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Migration status and prevalence of diabetes and hypertension in Gauteng province, South Africa: effect modification by demographic and socio-economic characteristics

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Abstract

Introduction: Evidence from developing countries suggests that migration status has an impact on health. However, little is known about the effect that migration status has on morbidity in sub-Saharan Africa. The aim of this study is to investigate the association between migration status and hypertension and diabetes and to assess whether the association was modified by demographic and socio-economic characteristics.
Methods: A Quality of Life survey conducted in 2015 collected data on migration status and morbidity from a sample of 28,007 adults in 508 administrative wards in Gauteng province. Migration status was divided into three groups: non-migrant if born in Gauteng province, internal migrant if born in other South African provinces, and external migrant if born outside of South Africa. Diabetes and hypertension were defined based on self-reported clinical diagnosis. We applied a recently developed original, stepwise-multilevel logistic regression of discriminatory accuracy to investigate the association between migration status and hypertension and diabetes. Potential effect modification by age, sex, race, SES and ward-level deprivation on the association between migration status and morbidities was tested.
Results: Migrants have lower prevalence of diabetes and hypertension. In multilevel models, migrants had lower odds of reporting hypertension than internal migrants (OR = 0.86 95%CI: 0.78-0.95) and external migrant (OR = 0.60; 95%CI: 0.49-0.75). Being a migrant was also associated with lower diabetes prevalence than being an internal migrant (OR = 0.84; 95%CI: 0.75-0.94) and external migrant (OR = 0.53; 95%CI: 0.41-0.68). Age, race and SES were significant effect modifiers of the association between migration status and morbidities. There was also substantial residual between-ward variance in hypertension and diabetes with median odds ratio of 1.61 and 1.24, respectively.
Conclusions: Migration status is associated with prevalence of two non-communicable conditions. The association was modified by age, race and SES. Ward-level effects also explain differences in association.

Keywords: migration status, prevalence, diabetes, hypertension and Gauteng province.

Strengths and limitations of this study

- The study population is part of a provincial representative sample on quality of life of adult residents in Gauteng province.
- The association between migration and health was analysed by applying, stepwise-multilevel logistic regression of discriminatory accuracy.
- Migrants (both internal and external) had lower odds of both hypertension and diabetes than people born in Gauteng province.
- Effect of migration status on health differed by age, race and SES.
- However, residual confounding is possible due to data availability.

Introduction

Migration status is one of the important socioeconomic determinants of health [1]. Migration is also associated with profound social, economic and cultural changes, which may affect the migrant's health [2]. Post the year 2005, more than 62% of the South African population were living in urban areas, with the rapid urbanization being attributed to migration [3, 4]. The rapid urbanization and increase in the urban poor in metropolitan areas of Gauteng province, South Africa has become a major public health concern due to its linkage with increased disease burden [5, 6].

Migrants are heterogeneous both in their origin status and migration histories. Gauteng province attracts both internal and external migrants [3, 4]. Several studies on migration and morbidities have been done worldwide [1, 2, 7]. Morbidities often present with low functioning level, poorer quality of life, increased health care utilization and mortality rates [7]. The first South African National Health and Nutrition Examination Survey (SANHANES) reported the prevalence of 19.4% and 25.7% for diabetes and hypertension respectively in Gauteng province [8]. However, little is known about the prevalence of these morbidities among different migrant status. A better understanding of the differences in morbidities according to different migration status is needed to target high risk groups in provision of services and to arrest the growing burden of certain diseases.

Study objectives

The study aims to:

- Investigate the association between morbidities and migration status in Gauteng province, South Africa.
- To assess whether the association was modified by demographic and socio-economic characteristics.

Methods

Study setting

Gauteng is the province with the largest population, estimated to be 12,272263, despite having the smallest area; thus, it has the highest population density in South Africa of 675 people per km^2 [9]. According to data from Census 2011 Gauteng province accounted for the highest concentration of international and internal migrants in South Africa, approximately 7.4% and 44% respectively [10]. The study population consists of all people residing permanently in Gauteng province who were aged 18 or older in 2015.

Data sources

We used data from the fourth Quality of Life (QoL) Survey conducted by Gauteng City Region Observatory (GCRO) in Gauteng province in 2015. The QoL survey has been conducted every 2 years since 2009 with the intention of providing up-to-date information on 'a fast growing and dynamic urban region' to support 'better planning and management, and improved co-operative government relations' [11]. QoL survey measured a wide range of variables including socio-

demographic variables, migration status and self-reported health status from a sample of 28,007 adults in 508 administrative wards in Gauteng province. The data on ward-level migrant African population, African population, migrant SADC population, employed population, no income population, deprivation index (sampi) and average household size was obtained from Statistics South Africa (StatsSA).

Survey design

Simple random sampling was employed to select the respondents. Gauteng province consists of 10 municipalities and it is subdivided into 508 wards. Within these wards there are Small Area Levels (SALs) which were derived from the Population Census Enumerator Area (EA) polygons. SAL codes and geography were derived from the Statistics South Africa Census 2011 report. The simple random sampling method was used to select the SALs from each ward, and then the minimum numbers of interviews for each ward were 30 and 60 interviews for those falling in district municipalities and metropolitan municipalities, respectively. The end result was that across the 508 wards, 28,456 successful interviews were completed, and these interviews were distributed across 16,400 SALs out of a total of 17,840 SALs. The 'NEXT' birthday method was used to select the respondents from the selected households. Data were collected via a digital data collection instrument using an open source system called Formhub and administered on a tablet device. Questionnaires were administered in the field and uploaded using Internet connectivity to a cloud server from where they could be accessed and downloaded online.

Patient and Public Involvement

The development of the research questions and outcome measures were not informed by patients' priority experiences and preferences. Patients were not involved in the design of this study. Patients were not involved in the recruitment and conduct of the study. This study used data from 2015 QoL survey which measured a wide range of variables including socio-demographic variables, migration status and self-reported health status.

Outcome and independent variables

The main outcomes were hypertension and diabetes. The information on disease status, such as diabetes, hypertension, HIV, TB, Influenza, and others, was collected in the QoL survey by asking question: "In the past 12 months, have you been told by health provider that you have one or more of the following conditions. The morbidities were binary variables measuring the presence of the different morbidities, coded as 1 (or 'yes') if the respondents self-reported the morbidity and as 0 (or 'no') if the respondent did not report the presence of a given morbidity.

Migration status was derived from the following QoL survey questions: (i) *"Were you born in Gauteng province or did you move into Gauteng province from another province or country?"*; (ii) *When (year) did you move into Gauteng province?*; (iii) *Did you move to Gauteng province from a province in South Africa or from another country?;* (iv) *From which province did you move from into Gauteng province?; and* (v) *Which country did you move into Gauteng province from?.* Migration status then was divided into three groups: non-migrant, internal migrant, and external migrant. The explanatory variables included sex, age, race, education, employment status, dwelling, total household income, grow own vegetables, medical aid, physical activity, household size, household food security and socioeconomic status quintile. Information collected included demographic and socio-economic variables: sex (female, male); age (18 years and above); race (African, Coloured, Indian/Asian, White and Other); Education was categorized into 'No formal education', grades R-7 'Primary only', grades 8-11 'Secondary incomplete', 'Matric' grade 12 'More' Tertiary and above and 'Unspecified' for those who didn't specify; employment status ('employed', 'unemployed and other).

Dwelling (formal, informal and other); Total household income was categorized into 'Lower class income' (< 6400 Rand [ZAR] per month), 'Middle class income' (R6400 - R51, 200 per month) and 'Upper class income' (> R51, 200 per month); grow own vegetables (do not grow own vegetables and grow their own vegetables); Medical insurance was categorized into 'medically insured' for respondents with either medical aid or a hospital plan and 'medically not insured' for respondents without any of these; physical activity (never, hardly ever, few times a month, few times a week and everyday); household size (1-3, 4-6 and 7+); household food security (never, seldom, sometimes, often and always) and socioeconomic status quintile (richest, 2nd, 3rd, 4th and poorest). The ward level variables included migrant African population, African population, migrant SADC population, employed population, no income population, sampi and household of less than three.

Analysis

Descriptive analysis was performed to describe the migration status of the community by socio demographic characteristics of study respondents using proportions. The prevalence of morbidities in Gauteng province, South Africa was estimated using proportions and presented as percentages with 95% confidence intervals. Prevalence of morbidities was stratified by age, gender and migration status.

In the present analysis the data used was in multilevel structure as the respondents were within administrative wards [12]. We applied a recently developed original, stepwise-multilevel logistic regression of discriminatory accuracy to investigate the effect of migration status. We fitted separate models for effect of migration status and diabetes and hypertension, respectively. Four progressively adjusted multilevel models were carried out: model 0 with no covariates; model 1 including only sociodemographic characteristics at the individual level; model 2 additionally analysing municipal deprivation as contextual variable and model 3 is the full adjusted model. The models were adjusted for years in GP, age, sex, race, dwelling, education level, household size, household head, physical activity, medical aid, grow own vegetables, household food security, sampi, year moved to GP and socioeconomic status quintile. Potential effect modification by age, sex, race, SES and sampi was tested.

To take account of the hierarchical data structure (level 1: individuals; level 2: administrative wards), an Intraclass Correlation Coefficient (ICC) and ward-level variances were reported for every model and for reasons of better interpretability, ward-level variances were converted into median ORs (MORs) by applying the formula of Merlo *et al*, [12, 13]. Multilevel logistic regression analyses with administrative wards as random intercepts were performed calculating ORs with their 95% CIs. ORs were plotted using the user-written *coefplot* Stata command [14]. All analysis was performed using Stata version 13 (Stata Corporation, College Station, Texas, USA).

