Linguistic mortality gradients in Quebec and the role of migrant composition

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Abstract

Objective Anglophones and Allophones in Quebec (Canada) have lower mortality than Francophones, despite being linguistic minorities. This study assesses whether (1) language is a risk factor for mortality after accounting for migrant composition and (2) interprovincial migrants differ in mortality with respect to Quebec-born individuals.

Methods We analyzed death records between 2004 and 2008 from Quebec (all-cause and main causes) and population data from the 2006 census to estimate age-adjusted mortality rates according to language and migrant status. Risk ratios by language and migrant status, adjusted for age, sex, and socioeconomic status, were estimated using Poisson generalized estimating equations.

Results Francophone Quebec-borns had the highest mortality. Among Quebec-borns, Anglophones [RR = 0.85, 95% CI (0.79–0.91)] and Allophones [RR = 0.16, 95% CI (0.12–0.22)] had lower mortality relative to Francophones. Interprovincial migrants had lower mortality (Anglophones [RR = 0.58, 95% CI (0.53–0.63)], Francophones [RR = 0.55, 95% CI (0.50–0.60)]) relative to Francophone Quebec-borns (Allophones were excluded due to small sample size). Among immigrants, mortality was lower for Francophones [RR = 0.62, 95% CI (0.57–0.67)] and Allophones [RR = 0.35, 95% CI (0.31–0.38)], but not Anglophones [RR = 0.92, 95% CI (0.84–1.01)], relative to Francophone Quebec-borns.

Conclusion In Quebec, linguistic disparities in mortality remained after accounting for migrant status, and both Francophone and Anglophone interprovincial migrants in Quebec had lower mortality than Quebec-born Francophones. Public health initiatives to reduce linguistic disparities in health should account for migrant status.

Résumé

Objectif Les anglophones et les allophones du Québec (Canada) ont un taux de mortalité inférieur à celui des francophones, malgré leur statut de minorité linguistique. Cette étude évalue si: 1) la langue est un facteur de risque de mortalité, après avoir contrôlé pour le statut migratoire; 2) la mortalité chez les migrants interprovinciaux diffère de celle des individus nés au Québec.

Méthode Nous avons analysé les données de décès qui ont eu lieu de 2004 à 2008 au Québec (toutes causes confondues et selon les principales causes) et les données de population du recensement 2006, afin d'estimer les taux de mortalité ajustés pour l'âge selon la langue et le statut migratoire. Les risques relatifs par langue et par statut migratoire, ajustés selon l'âge, le sexe et le statut socioéconomique, ont été estimés en utilisant les équations d'estimation généralisées de Poisson.

Résultats Les Francophones nés au Québec avaient le risque de mortalité le plus élevé. Parmi les personnes nées au Québec, les anglophones [RR = 0,85, IC 95% (0,79–0,91)] et les allophones [RR = 0,16, IC 95% (0,12–0,22)] avaient un risque relatif de mortalité plus faible comparativement aux francophones. Les migrants interprovinciaux avaient des risques relatifs de mortalité plus faibles (anglophones [RR = 0,58, IC 95% (0,53–0,63)], francophones [RR = 0,55, IC 95% (0,50–0,60)]), comparativement

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aux francophones nés au Québec (les allophones ont été exclus des analyses en raison de leur faible taille d'échantillon). Parmi les immigrants, le risque relatif de mortalité était plus faible pour les francophones [RR = 0,62, IC 95% (0,57–0,67)] et les allophones [RR = 0,35, IC 95% (0,31–0,38)], mais pas pour les anglophones [RR = 0,92, IC 95% (0,84–1,01)], comparativement aux francophones nés au Québec.

Conclusion Au Québec, les différences linguistiques dans la mortalité demeurent après avoir contrôlé pour le statut

migratoire. Les migrants interprovinciaux, autant pour les francophones que pour les anglophones, ont un taux et un risque relatif de mortalité plus bas que les francophones nés au Québec. Les initiatives en santé publique pour réduire les différences linguistiques en santé devraient prendre en considération le statut d'immigrant.

Keywords Mortality · Minority language · Healthy immigrant effect · Moderation · Quebec

Mots-clés Mortalité · Langue minoritaire · Effet de l'immigrant en santé · Modération · Québec

Introduction

In the Canadian province of Quebec, Anglophones and Allophones have better observed health despite being a linguistic minority with respect to the predominant Francophones, who account for over 80% of the population (Auger et al. 2016; Bouchard and Desmeules 2013; Trempe et al. 2013; Statistics Canada 2007; Burrows et al. 2013, 2016; Auger et al. 2012a). This finding is counterintuitive as minority linguistic groups tend to have poorer health status due to reduced opportunities in education and employment, social adaptation difficulties, or language barriers to access to services (Bouchard and Desmeules 2013), though exceptions do exist (Sipila and Martikainen 2009). The causes of the inverse linguistic health disparity in Quebec are not fully understood but hypotheses include differences in socioeconomic status, social capital, and health-related behaviour and lifestyle differences (Auger et al. 2012b, 2016; Bouchard and Desmeules 2013; Trempe et al. 2013; Lussier and Trempe 2013). Anglophones have had a persisting health advantage over Francophones, though the magnitude has decreased over time; this decrease has been attributed to corresponding decreases in the vitality and socioeconomic status of the Anglophone community.

