	−13% (−20%, −6%)
White recent immigrants vs. white Canadian-born	(1) Generalized product method approach[a]	1.24 (1.08, 1.40)	1.24 (1.12, 1.35)	−2% (−29%, 24%)
	(2) IPW marginal structural model approach[b]	1.31 (1.15, 1.48)	1.32 (1.18, 1.47)	1% (−21%, 24%)
	(3) IPW Average Marginal Effect approach[c]	1.25 (1.13, 1.37)	1.27 (1.12, 1.42)	−10% (−51%, 36%)

Abbreviations: IPW, inverse probability weighted; PR, prevalence ratio.

[a]The generalized product method, proposed by VanderWeele and Vansteeladnt (2009), extends Baron and Kenny's (1986) product method to allow for effect estimation in the presence of exposure-mediator interaction. Note that when exposure–mediator interaction is not accounted for, effects were the following for visible minority recent immigrants (ref. white, Canadian-born): TE = 1.51 (1.38, 1.66), the CDE = 1.49 (1.42, 1.56), and the PE = 3.8% (1%, 7%); and for white recent immigrants (ref. white Canadian-born): TE = 1.24 (1.08, 1.40), CDE = 1.18 (1.08, 1.29), PE = 26% (15%, 43%).

[b]The inverse probability-weighted marginal structural model approach, proposed by VanderWeele (2009), fits inverse-probability-weighted TE and CDE models (on outcome Y) such that the exposed and unexposed are balanced in terms of measured covariates (for CDE, TE estimation) and primary care physician values (for CDE estimation).

[c]The IPW Average Marginal Effect approach estimates CDE by computing the ratio between (i) the average prevalence of lifetime screening in recent immigrants with physicians (who are weighted to be balanced in terms of measured covariates and mediators with those born in Canada) and (ii) the average prevalence of lifetime screening in Canadian-born respondents with physicians (who are weighted to be balanced in terms of measured covariates and mediators with recent immigrants). Similarly, the TE is estimated by computing ratio between (i) the average prevalence of lifetime screening in recent immigrants (weighted to be balanced in terms of measured covariates with those born in Canada) and (ii) the average prevalence of lifetime screening in Canadian-born respondents (weighted to be balanced in terms of measured covariates).

recent immigrants may not systematically receive screening recommendations from their regular PCPs—as is observed for patients of visible minorities or lower socioeconomic status in Canada (40). Recent immigrants to Canada have also reported gaps in the cultural competency of health care providers, specifically with regards to cultural understandings of health and health care (41), and to language and communication (42). These limitations of the Canadian health care system, in conjunction with general logistic and psychological barriers to colorectal screening (such as unreachable or inadequate resources, lower social support, fear, embarrassment or anxiety of the test, its required preparation—especially for endoscopic procedures—or of its result (43)) may explain why simply having a regular PCP may not be sufficient to ensure screening uptake.

The implication of these findings is that improving individuals' access to regular PCPs may improve screening participation overall (namely through large gains among Canadian-born individuals) but fail to reduce screening disparities according to recent immigration. We recommend that future studies explore alternative areas of intervention to both reduce these inequalities and increase screening uptake overall.

These findings are bound by certain limitations. First, the broad categories of white versus visible minority immigrants may obscure sub-group heterogeneity in the associations measured, as has been observed in previous studies (44). These findings should therefore be interpreted as the average mediating role of PCPs in white and visible minority immigrants. Second, the cross-sectional data used required additional assumptions of the temporal ordering of associations between recent immigration, regular PCP access, and screening. Replication of these analyses using longitudinal data will be beneficial. Third, although we stated effect estimates in the causal language used in epidemiologic research, the validity of these assertions rely on the satisfaction of the causal assumptions underpinning each method (23). Sensitivity analyses suggest that some residual confounding is likely present. Among the unmeasured factors in this study (and indeed, in the CCHS) are concordance of individuals' and PCPs' gender identity or economic, linguistic, ethnic, or cultural background (45, 46). Future mediation studies may benefit from incorporating the latter measures, as well as exploring downstream mediators such as knowledge and cultural beliefs around cancer or cancer prevention, and the frequency or recency of PCP visits. Finally, because self-reported screening data tend to overestimate recent screening [i.e., previous two year fecal occult blood test (FOBT) sensitivity is 77.4% and specificity is 89.8%; ref. 47], and studies at other cancer sites have observed differential self-reported screening according to racial and ethnic subpopulations (47), it is possible that the screening gaps between immigrants and non-immigrants observed in this study may be underestimated.

In sum, almost half of adults aged 50 to 75 years in Canada have never been screened for colorectal cancer, and the prevalence of having never been screened is even higher for recent immigrants. This study suggests that increasing individuals' access to regular PCPs may increase screening overall, but not eliminate immigration-based disparities in screening. Other levers will be necessary to decrease these inequalities.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: A. Blair, L. Gauvin, M.E. Schnitzer, G.D. Datta
Development of methodology: A. Blair, M.E. Schnitzer, G.D. Datta
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): A. Blair, M.E. Schnitzer, G.D. Datta
Writing, review, and/or revision of the manuscript: A. Blair, L. Gauvin, M.E. Schnitzer, G.D. Datta
Study supervision: G.D. Datta
Other (Cosupervision [with C.D. Datta] of first author [A. Blair] who is completing her doctoral work in public health at the Université de Montréal): L. Gauvin

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