Results

Most respondents were non-migrants 18,027 (64%) and the external migrants constituted only 8% of the total respondents. Of the total study population of 28,007 respondents 14,966 (53%) were female (**Table 1**). The majority of the respondents were aged between 18 to 27 years and were African 22,560 (79%). Most respondents 9,152 (33%) had matric level of education and only 443 (1.6%) had no formal education. Close to half of the respondents were employed 13,582 (49%). The majority of the respondents stayed in formal dwellings 24,043 (86%). A large proportion of the respondents fall under the lower income bracket based on their total house hold income 13,015 (71%) lower class was defined in this study as families with a total household income of less than R6,400 per month while 2.3% fall under the upper class (Upper

class is a family with an income more than R51,200). Few respondents reported growing their own vegetables 3,480 (12%).

Table 1: Demographic characteristics across migration status

Variable	Level	Non- migrants	Internal migrants	External migrants	Total
Sex	Female	9,746 (65.12)	4,226 (28.24)	994 (6.64)	14,966
	Male	8,281 (63.50)	3,593 (27.55)	1,167 (8.95)	13,041
Age group	18-27	5,288 (64.54)	2,205 (26.91)	701 (8.56)	8,194
	28-37	4,400 (59.64)	2,197 (29.78)	781 (10.59)	7,378
	38-47	3,362 (64.46)	1,507 (28.89)	347 (6.65)	5,216
	48-57	2,456 (69.12)	938 (26.40)	159 (4.48)	3,553
	58-67	1,493 (71.78)	503 (24.18)	84 (4.04)	2,080
	68+	1,028 (64.82)	469 (29.57)	89 (5.61)	1,586
Race	African	13,819 (61.25)	6,901 (30.59)	1 840 (8.16)	22,560
	Coloured	940 (83.26)	180 (15.94)	9 (0.80)	1,129
	Indian/Asian	389 (62.94)	154 (24.92)	75 (12.14)	618
	White	2,848 (79.55)	575 (16.06)	157 (4.39)	3,580
	Other	31 (25.83)	9 (7.50)	80 (66.67)	120
Education	No education	223 (50.34)	162 (36.57)	58 (13.09)	443
	Primary only	1,621 (53.71)	1,029 (34.10)	368 (12.19)	3,018
	Secondary incomplete	5,007 (61.29)	2,451 (30.00)	712 (8.71)	8,170
	Matric	6,210 (67.85)	2,468 (26.97)	474 (5.18)	9,152
	More	4,399 (69.34)	1,526 (24.05)	419 (6.60)	6,344
	Unspecified	371 (65.78)	88 (15.60)	105 (18.62)	564
Employment status	Employed	8,426 (62.04)	3,838 (28.26)	1,318 (9.70)	13,582
	Unemployed	4,808 (63.82)	2,282 (30.29)	444 (5.89)	7,534
	Other	4,664 (69.80)	1,636 (24.48)	382 (5.72)	6,682
Dwelling	Formal	16,478 (68.54)	5,954 (24.76)	1,611 (6.70)	24,043
	Informal	1,442 (40.25)	1,659 (46.30)	482 (13.45)	3,583
	Other	107 (28.08)	206 (54.07)	68 (17.85)	381
Total HH Income	Lower Class	7,991 (61.40)	4,000 (30.73)	1,024 (7.87)	13,015
	Middle Class	3,325 (67.49)	1,246 (25.29)	356 (7.23)	4,927
	Upper class	291 (70.29)	85 (20.53)	38 (9.18)	414
Grow own vegetables	Do not grow vegetables	15,850 (64.62)	6,772 (27.61)	1,905 (7.77)	24,527
	Grow vegetables	2,177 (62.56)	1,047 (30.09)	256 (7.36)	3,480
Medical Aid	No medical insurance	12,219 (61.68)	5,883 (29.70)	1,707 (8.62)	19,809
	Medical insurance	4,927 (71.39)	1,617 (23.43)	358 (5.19)	6,902
Physical activity	Never	4,478 (58.59)	2,481 (32.46)	684 (8.95)	7,643
	Hardly ever	2,357 (66.17)	934 (26.22)	271 (7.61)	3,562
	Few times a month	2,447 (69.91)	851 (24.31)	202 (5.77)	3,500
	Few times a week	4,356 (67.14)	1,687 (26.00)	445 (6.86)	6,488

	Everyday	4,193 (64.53)	1,771 (27.25)	534 (8.22)	6,498
HH size	1-3	9,167 (60.67)	4,451 (29.46)	1,491 (9.87)	15,109
	4-6	6,736 (67.84)	2,631 (26.50)	562 (5.66)	9,929
	7+	1,928 (72.67)	642 (24.20)	83 (3.13)	2,653
HH Food security	Never	14,372 (64.51)	6,095 (27.36)	1,813 (8.14)	22,280
	Seldom	1,138 (65.25)	496 (28.44)	110 (6.31)	1,744
	Sometimes	2,008 (62.75)	993 (31.03)	199 (6.22)	3,200
	Often	345 (66.99)	147 (28.54)	23 (4.47)	515
	Always	164 (61.19)	88 (32.84)	16 (5.97)	268
SES quintiles	Richest	2,716 (49.27)	2,136 (38.74)	661 (11.99)	5,513
	2nd quintile	3,549 (63.89)	1,608 (28.95)	398 (7.16)	5,555
	3rd quintile	3,627 (66.03)	1,498 (27.27)	368 (6.70)	5,493
	4th quintile	3,972 (70.79)	1,293 (23.04)	346 (6.17)	5,611
	Poorest	4,066 (73.09)	1,146 (20.60)	351 (6.31)	5,563
Year moved to Gauteng	After 2009		1,543 (69.63)	673 (30.37)	2,216
	2005-2009		1,242 (67.83)	589 (32.17)	1,831
	1995-2004		2,524 (82.94)	519 (17.06)	3,043
	1985-1994		1,290 (85.60)	217 (14.40)	1,507
	Before 1985		1,219 (88.21)	163 (11.79)	1,382

The prevalent morbidities in Gauteng province

The overall prevalence of hypertension and diabetes was 15.5% (95% CI: 15.1-15.9), 11.2% (95% CI: 10.8-11.6), respectively (**Table 2**). The prevalence of hypertension and diabetes was higher among non-migrants.

Table 2: Prevalence of hypertension and diabetes

Characteristics	Hypertension % (95% CI)	Diabetes % (95% CI)
Overall	15.5 (15.1 - 15.9)	11.2 (10.8 - 11.6)
Age group years		
18-27	11.3 (10.5 - 12.1)	8.4 (7.7 - 9.1)
28-37	8.7 (8.1 - 9.4)	6.3 (5.7 - 6.8)
38-47	11.8 (11.0 - 12.6)	9.0 (8.3 - 9.7)
48-57	21.1 (19.9 - 22.5)	14.6 (13.5 - 15.8)
58-67	32.2 (30.3 - 34.1)	21.4 (19.7 - 23.1)
68+	39.8 (37.5 - 42.2)	30.5 (28.3 - 32.7)
Sex		
Male	12.1 (11.5 - 12.7)	10.1 (9.6 - 10.6)
Female	18.5 (17.9 - 19.1)	12.1 (11.7 – 12.7)
Migration status		
Non-migrant	16.8 (16.3 - 17.4)	12.6 (12.1 - 13.1)
Internal migrant	14.4 (13.7 - 15.2)	9.7 (9.1 - 10.4)
External migrant	8.1 (7.1 - 9.4)	5.1 (4.3 - 6.2)

Note: % = percentage, 95%CI = 95% Confidence Interval

The effect of migration status on hypertension and diabetes

The effect of migration status on hypertension and diabetes based on analysis of multilevel logistic regression models is presented on **Table 3.** Three models were fitted, the first model only included the individual or household factors, the second model included ward factors and the final model included all factors. Compared to non-migrants, internal migrants and external migrants in the final model had reduced odds of self-reporting hypertension with the OR of 0.86 (95% CI: 0.78-0.95) and 0.60 (95% CI: 0.49-0.75) respectively. Being a migrant was also associated with lower risk of diabetes with OR of 0.84 (95% CI: 0.75-0.94) and 0.53 (95% CI: 0.41-0.68). While there was a reduction in the variance between the null and full models and ICC vary for both outcomes. There was substantial residual between-ward variance in hypertension and diabetes with median odds ratio of 1.31 and 1.14 respectively as presented in the final model.

Table 3: The effect of migration status on the most prevalent morbidities

Characteristics	Null Model	Model 1[a] OR (95% CI)	Model 2[b] OR (95% CI)	Model 3[c] OR (95% CI)
Hypertension				
Migration status				
Non-migrant		1.00	1.00	1.00
Internal migrant		0.85 (0.77-0.95)	0.90 (0.83-0.97)	0.86 (0.78-0.95)
External migrant		0.59 (0.48-0.74)	0.52 (0.44-0.61)	0.60 (0.49-0.75)
Random Effects				
Between-ward variance (SE)	0.25 (0.050)	0.15 (0.035)	0.10 (0.023)	0.08 (0.021)
ICC	0.07	0.04	0.03	0.02
MOR	1.61 (1.46-1.76)	1.45 (1.33-1.57)	1.35(1.26-1.44)	1.31 (1.22-1.40)
Diabetes				
Migration status				
Non-migrant		1.00	1.00	1.00
Internal migrant		0.84 (0.75-0.94)	0.77 (0.70-0.84)	0.84 (0.75-0.94)
External migrant		0.51 (0.40-0.66)	0.41 (0.37-0.50)	0.53 (0.41-0.68)
Random Effects				
Between-ward variance (SE)	0.05 (0.014)	0.04 (0.015)	0.02 (0.007)	0.02 (0.011)
ICC	0.02	0.01	0.01	0.00
MOR	1.24 (1.17-1.31)	1.22 (1.13-1.30)	1.13 (1.07-1.19)	1.14 (1.06-1.22)

Note: OR = Odds ratio, 95%CI = 95% Confidence Interval, ICC = intraclass correlation coefficient, MOR = median odds ratio, [a] = the individual/HH level factors, [b] = the Ward level factors and [c] = all factors.