To our knowledge, migrant status has not previously been examined as a possible contributor to linguistic health disparities despite marked differences in migrant compositions of linguistic communities. Quebec Anglophones are a dynamic and mobile population, with substantial migration exchanges with other Canadian provinces as well as inflow of immigrants (Statistics Canada 2007; Corbeil et al. 2010). The decades since the Quiet revolution (ca. 1970s) however have seen a decline in the demographic and socioeconomic vitality of Anglophones (Corbeil et al. 2010; Floch and Pocock 2008; Jedwab 2008; Lussier 2012), including a net outflow in interprovincial migration. Quebec Allophones consist of diverse immigrants (Corbeil et al. 2010) who collectively form a population comparable to Anglophones in size. The proportion of Allophones in Quebec is expected to continue increasing due to sustained immigration, though the distribution of countries of origin of new arrivals (Girard 2016) has changed over time and the direction of language transfer due to acculturation has shifted from English to French (Corbeil et al. 2010). In

contrast, Quebec Francophones are predominantly Quebec-born and experience extremely low outmigration to other provinces (Floch and Pocock 2008). Though substantial immigration of Francophones to Quebec occurs, the proportion of immigrants in the Francophone population remains quite small (<6%). These widely varying differences in migrant composition may thus be an explanation for linguistic disparities in health in Quebec; in other words, observed linguistic disparities may in fact reflect differential migrant composition and associated migrant-specific health levels.

The healthy migrant effect (Kennedy et al. 2015) postulates that self-selection, healthier lifestyle habits, as well as the selection effect of immigration policies may lead to health levels in immigrants that are superior to those of the host country population. This effect has been observed in Canadian immigrants (Gushulak et al. 2011). However, a possible healthy migrant effect in Canadian interprovincial migrants has not previously been assessed. While some (non-Canadian) studies have indicated the presence of a healthy migrant effect in internal (non-international) migrants (Wingate and Alexander 2006), others have found that migrant health correlates with the source or destination region (Kravdal 2009). As Quebec is a largely Francophone society embedded within an Anglophone majority, its borders likely constitute a linguistic barrier that may substantially impede or filter migration from other surrounding regions or provinces (Girard 2010; Schoumaker et al. 1998). This barrier effect may result in sufficiently strong selection forces that could produce a substantial healthy migrant effect in interprovincial migrants. The existence of a healthy migrant effect in interprovincial migrants to Quebec is thus a compelling hypothesis that has not previously been examined.

While the effect of migration on driving geographic disparities in health has been well documented (Kennedy et al. 2015), its possible contribution to linguistic disparities has not previously been studied. The objectives of our study are thus to (1) assess if language disparities persist when accounting for migrant composition and (2) assess if mortality risk in interprovincial migrants differs from that in the Quebec-born population. Our analysis covers aggregate data from 2004 to 2008 and complements previous studies on linguistic health disparities in Quebec that have covered similar time periods (Auger et al. 2016; Trempe et al. 2013; Burrows et al. 2013, 2016; Auger et al. 2012a, b).

Methods

Study design This study followed an observational, quantitative, cross-sectional design.

Data sources We extracted death counts from Quebec health ministry vital statistics for the period 2004 to 2008 and used 2006 long-form census data, purchased from Statistics Canada, for the population denominator counts, for the population 15 years of age and over. Deceased individuals whose place of residence was located in dissemination areas (census areas of 400–800 people) with a high proportion (>25%) of the population in collective dwellings were excluded. Long-form census data do not include collective dwellings. Death counts were further classified into six principal causes: all-site cancer, lung cancer, circulatory diseases, respiratory diseases, non-intentional injuries, and suicide (see Appendix Table 8). These causes have been identified in previous studies of linguistic mortality differentials in Quebec (Burrows et al. 2013, 2016; Auger et al. 2012a, 2013) and fall within the 10 leading causes of death in Canada.

Language Death certificates in the province of Quebec collect only language spoken at home, a variable also reported in the long-form census. Identical rules were applied to both data sources to form the following linguistic categories: Anglophone (English with or without a language other than French), Francophone (French with or without a language other than English), Allophone (neither French nor English), or bilingual (speaking French and English equally at home). Bilingual individuals represented <0.9% of the total population and were excluded from the analyses.

Migrant status Migrant status was derived from “place of birth” which is collected in both death certificates and the long-form census. Identical rules were applied on both data sources to form the following migrant status categories: Quebec-born, interprovincial migrant (non-immigrant, born in a Canadian province outside of Quebec) and immigrant (born in a foreign country). The Allophone subcategory of interprovincial migrants was further excluded from the analysis due to small sample size.