To further assess effect modification of age, race and SES, we ran grade-stratified analysis. The association between migration status and hypertension is significantly modified by race. For Africans, migration status (both internal and external) was associated with lower odds of hypertension, while internal and external Asian migrants have higher odds of hypertension. From the interaction assessment between migration status and race, age group and socioeconomic status, respectively were found to be effect modifiers for hypertension (**Figure 1**) and diabetes (**Figure 2**).

Figure 1: Association between migration status and hypertension, by race, age group and SES
Figure shows race-, age group- and SES-stratified, fully adjusted ORs in hypertension and associated 95% CIs.

Figure 2: Association between migration status and diabetes, by race, age group and SES

Figure shows race-, age group- and SES-stratified, fully adjusted ORs in diabetes and associated 95% CIs.

Discussion

The findings from this study provide important information on migration status and the prevalence of morbidities among residents of 508 administrative wards in Gauteng province from a population-based survey. The study also adds to a pool of knowledge on prevalent morbidities and migration status in Gauteng province South Africa. The major strength of this study is that it tries to assess prevalence of morbidities and predictors of the most prevalent morbidities from a large population-based survey. The potential of the study was maximized and included the vulnerable population like migrants. The migrants made up 36% of the total respondents.

The most prevalent morbidities in Gauteng province were hypertension and diabetes at 15,5% and 11.2% respectively. The prevalence of diabetes in South Africa is increasing rapidly [15]. In 2009 it was approximately 9% among those aged 30 years and older [16]. Based on the population census the prevalence of diabetes was around 7% according to the International Diabetes Federation (IDF) [17, 18]. Hypertension was found to be around 14.0% for those aged 25 and older [19]. South African National Health and Nutrition Examination Survey (SANHANES) reported slightly higher prevalence of diabetes (19.4%) and hypertension (25.7%) [8]. Hypertension and diabetes were higher among non-migrants. The migrant population is believed to keep increasing in different countries; their heterogeneity becomes apparent with respect to the differences in the prevalence of diseases [7]. Prevalence is likely to increase therefore, these findings can be used to inform future policy, planning and funding allocation to assist in controlling as well as managing different conditions [20].

Migration status was associated with prevalence of two non-communicable conditions. Non-communicable diseases are the most common health problem and are the primary cause of death in many countries [21]. Research revealed that compared to native-born respondents, migrants reported better health [22]. This is consistent with our findings, migrants reported lower prevalence of diabetes and hypertension. Effect of migration status on health differed by age group, race and socio-economic status. Migrants might find themselves in a worse socioeconomic status, with less access to health care services, and experiencing greater linguistic and cultural barriers related to accessing health information, despite the conditions they tend to have better health profiles compared to the natives [23]. A number of studies have shown that this health advantage deteriorates over time and with successive generations [22, 24, 25]. There is a lack of studies on morbidity among migrants compared to natives [7]. This study clearly demonstrates a need for more research on migration and different morbidities.

Strengths and limitations

This study contributes to the pool of knowledge as little research has been done on migration status and morbidities in Gauteng province, South Africa. Assessment of predicts for the most prevalent morbidities was done from a very large population based representative sample survey. Therefore, the power of the study to detect significant associations was maximized. The respondents were selected by random sampling thus both internal and external validity of the study were improved. The study included the migrant population and little research has been done on the morbidities affecting this sub-population. A wide variety of socio-demographic factors were employed to assess their association with the two most prevalent morbidities.

The morbidities were self-reported thus prevalence might be underestimated. Self-reported data can be biased by differential access to healthcare services between groups of different

socioeconomic status [26]. When self-reported information was compared with medical records or clinical measurements from health examination surveys in Colorado, Netherlands and 12 countries in Europe, self-reported information underestimated the prevalence of hypertension [27, 28].

Missing data of some important health-related information, might have resulted in residual confounding because of unmeasured potential confounders.

Conclusion

Migration status is associated with two non-communicable conditions prevalent in Gauteng province. From the public health perspective, it is important to evaluate the prevalence of morbidities because the information can inform the development of prevention programme on a community level.

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Author contributions

Concept and design of the study: JN, Acquisition of data: JN, Analysis and interpretation of data: JN, MM, Drafting the manuscript: JN, MM, Revising the manuscript critically for important intellectual content: JN, MM and approval of the manuscript to be published: JN and MM

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics and Consent

For the primary study ethics approval was obtained from the local ethics committee and the Human Research Ethics Committee of University of the Witwatersrand. All respondents provided informed consent before data collection. The study was granted ethics clearance by the Human Research Ethics Committee of University of the Witwatersrand.

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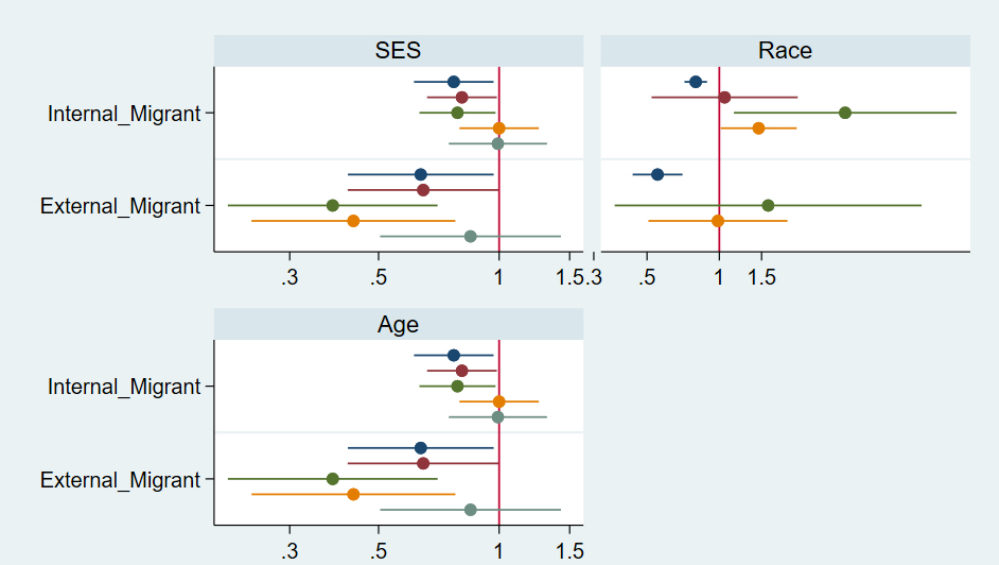
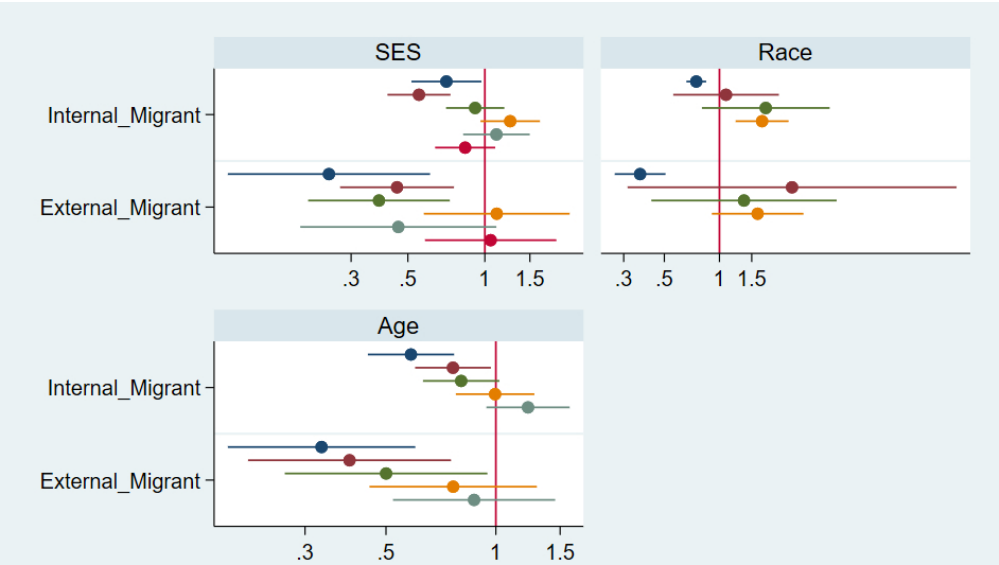


Association between migration status and hypertension, by race, age group and SES



Association between migration status and diabetes, by race, age group and SES

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

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	2
Objectives	3	State specific objectives, including any pre-specified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3
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	3
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	3
		(*b*) Describe any methods used to examine subgroups and interactions	4
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	

		(*e*) Describe any sensitivity analyses	
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	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	3
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	3
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	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	4
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
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	9

*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

Migration status and prevalence of diabetes and hypertension in Gauteng province, South Africa: effect modification by demographic and socio-economic characteristics-A cross-sectional population-based study

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Migration status and prevalence of diabetes and hypertension in Gauteng province, South Africa: effect modification by demographic and socio-economic characteristics- A cross-sectional population-based study

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Abstract

Introduction: Evidence from developing countries suggests that migration status has an impact on health. However, little is known about the effect that migration status has on morbidity in sub-Saharan Africa. The aim of this study is to investigate the association between migration status and hypertension and diabetes and to assess whether the association was modified by demographic and socio-economic characteristics.
Methods: A Quality of Life survey conducted in 2015 collected data on migration status and morbidity from a sample of 28,007 adults in 508 administrative wards in Gauteng province. Migration status was divided into three groups: non-migrant if born in Gauteng province, internal migrant if born in other South African provinces, and external migrant if born outside of South Africa. Diabetes and hypertension were defined based on self-reported clinical diagnosis. We applied a recently developed original, stepwise-multilevel logistic regression of discriminatory accuracy to investigate the association between migration status and hypertension and diabetes. Potential effect modification by age, sex, race, SES and ward-level deprivation on the association between migration status and morbidities was tested.
Results: Migrants have lower prevalence of diabetes and hypertension. In multilevel models, migrants had lower odds of reporting hypertension than internal migrants (OR = 0.86 95%CI: 0.78-0.95) and external migrant (OR = 0.60; 95%CI: 0.49-0.75). Being a migrant was also associated with lower diabetes prevalence than being an internal migrant (OR = 0.84; 95%CI: 0.75-0.94) and external migrant (OR = 0.53; 95%CI: 0.41-0.68). Age, race and SES were significant effect modifiers of the association between migration status and morbidities. There was also substantial residual between-ward variance in hypertension and diabetes with median odds ratio of 1.61 and 1.24, respectively.
Conclusions: Migration status is associated with prevalence of two non-communicable conditions. The association was modified by age, race and SES. Ward-level effects also explain differences in association.

Keywords: migration status, prevalence, diabetes, hypertension and Gauteng province.

Strengths and limitations of this study

- The study population is part of a provincial representative sample on quality of life of adult residents in Gauteng province.
- The association between migration and health was analysed by applying, stepwise-multilevel logistic regression of discriminatory accuracy.
- Migrants (both internal and external) had lower odds of both hypertension and diabetes than people born in Gauteng province.
- Effect of migration status on health differed by age, race and SES.
- However, residual confounding is possible due to data availability.

Introduction

Migration status is one of the important socioeconomic determinants of health [1]. Migration is also associated with profound social, economic and cultural changes, which may affect the migrant's health [2]. Post the year 2005, more than 62% of the South African population were living in urban areas, with the rapid urbanization being attributed to migration [3, 4]. The rapid urbanization and increase in the urban poor in metropolitan areas of Gauteng province, South Africa has become a major public health concern due to its linkage with increased disease burden [5, 6].

Migrants are heterogeneous both in their origin status and migration histories. Gauteng province attracts both internal and external migrants [3, 4]. Several studies on migration and morbidities have been done worldwide [1, 2, 7]. Morbidities often present with low functioning level, poorer quality of life, increased health care utilization and mortality rates [7]. The age standardized global prevalence of diabetes has nearly doubled since 1980, from 4.7% to 8.5% in the adult population in 2014 [8]. In 2010, 31% of the global adult population had hypertension [9]. The first South African National Health and Nutrition Examination Survey (SANHANES) reported the prevalence of 19.4% and 25.7% for diabetes and hypertension respectively in Gauteng province [10]. However, little is known about the prevalence of these morbidities among different migrant status. The prevalence of diabetes and hypertension in Gauteng province is high. Gauteng provides is home to many migrants. Therefore, a better understanding of the differences in morbidities according to different migration status is needed to target high risk groups in provision of services and to arrest the growing burden of certain diseases.

Study objectives

The study aims to:

- Investigate the association between morbidities and migration status in Gauteng province, South Africa.
- To assess whether the association was modified by demographic and socio-economic characteristics.

Methods

Study setting

Gauteng is the province with the largest population, estimated to be 12,272263, despite having the smallest area; thus, it has the highest population density in South Africa of 675 people per km^2 [11]. According to data from Census 2011 Gauteng province accounted for the highest concentration of international and internal migrants in South Africa, approximately 7.4% and 44% respectively [12]. The study population consists of all people residing permanently in Gauteng province who were aged 18 or older in 2015.

Data sources

We used data from the fourth Quality of Life (QoL) survey conducted by Gauteng City Region Observatory (GCRO) in Gauteng province in 2015. The QoL survey has been conducted every 2 years since 2009 with the intention of providing up-to-date information on 'a fast growing and dynamic urban region' to support 'better planning and management, and improved co-operative government relations' [13]. QoL survey measured a wide range of variables including socio-demographic variables, migration status and self-reported health status from a sample of 28,007 adults in 508 administrative wards in Gauteng province. The data on ward-level migrant African population, African population, migrant SADC population, employed

population, no income population, deprivation index (sampi) and average household size was obtained from Statistics South Africa (StatsSA).

Survey design

Simple random sampling was employed to select the respondents. Gauteng province consists of 10 municipalities and it is subdivided into 508 wards. Within these wards, there are Small Area Levels (SALs) which were derived from the Population Census Enumerator Area (EA) polygons. SAL codes and geography were derived from the Statistics South Africa Census 2011 report. The simple random sampling method was used to select the SALs from each ward, and then the minimum numbers of interviews for each ward were 30 and 60 interviews for those falling in district municipalities and metropolitan municipalities, respectively. The end result was that across the 508 wards, 28,456 successful interviews were completed, and these interviews were distributed across 16,400 SALs out of a total of 17,840 SALs. The 'NEXT' birthday method was used to select the respondents from the selected households. Data were collected via a digital data collection instrument using an open source system called Formhub and administered on a tablet device. Questionnaires were administered in the field and uploaded using Internet connectivity to a cloud server from where they could be accessed and downloaded online.

Patient and Public Involvement

The development of the research questions and outcome measures were not informed by patients' priority experiences and preferences. Patients were not involved in the design of this study. Patients were not involved in the recruitment and conduct of the study. This study used data from 2015 QoL survey which measured a wide range of variables including socio-demographic variables, migration status and self-reported health status.

Outcome and independent variables

The main outcomes were hypertension and diabetes. The information on disease status, such as diabetes, hypertension, HIV, TB, Influenza, and others, was collected in the QoL survey by asking question: "In the past 12 months, have you been told by health provider that you have one or more of the following conditions. The morbidities were binary variables measuring the presence of the different morbidities, coded as 1 (or 'yes') if the respondents self-reported the morbidity and as 0 (or 'no') if the respondent did not report the presence of a given morbidity.

Migration status was derived from the following QoL survey questions: (i) *"Were you born in Gauteng province or did you move into Gauteng province from another province or country?"*; (ii) *When (year) did you move into Gauteng province?*; (iii) *Did you move to Gauteng province from a province in South Africa or from another country?;* (iv) *From which province did you move from into Gauteng province?; and* (v) *Which country did you move into Gauteng province from?.* Migration status then was divided into three groups: non-migrant, internal migrant, and external migrant. The explanatory variables included sex, age, race, education, employment status, dwelling, total household income, grow own vegetables, medical aid, physical activity, household size, household food security and socioeconomic status quintile. Information collected included demographic and socio-economic variables: sex (female, male); age (18 years and above); race (African, Coloured, Indian/Asian, White and Other); Education was categorized into 'No formal education', grades R-7 'Primary only', grades 8-11 'Secondary incomplete', 'Matric' grade 12 'More' Tertiary and above and 'Unspecified' for those who didn't specify; employment status ('employed', 'unemployed and other).

Dwelling (formal, informal and other); Total household income was categorized into 'Lower class income' (< 6400 Rand [ZAR] per month), 'Middle class income' (R6400 - R51, 200 per month) and 'Upper class income' (> R51, 200 per month); grow own vegetables (do not grow own vegetables and grow their own vegetables); Medical insurance was categorized into 'medically insured' for respondents with either medical aid or a hospital plan and 'medically not insured' for respondents without any of these; physical activity (never, hardly ever, few

times a month, few times a week and everyday); household size (1-3, 4-6 and 7+); household food security (never, seldom, sometimes, often and always) and socioeconomic status quintile (richest, 2nd, 3rd, 4th and poorest). The ward level variables included migrant African population, African population, migrant SADC population, employed population, no income population, sampi and household of less than three.

Analysis

Descriptive analysis was performed to describe the migration status of the community by socio demographic characteristics of study respondents using proportions. The prevalence of morbidities in Gauteng province, South Africa was estimated using proportions and presented as percentages with 95% confidence intervals. Prevalence of morbidities was stratified by age, gender and migration status.

In the present analysis the data used was in multilevel structure as the respondents were within administrative wards [14]. We applied a recently developed original, stepwise-multilevel logistic regression of discriminatory accuracy to investigate the effect of migration status. We fitted separate models for effect of migration status and diabetes and hypertension, respectively. Four progressively adjusted multilevel models were carried out: model 0 with no covariates; model 1 including only sociodemographic characteristics at the individual level; model 2 additionally analysing municipal deprivation as contextual variable and model 3 is the full adjusted model. The models were adjusted for years in GP, age, sex, race, dwelling, education level, household size, household head, physical activity, medical aid, grow own vegetables, household food security, sampi, year moved to GP and socioeconomic status quintile. Potential effect modification by age, sex, race, SES and sampi was tested.

To take account of the hierarchical data structure (level 1: individuals; level 2: administrative wards), an Intraclass Correlation Coefficient (ICC) and ward-level variances were reported for every model and for reasons of better interpretability, ward-level variances were converted into median ORs (MORs) by applying the formula of Merlo *et al*, [14, 15]. Multilevel logistic regression analyses with administrative wards as random intercepts were performed calculating ORs with their 95% CIs. ORs were plotted using the user-written *coefplot* Stata command [16]. All analysis was performed using Stata version 13 (Stata Corporation, College Station, Texas, USA).