Covariates Covariates comprised age, sex, and SES. Age was grouped into seven categories (15–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75+). Data were further aggregated spatially at the level of 166 administrative local community service centres (CLSC). CLSCs comprise about 45,000 inhabitants on average, cover the whole of Quebec, and are neighbourhoods within which residents report a subjective sense of place (Gauvin et al. 2007). Pampalon’s material and social deprivation indices (Pampalon et al. 2012) were used to represent the average socioeconomic status (SES) measures for each CLSC.

The indices are composite measures derived from census variables; the material dimension comprises proportion of persons with no high school diploma, ratio of employment to population, and average income, while the social dimension comprises proportion of separated, divorced or widowed individuals, single-parent families, and persons living alone. For comparison of mortality rates, CLSCs were grouped into low, moderate, and high categories of material and social deprivation, corresponding to 0–20th, 20th–80th, and 80th–100th percentiles respectively. For subsequent regression analyses, the deprivation indices were retained as continuous variables and scaled from –1 to 1.

Missing data Multiple imputation was used to jointly impute the 15.8% of deaths that were missing language or migrant status (Survey Methodology Program 2011). The imputation model used the distribution of age, sex, material and social deprivation, as well as area proportions of Anglophones, Francophones, and Allophones.

Statistical analysis

Age-adjusted mortality rates Age-adjusted rates (number of deaths per 100,000 persons) were estimated using the direct standardization method with the 2006 Quebec population as reference. Rates were estimated by language, migrant status, and sociodemographic variables for all-cause mortality. Rates were further estimated by language within each category of migrant status for all-cause and cause-specific mortality.

Regression analyses Relative risks of mortality for language and migrant status were estimated with Poisson generalized estimating equations (GEE) using an exchangeable correlation structure to account for clustering within CLSCs. The fully adjusted regression model accounted for language, migrant status, interaction between language and migrant status, age, sex, and SES.

Statistical tests and comparisons ANOVA tests and QIC (quasi-likelihood criterion) (Pan 2001) were used to compare the full regression model vs. reduced models to provide further evidence for the hypotheses. To test if language was a risk factor for mortality once migrant status was accounted for, the full model was compared against a reduced model with all language variables removed. To test if interprovincial migrants differed in their mortality risk from Quebec-borns, the full model was compared against a reduced model that grouped all non-immigrants (Quebec-borns and interprovincial migrants) into one category.

Ethics This study conformed to the 2010 Tri-Council Policy Statement for ethical conduct of research on humans in

Canada, and we obtained an ethics waiver from the University of Montreal Hospital Centre.

Results

Composition of Quebec linguistic communities Table 1 shows the distribution of linguistic and migrant communities within the population, as well as the distribution of migrant status and sociodemographic characteristics within each linguistic community. Francophones accounted for the majority (82.6%) of the population, while Anglophones and Allophones represented 10.4 and 6.9% respectively. Quebec-borns accounted for 82.5% of the population overall, while interprovincial migrants and immigrants accounted for 4.1 and 13.4% respectively. Francophones were predominantly Quebec-borns (91.3%), while interprovincial migrants and immigrants accounted for 3.0 and 5.7% respectively. In contrast, there was a much stronger presence of both interprovincial migrants and immigrants within the Anglophone community (14.7 and 26.5% respectively), while the Allophone community consisted mainly of immigrants (85.0%), with a minority of Quebec-borns (14.0%) and very few interprovincial migrants (1.0%).

Table 1 shows that Francophones and Allophones were fairly evenly represented over categories of material deprivation; however, the majority (54.0%) of Anglophones resided in areas of low material deprivation. Regarding social deprivation, Francophones and Anglophones were relatively evenly represented over categories, while nearly half (47.6%) of Allophones resided in areas of high social deprivation.

Age-adjusted mortality rates by linguistic community, migrant status, and sociodemographic characteristics Age-adjusted mortality rates shown in Table 2 illustrate the overall lower mortality rates in the Anglophone (858, 95% CI 847–868) and Allophone (367, 95% CI 358–375) minorities with respect to the Francophone majority (954, 95% CI 950–958). A marked health advantage appears to apply to both interprovincial migrants (589, 95% CI 574–605) and immigrants (593, 95% CI 585–601) compared to Quebec-borns (969, 95% CI 965–973). Women had overall lower mortality rates (778, 95% CI 774–782) than men (1042, 95% CI 1036–1047). An increasing mortality gradient with respect to increasing material and social deprivation was present.

Cause-specific age-adjusted mortality rates Cause-specific mortality rates by language and by migrant status are shown in Table 3. Cancer and cardiovascular diseases were the leading causes of death during 2004–2008 for all linguistic communities and migrant categories. Patterns by language and migrant status were similar across all causes presented, and followed those seen in all-cause

mortality. In general, Francophones had the highest mortality rates, while Allophones had the lowest. Mortality rates were the highest in Quebec-borns, with interprovincial migrants and immigrants having lower mortality rates over all the causes.