Results

Most respondents were non-migrants 18,027 (64%) and the external migrants constituted only 8% of the total respondents. Of the total study population of 28,007 respondents 14,966 (53%) were female (**Table 1**). The majority of the respondents were aged between 18 to 27 years and were African 22,560 (81%). Most respondents 9,152 (33%) had matric level of education and only 443 (1.6%) had no formal education. Close to half of the respondents were employed 13,582 (49%). The majority of the respondents stayed in formal dwellings 24,043 (86%). A large proportion of the respondents fall under the lower income bracket based on their total house hold income 13,015 (71%) lower class was defined in this study as families with a total household income of less than R6,400 per month while 2.3% fall under the upper class (Upper class is a family with an income more than R51,200). Few respondents reported growing their own vegetables 3,480 (12%).

Table 1: Demographic characteristics across migration status

Variable	Level	Non- migrants	Internal migrants	External migrants	Total
Sex	Female	9,746 (54.06)	4,226 (54.05)	994 (46.00)	14,966 (53.44)
	Male	8,281 (45.94)	3,593 (45.95)	1,167 (54.00)	13,041 (46.56)
Age group	18-27	5,288 (29.33)	2,205 (28.20)	701 (32.44)	8,194 (29.26)

	28-37	4,400 (24.41)	2,197 (28.10)	781 (36.14)	7,378 (26.34)
	38-47	3,362 (18.65)	1,507 (19.27)	347 (16.06)	5,216 (18.62)
	48-57	2,456 (13.62)	938 (12.00)	159 (7.36)	3,553 (12.69)
	58-67	1,493 (8.28)	503 (6.43)	84 (3.89)	2,080 (7.43)
	68+	1,028 (5.70)	469 (6.00)	89 (4.12)	1,586 (5.66)
Race	African	13,819 (76.66)	6,901 (88.26)	1 840 (85.15)	22,560 (80.55)
	Coloured	940 (5.21)	180 (2.30)	9 (0.42)	1,129 (4.03)
	Indian/Asian	389 (2.16)	154 (1.97)	75 (3.47)	618 (2.21)
	White	2,848 (15.80)	575 (7.35)	157 (7.27)	3,580 (12.78)
	Other	31 (0.17)	9 (0.12)	80 (3.70)	120 (0.43)
Education	No education	223 (1.25)	162 (2.10)	58 (2.72)	443 (1.60)
	Primary only	1,621 (9.09)	1,029 (13.32)	368 (17.23)	3,018 (10.90)
	Secondary incomplete	5,007 (28.08)	2,451 (31.73)	712 (33.33)	8,170 (29.50)
	Matric	6,210 (34.83)	2,468 (31.95)	474 (22.19)	9,152 (33.05)
	More	4,399 (24.67)	1,526 (19.76)	419 (19.62)	6,344 (22.91)
	Unspecified	371 (2.08)	88 (1.14)	105 (4.92)	564 (2.04)
Employment status	Employed	8,426 (47.08)	3,838 (49.48)	1,318 (61.47)	13,582 (48.86)
	Unemployed	4,808 (26.86)	2,282 (29.42)	444 (20.71)	7,534 (27.10)
	Other	4,664 (26.06)	1,636 (21.09)	382 (17.82)	6,682 (24.04)
Dwelling	Formal	16,478 (91.41)	5,954 (76.15)	1,611 (74.55)	24,043 (85.85)
	Informal	1,442 (8.00)	1,659 (21.22)	482 (22.30)	3,583 (12.79)
	Other	107 (0.59)	206 (2.63)	68 (3.15)	381 (1.36)
Total HH Income	Lower Class	7,991 (68.85)	4,000 (75.03)	1,024 (72.21)	13,015 (70.90)
	Middle Class	3,325 (28.65)	1,246 (23.37)	356 (25.11)	4,927 (26.84)
	Upper class	291 (2.51)	85 (1.59)	38 (2.68)	414 (2.26)
Grow own vegetables	Do not grow vegetables	15,850 (87.92)	6,772 (86.61)	1,905 (88.15)	24,527 (87.57)
	Grow vegetables	2,177 (12.08)	1,047 (13.39)	256 (11.85)	3,480 (12.43)
Medical Aid	No medical insurance	12,219 (71.26)	5,883 (78.44)	1,707 (82.66)	19,809 (74.16)
	Medical insurance	4,927 (28.74)	1,617 (21.56)	358 (17.34)	6,902 (25.84)
Physical activity	Never	4,478 (25.11)	2,481 (32.12)	684 (32.02)	7,643 (27.60)
	Hardly ever	2,357 (13.22)	934 (12.09)	271 (12.69)	3,562 (12.86)
	Few times a month	2,447 (13.72)	851 (11.02)	202 (9.46)	3,500 (12.64)
	Few times a week	4,356 (24.43)	1,687 (21.84)	445 (20.83)	6,488 (23.43)
	Everyday	4,193 (23.52)	1,771 (22.93)	534 (25.00)	6,498 (23.47)
HH size	1-3	9,167 (51.41)	4,451 (57.63)	1,491 (69.80)	15,109 (54.56)
	4-6	6,736 (37.78)	2,631 (34.06)	562 (26.31)	9,929 (35.86)
	7+	1,928 (10.81)	642 (8.31)	83 (3.89)	2,653 (9.58)
HH Food security	Never	14,372 (79.72)	6,095 (77.95)	1,813 (83.90)	22,280 (79.55)
	Seldom	1,138 (6.31)	496 (6.34)	110 (5.09)	1,744 (6.23)
	Sometimes	2,008 (11.14)	993 (12.70)	199 (9.21)	3,200 (11.43)
	Often	345 (1.91)	147 (1.88)	23 (1.06)	515 (1.84)
	Always	164 (0.91)	88 (1.13)	16 (0.74)	268 (0.96)
SES quintiles	Richest	2,716 (15.15)	2,136 (27.81)	661 (31.12)	5,513 (19.88)

	2nd quintile	3,549 (19.79)	1,608 (20.93)	398 (18.74)	5,555 (20.03)
	3rd quintile	3,627 (20.23)	1,498 (19.50)	368 (17.33)	5,493 (19.81)
	4th quintile	3,972 (22.15)	1,293 (16.83)	346 (16.29)	5,611 (20.23)
	Poorest	4,066 (22.68)	1,146 (14.92)	351 (16.53)	5,563 (20.06)
Year moved to Gauteng	After 2009		1,543 (19.74)	673 (31.14)	2,216 (22.21)
	2005-2009		1,242 (15.89)	589 (27.26)	1,831 (18.35)
	1995-2004		2,524 (32.28)	519 (24.02)	3,043 (30.49)
	1985-1994		1,290 (16.50)	217 (10.04)	1,507 (15.10)
	Before 1985		1,219 (15.59)	163 (7.54)	1,382 (13.85)

The prevalent morbidities in Gauteng province

The overall prevalence of hypertension and diabetes was 15.5% (95% CI: 15.1-15.9), 11.2% (95% CI: 10.8-11.6), respectively (**Table 2**). The prevalence of hypertension and diabetes was higher among non-migrants.

Table 2: Prevalence of hypertension and diabetes

Characteristics	Hypertension % (95% CI)	Diabetes % (95% CI)
Overall	15.5 (15.1 - 15.9)	11.2 (10.8 - 11.6)
Age group years		
18-27	11.3 (10.5 - 12.1)	8.4 (7.7 - 9.1)
28-37	8.7 (8.1 - 9.4)	6.3 (5.7 - 6.8)
38-47	11.8 (11.0 - 12.6)	9.0 (8.3 - 9.7)
48-57	21.1 (19.9 - 22.5)	14.6 (13.5 - 15.8)
58-67	32.2 (30.3 - 34.1)	21.4 (19.7 - 23.1)
68+	39.8 (37.5 - 42.2)	30.5 (28.3 - 32.7)
Sex		
Male	12.1 (11.5 - 12.7)	10.1 (9.6 - 10.6)
Female	18.5 (17.9 - 19.1)	12.1 (11.7 - 12.7)
Migration status		
Non-migrant	16.8 (16.3 - 17.4)	12.6 (12.1 - 13.1)
Internal migrant	14.4 (13.7 - 15.2)	9.7 (9.1 - 10.4)
External migrant	8.1 (7.1 - 9.4)	5.1 (4.3 - 6.2)

Note: % = percentage, 95%CI = 95% Confidence Interval

The effect of migration status on hypertension and diabetes

The effect of migration status on hypertension and diabetes based on analysis of multilevel logistic regression models is presented on **Table 3.** Three models were fitted, the first model only included the individual or household factors, the second model included ward factors and the final model included all factors. Compared to non-migrants, internal migrants and external migrants in the final model had reduced odds of self-reporting hypertension with the OR of 0.86 (95% CI: 0.78-0.95) and 0.60 (95% CI: 0.49-0.75) respectively. Being a migrant was also associated with lower risk of diabetes with OR of 0.84 (95% CI: 0.75-0.94) and 0.53 (95% CI: 0.41-0.68). While there was a reduction in the variance between the null and full models and ICC vary for both outcomes. There was substantial residual between-ward variance in hypertension and diabetes with median odds ratio of 1.31 and 1.14 respectively as presented in the final model.

Table 3: The effect of migration status on the most prevalent morbidities

Characteristics	Null Model	Model 1[a] OR (95% CI)	Model 2[b] OR (95% CI)	Model 3[c] OR (95% CI)
Hypertension				

Migration status				
Non-migrant		1.00	1.00	1.00
Internal migrant		0.85 (0.77-0.95)	0.90 (0.83-0.97)	0.86 (0.78-0.95)
External migrant		0.59 (0.48-0.74)	0.52 (0.44-0.61)	0.60 (0.49-0.75)
Random Effects				
Between-ward variance (SE)	0.25 (0.050)	0.15 (0.035)	0.10 (0.023)	0.08 (0.021)
ICC	0.07	0.04	0.03	0.02
MOR	1.61 (1.46-1.76)	1.45 (1.33-1.57)	1.35(1.26-1.44)	1.31 (1.22-1.40)
Diabetes				
Migration status				
Non-migrant		1.00	1.00	1.00
Internal migrant		0.84 (0.75-0.94)	0.77 (0.70-0.84)	0.84 (0.75-0.94)
External migrant		0.51 (0.40-0.66)	0.41 (0.37-0.50)	0.53 (0.41-0.68)
Random Effects				
Between-ward variance (SE)	0.05 (0.014)	0.04 (0.015)	0.02 (0.007)	0.02 (0.011)
ICC	0.02	0.01	0.01	0.00
MOR	1.24 (1.17-1.31)	1.22 (1.13-1.30)	1.13 (1.07-1.19)	1.14 (1.06-1.22)

Note: OR = Odds ratio, 95%CI = 95% Confidence Interval, ICC = intraclass correlation coefficient, MOR = median odds ratio, **Model 1**[a] = the individual/HH level factors, **Model 2**[b] = the Ward level factors and **Model 3**[c] = all factors.

To further assess effect modification of age, race and SES, we ran grade-stratified analysis. The association between migration status and hypertension is significantly modified by race. For Africans, migration status (both internal and external) was associated with lower odds of hypertension, while internal and external Asian migrants have higher odds of hypertension. From the interaction assessment between migration status and race, age group and socioeconomic status, respectively were found to be effect modifiers for hypertension (**Figure 1**) and diabetes (**Figure 2**).

Figure 1: Association between migration status and hypertension, by SES, race and age group
Figure shows SES-, race-, and age group-stratified, fully adjusted ORs in hypertension and associated 95% CIs.

Figure 2: Association between migration status and diabetes, by SES, race, and age group
Figure shows SES-, race-, and age group- stratified, fully adjusted ORs in diabetes and associated 95% CIs.

Discussion

The findings from this study provide important information on migration status and the prevalence of morbidities among residents of 508 administrative wards in Gauteng province from a population-based survey. The study indicates that migration status is associated with prevalence hypertension and diabetes conditions. Internal and external migrants had lower odds of both hypertension and diabetes than people born in Gauteng province. Age, race and SES of the respondents were significant effect modifiers of the association between migration status and morbidities. The major strength of this study is that it assesses prevalence of morbidities and predictors of the most prevalent morbidities from a large population-based survey. The potential of the study was maximized and included the vulnerable population like migrants. The migrants made up 36% of the total respondents.

The most prevalent morbidities in Gauteng province were hypertension and diabetes at 15,5% and 11.2% respectively. The prevalence of diabetes in South Africa is increasing rapidly [17]. In 2009 it was approximately 9% among those aged 30 years and older [18]. Based on the population census the prevalence of diabetes was around 9% according to the International Diabetes Federation (IDF) [19, 20]. Hypertension was found to be around 14.0% for those aged 25 and older [21]. SANHANES reported slightly higher prevalence of diabetes (19.4%)

and hypertension (25.7%) [10]. Hypertension and diabetes were higher among non-migrants. The migrant population is believed to keep increasing in different countries; their heterogeneity becomes apparent with respect to the differences in the prevalence of diseases [7]. Prevalence is likely to increase therefore, these findings can be used to inform future policy, planning and funding allocation to assist in controlling as well as managing different conditions [22].

Migration status was associated with prevalence of two non-communicable conditions. Non-communicable diseases are the most common health problem and are the primary cause of death in many countries [23]. Research revealed that compared to native-born respondents, migrants reported better health [24]. This could be attributed to healthy migration effect, healthier individuals are more likely to migrate. This is consistent with our findings, migrants reported lower prevalence of diabetes and hypertension. Reasons for migration were not included in the questionnaire administered in the primary study; these might have a bearing on the prevalence of hypertension and diabetes among migrants in Gauteng province. Effect of migration status on health differed by age group, race and socio-economic status. Migrants might find themselves in a worse socioeconomic status, with less access to health care services, and experiencing greater linguistic and cultural barriers related to accessing health information, despite the conditions they tend to have better health profiles compared to the natives [25]. A number of studies have shown that this health advantage deteriorates over time and with successive generations [24, 26, 27]. There is a lack of studies on morbidity among migrants compared to natives [7]. This study clearly demonstrates a need for more research on migration and different morbidities.

Strengths and limitations

This study contributes to the pool of knowledge as little research has been done on migration status and morbidities in Gauteng province, South Africa. Assessment of predicts for the most prevalent morbidities was done from a very large population based representative sample survey. Therefore, the power of the study to detect significant associations was maximized. The respondents were selected by random sampling thus both internal and external validity of the study were improved. The study included the migrant population and little research has been done on the morbidities affecting this sub-population. A wide variety of socio-demographic factors were employed to assess their association with the two most prevalent morbidities.

The morbidities were self-reported thus prevalence might be underestimated. Self-reported data can be biased by differential access to healthcare services between groups of different socioeconomic status [28]. When self-reported information was compared with medical records or clinical measurements from health examination surveys in Colorado, Netherlands and 12 countries in Europe, self-reported information underestimated the prevalence of hypertension [29, 30]. It is worth noting that the results from these studies may not be valid for the South African context. This calls for more research on migration status and morbidities, as well as validity studies of self-reported morbidities in the South African setting.

Missing data of some important health-related information, might have resulted in residual confounding because of unmeasured potential confounders.

Conclusion

Migration status is associated with two non-communicable conditions prevalent in Gauteng province. From the public health perspective, it is important to evaluate the prevalence of morbidities because the information can inform the development of prevention programme on a community level.

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Author contributions
Concept and design of the study: JN, Acquisition of data: JN, Analysis and interpretation of data: JN, MM, Drafting the manuscript: JN, MM, Revising the manuscript critically for important intellectual content: JN, MM and approval of the manuscript to be published: JN and MM

Disclosure statement
No potential conflict of interest was reported by the authors.

Ethics and Consent
For the primary study ethics approval was obtained from the local ethics committee and the Human Research Ethics Committee of University of the Witwatersrand. All respondents provided informed consent before data collection. The study was granted ethics clearance by the Human Research Ethics Committee of University of the Witwatersrand.

Data Availability Statement
Data may be obtained from a third party and are not publicly available. The de-identified participant data are available from GCRO.

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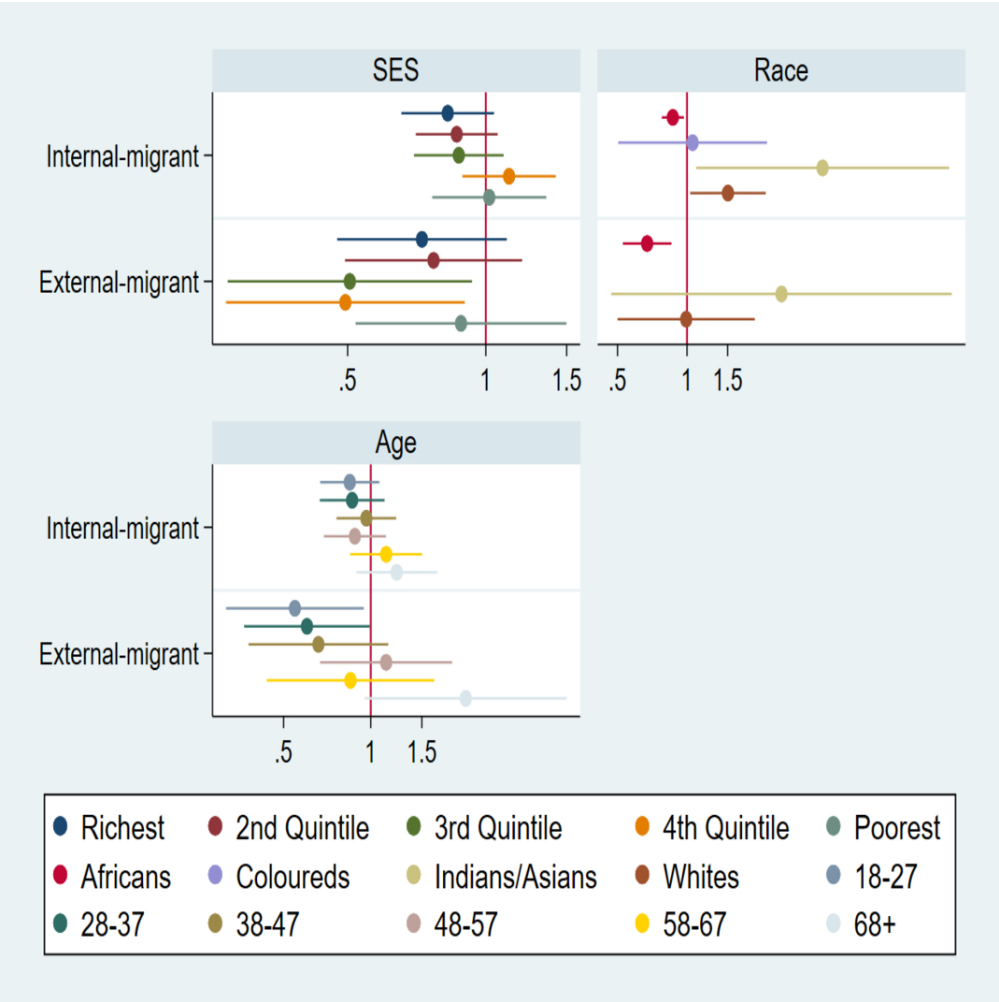

Association between migration status and hypertension, by SES, race and age group