Cause-specific age-adjusted mortality rates within migrant categories Table 4 shows all-cause and cause-specific mortality rates by language within each category of migrant status. Cause-specific patterns were similar to those for all-cause mortality rates. Linguistic patterns in mortality differed markedly according to migrant status. Among Quebec-borns, Anglophones exhibited lower mortality rates compared to Francophones while Allophones had the lowest rates of the three linguistic groups. In interprovincial migrants however, Anglophone and Francophone mortality rates were similar and both were substantially lower than their Quebec-born counterparts. Within immigrants, while Francophones showed a marked health advantage with respect to Quebec-borns, the mortality rate of Anglophone immigrants was much higher and closer to that of Quebec-born Anglophones and Francophones. Finally, Allophone immigrants showed mortality rates lower than those of both Anglophone and Francophone immigrants.

Adjusted relative risks of mortality by migrant status and linguistic communities Adjusted relative risks are shown in Table 5 for all-cause and cause-specific mortality. Francophone Quebec-borns, who constituted over 75% of the study population, and had the highest adjusted relative risks, represented the reference group. Patterns by language and migrant status mirror those for age-adjusted mortality rates (Table 4) and were similar over different causes. Among Quebec-borns, Anglophones had lower mortality risks compared to Francophones, with Allophones having the lowest risks of all. In interprovincial migrants, Anglophone and Francophone mortality risks were similar and substantially lower than their Quebec-born counterparts. Within immigrants, Anglophones had mortality rates that were substantially higher than those of Francophones; while Francophone immigrants showed a marked health advantage with respect to Quebec-borns, the mortality rate of Anglophone immigrants was slightly higher than that of Quebec-born Anglophones. Allophone immigrants showed mortality risks lower than those of both Anglophones and Francophones.

Statistical tests ANOVA tests comparing the fully adjusted model with a reduced model with no language effect provided further evidence that language contributes to mortality risk after accounting for migrant status. *p* values for these ANOVA tests were consistently below 0.0001 for all-cause

Table 1 Composition of the Quebec linguistic communities by migrant status and sociodemographic characteristics, for the population living in non-collective dwellings (source: Statistics Canada, 2006 Long Form Census data)

	Francophones (82.6%)	Anglophones (10.4%)	Allophones (6.9%)
All migrant status (<i>n</i> = 6,134,050)	5,069,715 (100%)	639,120 (100%)	425,215 (100%)
Quebec-borns (<i>n</i> = 5,063,580, 82.5%)	4,628,430 (91.3%)	375,635 (58.8%)	59,515 (14.0%)
Interprovincial migrants (<i>n</i> = 250,790, 4.1%)	152,405 (3.0%)	94,175 (14.7%)	4210 (1.0%)
Immigrants (international) (<i>n</i> = 819,680, 13.4%)	288,880 (5.7%)	169,310 (26.5%)	361,490 (85.0%)
Material deprivation			
Low deprivation (<i>mat</i> ≥ 0.6)	1,550,630 (30.6%)	345,420 (54.0%)	145,415 (34.2%)
Moderate deprivation ($-0.6 < \text{mat} < 0.6$)	1,736,920 (34.3%)	167,505 (26.2%)	135,245 (31.8%)
High deprivation (<i>mat</i> ≤ −0.6)	1,782,165 (35.2%)	126,195 (19.7%)	144,555 (34.0%)
Social deprivation			
Low deprivation (<i>soc</i> ≥ 0.6)	1,658,500 (32.7%)	230,360 (36.0%)	102,755 (24.2%)
Moderate deprivation ($-0.6 < \text{soc} < 0.6$)	1,739,675 (34.3%)	181,830 (28.5%)	120,195 (28.3%)
High deprivation (<i>soc</i> ≤ −0.6)	1,671,540 (33.0%)	226,930 (35.5%)	202,265 (47.6%)
Age groups (years)			
15–24	770,645 (15.2%)	106,230 (16.6%)	57,715 (13.6%)
25–34	765,855 (15.1%)	104,310 (16.3%)	76,590 (18.0%)
35–44	892,620 (17.6%)	125,360 (19.6%)	86,955 (20.4%)
45–54	1,035,420 (20.4%)	113,220 (17.7%)	67,600 (15.9%)
55–64	798,530 (15.8%)	85,685 (13.4%)	53,410 (12.6%)
65–74	467,755 (9.2%)	53,780 (8.4%)	46,540 (10.9%)
≥ 75	338,890 (6.7%)	50,535 (7.9%)	36,405 (8.6%)

Table 2 All-cause mortality rates (expressed as number of deaths per 100,000 persons, and 95% CI) by linguistic communities, migrant status, and sociodemographic characteristics, for the population living in non-collective dwellings (source: Death registry certificates, Quebec, 2004–2008; Statistics Canada, 2006 Long Form Census data)

	Number of individuals	Crude mortality rate (95% CI)	Age-adjusted mortality rate (and 95% CI)
Study population	6,134,050	897 (894–897)	897 (894–901)
Linguistic communities			
Francophone	5,069,715	936 (933–940)	954 (950–958)
Anglophone	639,120	904 (893–915)	858 (847–868)
Allophone	425,215	420 (410–430)	367 (358–375)
Migrant status			
Quebec-borns	5,063,580	949 (946–953)	969 (965–973)
Interprovincial migrants	250,790	633 (616–649)	589 (574–605)
Immigrants (international)	819,680	656 (647–665)	593 (585–601)
Sex			
Men	2,982,810	919 (914–924)	1042 (1036–1047)
Women	3,151,240	876 (872–881)	778 (774–782)
Material deprivation			
Low	1,219,285	775 (768–782)	801 (794–809)
Moderate	3,670,585	887 (883–891)	911 (906–915)
High	1,244,180	1047 (1039–1055)	948 (941–955)
Social deprivation			
Low	1,211,780	814 (807–821)	876 (869–884)
Moderate	3,681,580	884 (879–888)	885 (881–890)
High	1,240,690	1019 (1011–1027)	960 (952–967)

Table 3 All-cause and cause-specific age-adjusted mortality rates (expressed as number of deaths per 100,000 persons, and 95% CI) by linguistic communities and migrant status, for the population living in non-collective dwellings

	Mortality rate (95% CI)						
	All-cause	Cancer	Lung cancer	Cardiovascular	Respiratory	Injuries	Suicide
Language							
Francophone	954 (950-958)	197 (196-199)	99 (98-100)	200 (198-202)	69 (68-71)	36 (35-37)	21 (20-22)
Anglophone	858 (847-868)	163 (159-168)	68 (65-71)	188 (183-193)	55 (52-57)	28 (26-30)	11 (10-13)
Allophone	367 (358-375)	68 (65-72)	27 (25-30)	80 (76-83)	19 (17-21)	12 (10-14)	7 (5-8)
Migrant status							
Quebec-borns	969 (965-973)	200 (198-201)	101 (100-102)	204 (202-206)	71 (70-72)	37 (36-37)	21 (21-22)
Interprovincial migrants	589 (574-605)	123 (116-130)	58 (53-63)	122 (116-129)	40 (36-44)	21 (18-25)	9 (7-11)
Immigrants (international)	593 (585-601)	113 (110-117)	43 (40-45)	130 (126-134)	31 (29-33)	18 (16-19)	9 (7-10)

and cause-specific mortality (Appendix, Table 6). The QICs of the full model were also consistently lower than those of the reduced model, indicating improvement in model fit with the inclusion of language effects (Appendix, Table 6).

ANOVA tests comparing the full model with a reduced model with interprovincial migrants aggregated with Quebec-borns into a single “non-immigrant” category provided further evidence that interprovincial migrants had distinct mortality risks as compared with Quebec-borns. *p* values for these ANOVA tests were consistently below 0.0001 for all-cause and cause-specific mortality (Appendix, Table 7). The QICs of the full model were also consistently lower than that of the reduced model, over all-cause and cause-specific mortality, indicating improvement in model fit when interprovincial migrants were treated as distinct category (Appendix, Table 7).

Discussion

This study demonstrates that linguistic disparities in mortality remain after accounting for migrant composition. In particular, the Anglophone-Francophone-Allophone decreasing mortality gradient observed in the total population persists in the Quebec-born population. However, migrant status moderated the association between language and mortality, resulting in different linguistic patterns according to migrant status. Approximately equal though markedly lower mortality risks were observed in Anglophone and Francophone interprovincial migrants, while among immigrants, Anglophones had substantially higher mortality than Francophones.

The lower mortality of Anglophones relative to Francophones in Quebec-borns indicates that this pattern

Table 4 All-cause and cause-specific age-adjusted mortality rates (expressed as number of deaths per 100,000 persons, and 95% CI) by migrant status and linguistic communities, for the population living in non-collective dwellings

	All-cause	All-site cancer	Lung cancer	Circulatory diseases	Respiratory diseases	Non-intentional injuries	Suicide
Quebec-borns							
Francophones	983 (979-987)	203 (201-205)	103 (102-105)	206 (204-208)	72 (71-74)	38 (37-38)	22 (22-23)
Anglophones	868 (851-884)	166 (159-173)	74 (70-79)	191 (185-198)	61 (57-65)	28 (25-31)	9 (7-12)
Allophones	272 (249-297)	51 (41-64)	27 (20-36)	45 (36-56)	27 (20-35)	13 (8-21)	10 (8-13)
Interprovincial migrants							
Francophones	572 (552-593)	121 (112-130)	58 (53-65)	119 (111-127)	39 (34-43)	20 (16-24)	11 (9-13)
Anglophones	631 (608-654)	128 (118-140)	57 (50-66)	131 (121-142)	43 (36-51)	23 (19-29)	9 (6-14)
Allophones ^a							
Immigrants (international)							
Francophones	668 (652-685)	135 (127-143)	50 (45-55)	143 (135-152)	35 (31-39)	19 (16-22)	8 (4-13)
Anglophones	947 (924-971)	176 (168-185)	65 (59-71)	208 (199-218)	51 (46-57)	29 (24-36)	7 (2-31)
Allophones	376 (367-385)	70 (66-74)	28 (25-30)	83 (79-87)	18 (17-20)	12 (10-14)	6 (5-7)