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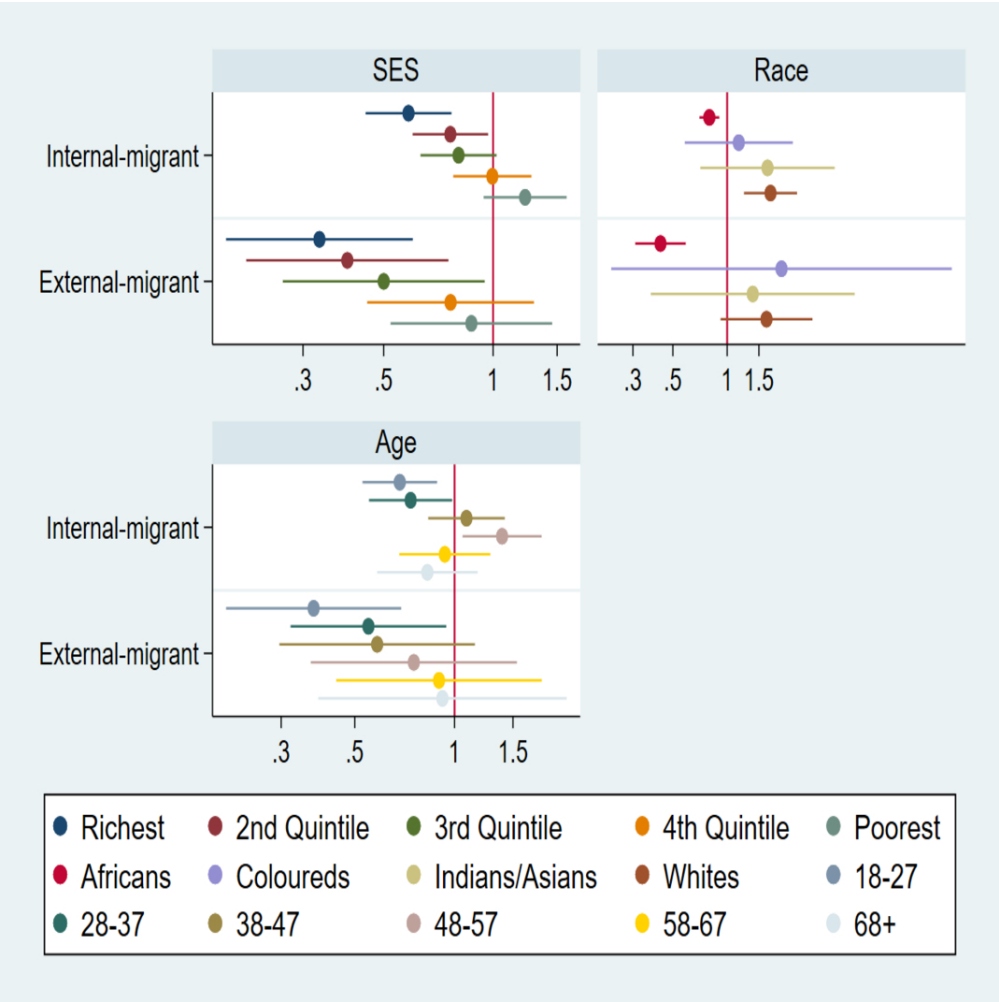

Association between migration status and diabetes, by SES, race, and age group

90x90mm (300 x 300 DPI)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

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	2
Objectives	3	State specific objectives, including any pre-specified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3
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	3
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	3
		(*b*) Describe any methods used to examine subgroups and interactions	4
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	

		(*e*) Describe any sensitivity analyses	
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	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	3
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	3
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	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	4
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
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	9

*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

Migration status and prevalence of diabetes and hypertension in Gauteng province, South Africa: effect modification by demographic and socio-economic characteristics-A cross-sectional population-based study

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Migration status and prevalence of diabetes and hypertension in Gauteng province, South Africa: effect modification by demographic and socio-economic characteristics- A cross-sectional population-based study

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Abstract

Introduction: Evidence from developing countries suggests that migration status has an impact on health. However, little is known about the effect that migration status has on morbidity in sub-Saharan Africa. The aim of this study is to investigate the association between migration status and hypertension and diabetes and to assess whether the association was modified by demographic and socio-economic characteristics.
Methods: A Quality of Life survey conducted in 2015 collected data on migration status and morbidity from a sample of 28,007 adults in 508 administrative wards in Gauteng province. Migration status was divided into three groups: non-migrant if born in Gauteng province, internal migrant if born in other South African provinces, and external migrant if born outside of South Africa. Diabetes and hypertension were defined based on self-reported clinical diagnosis. We applied a recently developed original, stepwise-multilevel logistic regression of discriminatory accuracy to investigate the association between migration status and hypertension and diabetes. Potential effect modification by age, sex, race, SES and ward-level deprivation on the association between migration status and morbidities was tested.
Results: Migrants have lower prevalence of diabetes and hypertension. In multilevel models, migrants had lower odds of reporting hypertension than internal migrants (OR = 0.86 95%CI: 0.78-0.95) and external migrant (OR = 0.60; 95%CI: 0.49-0.75). Being a migrant was also associated with lower diabetes prevalence than being an internal migrant (OR = 0.84; 95%CI: 0.75-0.94) and external migrant (OR = 0.53; 95%CI: 0.41-0.68). Age, race and SES were significant effect modifiers of the association between migration status and morbidities. There was also substantial residual between-ward variance in hypertension and diabetes with median odds ratio of 1.61 and 1.24, respectively.
Conclusions: Migration status is associated with prevalence of two non-communicable conditions. The association was modified by age, race and SES. Ward-level effects also explain differences in association.

Keywords: migration status, prevalence, diabetes, hypertension and Gauteng province.

Strengths and limitations of this study

- The study population is part of a provincial representative sample on quality of life of adult residents in Gauteng province.
- The association between migration and health was analysed by applying, stepwise-multilevel logistic regression of discriminatory accuracy.
- Migrants (both internal and external) had lower odds of both hypertension and diabetes than people born in Gauteng province.
- Effect of migration status on health differed by age, race and SES.
- However, residual confounding is possible due to data availability.

Introduction

Migration status is one of the important socioeconomic determinants of health [1]. Migration is also associated with profound social, economic and cultural changes, which may affect the migrant's health [2]. Post the year 2005, more than 62% of the South African population were living in urban areas, with the rapid urbanization being attributed to migration [3, 4]. The rapid urbanization and increase in the urban poor in metropolitan areas of Gauteng province, South Africa has become a major public health concern due to its linkage with increased disease burden [5, 6].

Migrants are heterogeneous both in their origin status and migration histories. Gauteng province attracts both internal and external migrants [3, 4]. Several studies on migration and morbidities have been done worldwide [1, 2, 7]. Morbidities often present with low functioning level, poorer quality of life, increased health care utilization and mortality rates [7]. The age standardized global prevalence of diabetes has nearly doubled since 1980, from 4.7% to 8.5% in the adult population in 2014 [8]. In 2010, 31% of the global adult population had hypertension [9].

The first South African National Health and Nutrition Examination Survey (SANHANES) reported the prevalence of 19.4% and 25.7% for diabetes and hypertension respectively in Gauteng province [10]. However, information on the prevalence of these morbidities among different migrant status in South Africa is scanty. The prevalence of diabetes and hypertension in Gauteng province is high. Gauteng provides is home to many migrants. Therefore, a better understanding of the differences in morbidities according to different migration status is needed to target high risk groups in provision of services and to arrest the growing burden of certain diseases.

Study objectives

The study aims to:

- Investigate the association between morbidities and migration status in Gauteng province, South Africa.
- To assess whether the association was modified by demographic and socio-economic characteristics.

Methods

Study setting

Gauteng is the province with the largest population, estimated to be 12,272263, despite having the smallest area; thus, it has the highest population density in South Africa of 675 people per km^2 [11]. According to data from Census 2011 Gauteng province accounted for the highest concentration of international and internal migrants in South Africa, approximately 7.4% and 44% respectively [12]. The study population consists of all people residing permanently in Gauteng province who were aged 18 or older in 2015.

Data sources

We used data from the fourth Quality of Life (QoL) Survey conducted by Gauteng City Region Observatory (GCRO) in Gauteng province in 2015. The QoL survey has been conducted every 2 years since 2009 with the intention of providing up-to-date information on 'a fast growing and dynamic urban region' to support 'better planning and management, and improved co-operative government relations' [13]. QoL survey measured a wide range of variables including socio-demographic variables, migration status and self-reported health status from a sample of 28,007 adults in 508 administrative wards in Gauteng province. The data on ward-level migrant African population, African population, migrant SADC population, employed

population, no income population, deprivation index (sampi) and average household size was obtained from Statistics South Africa (StatsSA).

Survey design

Simple random sampling was employed to select the respondents. Gauteng province consists of 10 municipalities and it is subdivided into 508 wards. Within these wards, there are Small Area Levels (SALs) which were derived from the Population Census Enumerator Area (EA) polygons. SAL codes and geography were derived from the Statistics South Africa Census 2011 report. The simple random sampling method was used to select the SALs from each ward, and then the minimum numbers of interviews for each ward were 30 and 60 interviews for those falling in district municipalities and metropolitan municipalities, respectively. The end result was that across the 508 wards, 28,456 successful interviews were completed, and these interviews were distributed across 16,400 SALs out of a total of 17,840 SALs. The 'NEXT' birthday method was used to select the respondents from the selected households. Data were collected via a digital data collection instrument using an open source system called Formhub and administered on a tablet device. Questionnaires were administered in the field and uploaded using Internet connectivity to a cloud server from where they could be accessed and downloaded online.

Patient and Public Involvement

The development of the research questions and outcome measures were not informed by patients' priority experiences and preferences. Patients were not involved in the design of this study. Patients were not involved in the recruitment and conduct of the study. This study used data from 2015 QoL survey which measured a wide range of variables including socio-demographic variables, migration status and self-reported health status.