^a Excluded from the analysis due to small sample size

Table 5 Adjusted relative risks of mortality by migrant status and linguistic communities, for the population living in non-collective dwellings

	All-cause	All-site cancer	Lung cancer	Circulatory diseases	Respiratory diseases	Non-intentional injuries	Suicide
Quebec-borns							
Francophones (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Anglophones	0.85 (0.79–0.91)	0.80 (0.73–0.86)	0.72 (0.65–0.79)	0.91 (0.83–0.98)	0.84 (0.75–0.94)	0.74 (0.63–0.86)	0.45 (0.37–0.56)
Allophones	0.16 (0.12–0.22)	0.17 (0.11–0.25)	0.19 (0.12–0.33)	0.16 (0.11–0.22)	0.23 (0.11–0.46)	0.17 (0.08–0.36)	0.28 (0.09–0.87)
Interprovincial migrants							
Francophones	0.55 (0.50–0.60)	0.57 (0.51–0.63)	0.54 (0.48–0.62)	0.56 (0.50–0.62)	0.51 (0.43–0.61)	0.51 (0.39–0.66)	0.35 (0.25–0.50)
Anglophones	0.58 (0.53–0.63)	0.58 (0.52–0.64)	0.52 (0.45–0.62)	0.60 (0.52–0.69)	0.56 (0.46–0.68)	0.56 (0.43–0.73)	0.31 (0.18–0.55)
Allophones ^a							
Immigrants							
Francophones	0.62 (0.57–0.67)	0.61 (0.55–0.67)	0.44 (0.39–0.49)	0.64 (0.58–0.71)	0.45 (0.40–0.52)	0.48 (0.40–0.57)	0.37 (0.27–0.50)
Anglophones	0.92 (0.84–1.01)	0.84 (0.77–0.91)	0.63 (0.57–0.71)	0.97 (0.87–1.08)	0.72 (0.63–0.82)	0.85 (0.70–1.04)	0.51 (0.35–0.74)
Allophones	0.35 (0.31–0.38)	0.32 (0.28–0.36)	0.25 (0.22–0.28)	0.37 (0.32–0.43)	0.24 (0.21–0.27)	0.28 (0.23–0.34)	0.18 (0.13–0.25)

^a Excluded from the analysis due to small sample size

is driving the Anglophone-Francophone mortality disparity that has been observed in the entire population (Auger et al. 2012a, b, 2016; Bouchard and Desmeules 2013; Trempe et al. 2013; Statistics Canada 2007; Burrows et al. 2013, 2016). These results indicate that the linguistic disparities in health reported in previous studies (Auger et al. 2012a, b, 2016; Bouchard and Desmeules 2013; Trempe et al. 2013; Statistics Canada 2007; Burrows et al. 2013, 2016) are likely not due to differences in migrant composition. While we observe consistently lower mortality in Anglophones over all causes examined, risk differences are the largest for suicide, lung cancer, and injuries, a finding coherent with previous studies (Auger et al. 2013). Language-specific differences in socioeconomic status (Auger et al. 2012a, 2016; Bouchard and Desmeules 2013; Burrows et al. 2013), health-related behaviour, and lifestyle (in particular smoking (Auger et al. 2013) and alcohol (Burrows et al. 2013, 2016; Auger et al. 2012a), culture and social capital (Bouchard and Desmeules 2013; Trempe et al. 2013; Burrows et al. 2013, 2016; Auger et al. 2012a, b, 2013; Sipila and Martikainen 2009)) have been proposed as contributing risk factors for all-cause and by-cause patterns. More generally however, the magnitude of the Anglophone-Francophone health disparity has been decreasing with time (Trempe et al. 2013; Auger et al. 2012a, b) and may diminish further with the continuing

erosion of their vitality and socioeconomic status (Floch and Pocock 2008; Jedwab 2008; Lussier 2012).

Anglophone and Francophone interprovincial migrants both show substantially lower all-cause and by-cause mortality risks with respect to their Quebec-born counterparts. Migration is typically motivated by economic reasons such as professional opportunities and advancement (Wingate and Alexander 2006; Connolly and O'Reilly 2007). Both Anglophone and Francophone interprovincial migrants may represent self-selected populations with above-average health, education, and vigour. With its policies on language and the dominance of French in the workplace and in public institutions, it is likely that a strong linguistic barrier effect (Girard 2010; Schoumaker et al. 1998) to the migration of Anglophones exists between Quebec and other provinces. Thus, while the health of Francophone migrants to Quebec may be fostered by a reduced difficulty of adaptation and acculturation, the health of Anglophone migrants may be heightened by a stronger self-selection effect. Interprovincial migrants make up a substantial proportion of Anglophones and thus are an important source of vitality to the Anglophone population as well as representing a contributor to linguistic health disparities. The net loss in Anglophone cross-province migration in recent years (e.g., approximately 8000 persons between 2001 and 2006) (Corbeil et al. 2010) represents a concern for this

community however. The lower mortality of interprovincial migrants has not previously been noted and represents an important and novel public health finding.

Anglophone and Francophone immigrants also exhibit linguistic health patterns that differ from those in Quebec-borns. While the mortality rate of Francophone immigrants is greatly reduced with respect to Quebec-borns, that of Anglophones is substantially higher than those of their Quebec-born counterparts and show little difference with respect to Quebec-born Francophones. Francophone immigrants appear to demonstrate a marked healthy immigrant effect likely due to self-selection, healthier lifestyle habits, as well as the selection effect of Canadian immigration policies (Gushulak et al. 2011). Health selection effects in Anglophone immigrants may be mitigated by a longer average residence time (Corbeil et al. 2010) in Quebec as well as countries of origin (e.g., UK, USA, Australia) with lifestyles that already resemble those of Canada (Ng 2011). Finally, while Allophone immigrants have historically (prior to 1976) experienced language transfer to English, language transfer to French has predominated in recent decades (Corbeil et al. 2010). This shift might further favour the health of the Francophone immigrant population due to the influx of more recent and healthier Allophone immigrants that have transferred to French spoken at home, in contrast with longer-term resident and less healthy Allophone immigrants that have transferred to speaking English.

Allophones are predominantly composed of immigrants; the lower mortality risk of Allophone immigrants thus likely represents a healthy immigrant effect (Ng 2011). The observed health advantage of Allophones immigrants may be amplified by language transfer to English or French (Lussier and Trempe 2013) that may occur concurrently with the reduction of the healthy immigrant effect with increasing residence time. The salmon bias effect may result in the further selective outflow of less healthy allophone immigrants back to their country of birth (Abraído-Lanza et al. 1999). Quebec-born Allophones also exhibit substantially lower mortality risk. These Allophones may be second-generation immigrants that have chosen to maintain their language of heritage, and have better educational opportunities, SES, and health, as well as First Nations. Further work on understanding the identity and characteristics of Quebec-born Allophones is needed.

Our study includes strengths as well as limits. First, to our knowledge, this is the first study to examine the contribution of migrant status to linguistic disparities in health. Though mortality represents but one measure of population health, it represents a standard for assessing and comparing the health of populations and communities, as well as evaluating the effect of prevention

programs in public health (Thacker et al. 2006). Linguistic and migrant status mortality patterns represent average, population-level patterns and could differ within subregions such as Gatineau where interprovincial migration and obtention of health services due to proximity to the Ontario border is greater. Material and social deprivation may also vary within subregions. However, sensitivity analyses showed that similar patterns were upheld within broad urban-rural zones, including the census metropolitan area of Montreal and non-metropolitan areas (Appendix Table 9). Further sensitivity analyses showed that language and migrant status distributions, as well as the sociodemographic profile, between complete and missing data cases were similar, suggesting that multiply imputed data were valid. Estimated mortality risks were adjusted for CLSC-level material and social deprivation; while these measures are ecological, CLSCs represent administrative units that offer health services and interventions (Santé Montréal. <https://www.santemontreal.qc.ca/reseau-de-la-sante/ressources/clsc/>) and are neighbourhoods within which residents report a subjective sense of place (Gauvin et al. 2007). Finally, our dataset did not permit adjustment for migrant length of residence in Quebec, immigrant birth country, or specific allophone language groups, which could have provided further insight on the causes of linguistic disparities by migrant status.

Measures were taken to minimize the possibility of numerator-denominator bias: identical questions for language and migrant status between death certificate and census data were used; and dissemination areas comprising collective dwellings were excluded from the death data in order to match the long-form census. A previous study of the validity of the language spoken at home variable on the death certificate showed that similar linguistic gradients in life expectancy were obtained when using linked census and death records (Trempe et al. 2014). Though comparable studies of migrant status are not available, this variable is thought to be more accurate than language due to an unambiguous definition that can be accessed from official documents (passport, birth certificate, hospital records). Further studies of linguistic and migrant status using other data sources could confirm or elucidate our results.

Use of death certificate data precluded use of “maternal language” to define linguistic communities. However, language spoken at home has been found to correlate well with maternal language and defines communities with a strong sense of identity (Jedwab 2008). As well this variable indicates language actually in use, and may capture aspects of acculturation and access to health services. Results of this study are also comparable to those of previous studies on linguistic mortality differentials in

Quebec (Burrows et al. 2013, 2016; Auger et al. 2012a, 2013) that have made use of language spoken at home.

In conclusion, we show that language disparities between the linguistic communities of Quebec remain even after accounting for migrant status composition. The effect of language appears to be strongly moderated by migrant status, with differing linguistic health patterns present within Quebec-borns, interprovincial migrants, and immigrants respectively. In particular, we find that interprovincial migrants have a health status that is distinct from and better than that of Quebec-borns, a finding that has not previously been reported. Further examination of the causes and pathways of language and migrant status on mortality (e.g., access to services, culture, lifestyle, social capital) may provide guidelines for public health interventions to reduce inequality in health and to improve health overall. More generally, Quebec experiences a substantial flow of immigrants as well as interprovincial migrants which results in Anglophone and Allophone

communities that are diverse and whose compositions are dynamically changing with time. Our preliminary study on the effect of language and migrant status on mortality motivates further work on how the health of the Quebec population may evolve with time in relation to trends in language and migration, and underlying associated risk factors.

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Compliance with ethical standards

Conflict of interest This study is part of a series of projects funded by Health Canada through the Community Health and Social Services Network (CHSSN).

Appendix

Table 6 ANOVA *p* values and QIC results for statistical comparisons between the full model and a reduced model with language effects removed, for all-cause and by-cause mortality

Cause	ANOVA test			
	<i>p</i> value	QIC _f ^a	QIC _r ^b	QIC _f – QIC _r ^c
All cause	< 0.0001	– 2,267,116	– 2,260,791	– 6325
All-site cancer	< 0.0001	– 279,182	– 277,893	– 1289
Lung cancer	< 0.0001	– 101,609	– 101,034	– 575
Circulatory diseases	< 0.0001	– 325,900	– 324,469	– 1430
Respiratory diseases	< 0.0001	– 76,449	– 76,007	– 442
Non-intentional injuries	< 0.0001	– 7394	– 7114	– 280
Suicide	< 0.0001	644	799	– 155

^a QIC (Quasi-likelihood criterion) of the full model

^b QIC (Quasi-likelihood criterion) of the reduced model

^c A negative difference indicates the improved fit of the full model

Table 7 ANOVA *p* values and QIC results for statistical comparisons between the full model and a reduced model with interprovincial migrants aggregated with Quebec-borns into a single “non-immigrant” category

Cause	ANOVA test			
	<i>p</i> value	QIC _f ^a	QIC _r ^b	QIC _f – QIC _r ^c
All cause	< 0.0001	– 2,267,116	– 2,265,154	– 1962
All-site cancer	< 0.0001	– 279,182	– 278,821	– 361
Lung cancer	< 0.0001	– 101,609	– 101,404	– 206
Circulatory diseases	< 0.0001	– 325,900	– 324,438	– 462
Respiratory diseases	< 0.0001	– 76,449	– 76,250	– 199
Non-intentional injuries	< 0.0001	– 7394	– 7325	– 69
Suicide	< 0.0001	644	698	– 54

^a QIC (Quasi-likelihood criterion) of the full model^b QIC (Quasi-likelihood criterion) of the reduced model^c A negative difference indicates the improved fit of the full model**Table 8** Codes from the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD) used to define the main causes of death

Main causes of death	ICD-10 codes
All-site cancer	C00-C97
Lung cancer	C33-C34
Circulatory diseases	I00-I99
Respiratory diseases	J00-J99
Non-intentional injuries	V01-X59, Y85-Y86
Suicide	X60-X84, Y87.0

Table 9 All-cause age-adjusted mortality rates (expressed as number of deaths per 100,000 persons, and 95% CI) by migrant status and linguistic communities, for the province of Quebec and over a broad urban-rural continuum

	Province of Quebec	Montreal ^b	Province of Quebec minus Montreal ^b	Non-metropolitan Areas ^c
Quebec-borns				
Francophones (reference)	1.00	1.00	1.00	1.00
Anglophones	0.85 (0.79–0.91)	0.83 (0.75–0.91)	0.83 (0.74–0.93)	0.86 (0.75–0.98)
Allophones	0.16 (0.12–0.22)	0.16 (0.11–0.23)	0.15 (0.09–0.24)	0.17 (0.11–0.28)
Interprovincial migrants				
Francophones	0.55 (0.50–0.60)	0.57 (0.52–0.63)	0.50 (0.42–0.60)	0.44 (0.37–0.52)
Anglophones	0.58 (0.53–0.63)	0.61 (0.56–0.67)	0.43 (0.36–0.51)	0.41 (0.31–0.54)
Allophones ^a				
Immigrants				
Francophones	0.62 (0.57–0.67)	0.61 (0.55–0.68)	0.58 (0.52–0.64)	0.55 (0.47–0.64)
Anglophones	0.92 (0.84–1.01)	0.93 (0.84–1.03)	0.61 (0.51–0.73)	0.60 (0.48–0.75)
Allophones	0.35 (0.31–0.38)	0.34 (0.30–0.38)	0.24 (0.19–0.30)	0.21 (0.14–0.29)

^a Excluded from the analysis due to small sample size^b Montreal is defined according to its Census Metropolitan Area (CMA) (cf. <http://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo009-eng.cfm>)^c Non-metropolitan areas consist of all non CMA areas in Quebec and exclude the CMAs of Montreal, Gatineau, Quebec City, Sherbrooke, Trois-Rivières, and Saguenay

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