Outcome and independent variables

The main outcomes were hypertension and diabetes. The information on disease status, such as diabetes, hypertension, HIV, TB, Influenza, and others, was collected in the QoL survey by asking question: "In the past 12 months, have you been told by health provider that you have one or more of the following conditions. The morbidities were binary variables measuring the presence of the different morbidities, coded as 1 (or 'yes') if the respondents self-reported the morbidity and as 0 (or 'no') if the respondent did not report the presence of a given morbidity.

Migration status was derived from the following QoL survey questions: (i) *"Were you born in Gauteng province or did you move into Gauteng province from another province or country?"*; (ii) *When (year) did you move into Gauteng province?*; (iii) *Did you move to Gauteng province from a province in South Africa or from another country?;* (iv) *From which province did you move from into Gauteng province?; and* (v) *Which country did you move into Gauteng province from?.* Migration status then was divided into three groups: non-migrant, internal migrant, and external migrant. The explanatory variables included sex, age, race, education, employment status, dwelling, total household income, grow own vegetables, medical aid, physical activity, household size, household food security and socioeconomic status quintile. Information collected included demographic and socio-economic variables: sex (female, male); age (18 years and above); race (African, Coloured, Indian/Asian, White and Other); Education was categorized into 'No formal education', grades R-7 'Primary only', grades 8-11 'Secondary incomplete', 'Matric' grade 12 'More' Tertiary and above and 'Unspecified' for those who didn't specify; employment status ('employed', 'unemployed and other).

Dwelling (formal, informal and other); Total household income was categorized into 'Lower class income' (< 6400 Rand [ZAR] per month), 'Middle class income' (R6400 - R51, 200 per month) and 'Upper class income' (> R51, 200 per month); grow own vegetables (do not grow own vegetables and grow their own vegetables); Medical insurance was categorized into 'medically insured' for respondents with either medical aid or a hospital plan and 'medically not insured' for respondents without any of these; physical activity (never, hardly ever, few

times a month, few times a week and everyday); household size (1-3, 4-6 and 7+); household food security (never, seldom, sometimes, often and always) and socioeconomic status quintile (richest, 2nd, 3rd, 4th and poorest). The ward level variables included migrant African population, African population, migrant SADC population, employed population, no income population, sampi and household of less than three.

Analysis

Descriptive analysis was performed to describe the migration status of the community by socio demographic characteristics of study respondents using proportions. The prevalence of morbidities in Gauteng province, South Africa was estimated using proportions and presented as percentages with 95% confidence intervals. Prevalence of morbidities was stratified by age, sex and migration status.

In the present analysis the data used was in multilevel structure as the respondents were within administrative wards [14]. We applied a recently developed original, stepwise-multilevel logistic regression of discriminatory accuracy to investigate the effect of migration status. We fitted separate models for effect of migration status on diabetes and hypertension, respectively. Four progressively adjusted multilevel models were carried out: model 0 with no covariates; model 1 including only sociodemographic characteristics at the individual level; model 2 additionally analysing municipal deprivation as contextual variable and model 3 is the full adjusted model. The models were adjusted for years in GP, age, sex, race, dwelling, education level, household size, household head, physical activity, medical aid, grow own vegetables, household food security, sampi, year moved to GP and socioeconomic status quintile. Potential effect modification by age, sex, race, SES and sampi was tested.

These variables were selected because they are strongly linked to migration status. There is evidence that migration is associated with age [12]. The hypothesis is that effect of migration will be modified age where young age will have protective effect hypertension and diabetes. There is also differential migration patterns by race and SES. In South Africa, race and SES are also strongly correlated [3,4,12]. The other variables were treated as potential confounders.

To take account of the hierarchical data structure (level 1: individuals; level 2: administrative wards), an Intraclass Correlation Coefficient (ICC) and ward-level variances were reported for every model and for reasons of better interpretability, ward-level variances were converted into median ORs (MORs) by applying the formula of Merlo *et al*, [14, 15]. Multilevel logistic regression analyses with administrative wards as random intercepts were performed calculating ORs with their 95% CIs. ORs were plotted using the user-written *coefplot* Stata command [16]. All analysis was performed using Stata version 13 (Stata Corporation, College Station, Texas, USA).

Results

Most respondents were non-migrants 18,027 (64%) and the external migrants constituted only 8% of the total respondents. Of the total study population of 28,007 respondents 14,966 (53%) were female (**Table 1**). The majority of the respondents were aged between 18 to 27 years and were African 22,560 (79%). Most respondents 9,152 (33%) had matric level of education and only 443 (1.6%) had no formal education. Close to half of the respondents were employed 13,582 (49%). The majority of the respondents stayed in formal dwellings 24,043 (86%). A large proportion of the respondents fall under the lower income bracket based on their total house hold income 13,015 (71%) lower class was defined in this study as families with a total household income of less than R6,400 per month while 2.3% fall under the upper class (Upper class is a family with an income more than R51,200). Few respondents reported growing their own vegetables 3,480 (12%).

Table 1: Demographic characteristics across migration status

Variable	Level	Non- migrants	Internal migrants	External migrants	Total
Sex	Female	9,746 (54.06)	4,226 (54.05)	994 (46.00)	14,966 (53.44)
	Male	8,281 (45.94)	3,593 (45.95)	1,167 (54.00)	13,041 (46.56)
Age group	18-27	5,288 (29.33)	2,205 (28.20)	701 (32.44)	8,194 (29.26)
	28-37	4,400 (24.41)	2,197 (28.10)	781 (36.14)	7,378 (26.34)
	38-47	3,362 (18.65)	1,507 (19.27)	347 (16.06)	5,216 (18.62)
	48-57	2,456 (13.62)	938 (12.00)	159 (7.36)	3,553 (12.69)
	58-67	1,493 (8.28)	503 (6.43)	84 (3.89)	2,080 (7.43)
	68+	1,028 (5.70)	469 (6.00)	89 (4.12)	1,586 (5.66)
Race	African	13,819 (76.66)	6,901 (88.26)	1 840 (85.15)	22,560 (80.55)
	Coloured	940 (5.21)	180 (2.30)	9 (0.42)	1,129 (4.03)
	Indian/Asian	389 (2.16)	154 (1.97)	75 (3.47)	618 (2.21)
	White	2,848 (15.80)	575 (7.35)	157 (7.27)	3,580 (12.78)
	Other	31 (0.17)	9 (0.12)	80 (3.70)	120 (0.43)
Education	No education	223 (1.25)	162 (2.10)	58 (2.72)	443 (1.60)
	Primary only	1,621 (9.09)	1,029 (13.32)	368 (17.23)	3,018 (10.90)
	Secondary incomplete	5,007 (28.08)	2,451 (31.73)	712 (33.33)	8,170 (29.50)
	Matric	6,210 (34.83)	2,468 (31.95)	474 (22.19)	9,152 (33.05)
	More	4,399 (24.67)	1,526 (19.76)	419 (19.62)	6,344 (22.91)
	Unspecified	371 (2.08)	88 (1.14)	105 (4.92)	564 (2.04)
Employment status	Employed	8,426 (47.08)	3,838 (49.48)	1,318 (61.47)	13,582 (48.86)
	Unemployed	4,808 (26.86)	2,282 (29.42)	444 (20.71)	7,534 (27.10)
	Other	4,664 (26.06)	1,636 (21.09)	382 (17.82)	6,682 (24.04)
Dwelling	Formal	16,478 (91.41)	5,954 (76.15)	1,611 (74.55)	24,043 (85.85)
	Informal	1,442 (8.00)	1,659 (21.22)	482 (22.30)	3,583 (12.79)
	Other	107 (0.59)	206 (2.63)	68 (3.15)	381 (1.36)
Total HH Income	Lower Class	7,991 (68.85)	4,000 (75.03)	1,024 (72.21)	13,015 (70.90)
	Middle Class	3,325 (28.65)	1,246 (23.37)	356 (25.11)	4,927 (26.84)
	Upper class	291 (2.51)	85 (1.59)	38 (2.68)	414 (2.26)
Grow own vegetables	Do not grow vegetables	15,850 (87.92)	6,772 (86.61)	1,905 (88.15)	24,527 (87.57)
	Grow vegetables	2,177 (12.08)	1,047 (13.39)	256 (11.85)	3,480 (12.43)
Medical Aid	No medical insurance	12,219 (71.26)	5,883 (78.44)	1,707 (82.66)	19,809 (74.16)
	Medical insurance	4,927 (28.74)	1,617 (21.56)	358 (17.34)	6,902 (25.84)
Physical activity	Never	4,478 (25.11)	2,481 (32.12)	684 (32.02)	7,643 (27.60)
	Hardly ever	2,357 (13.22)	934 (12.09)	271 (12.69)	3,562 (12.86)
	Few times a month	2,447 (13.72)	851 (11.02)	202 (9.46)	3,500 (12.64)
	Few times a week	4,356 (24.43)	1,687 (21.84)	445 (20.83)	6,488 (23.43)
	Everyday	4,193 (23.52)	1,771 (22.93)	534 (25.00)	6,498 (23.47)
HH size	1-3	9,167 (51.41)	4,451 (57.63)	1,491 (69.80)	15,109 (54.56)
	4-6	6,736 (37.78)	2,631 (34.06)	562 (26.31)	9,929 (35.86)
	7+	1,928 (10.81)	642 (8.31)	83 (3.89)	2,653 (9.58)
HH Food security	Never	14,372 (79.72)	6,095 (77.95)	1,813 (83.90)	22,280 (79.55)

Variable	Level	Non- migrants	Internal migrants	External migrants	Total
	Seldom	1,138 (6.31)	496 (6.34)	110 (5.09)	1,744 (6.23)
	Sometimes	2,008 (11.14)	993 (12.70)	199 (9.21)	3,200 (11.43)
	Often	345 (1.91)	147 (1.88)	23 (1.06)	515 (1.84)
	Always	164 (0.91)	88 (1.13)	16 (0.74)	268 (0.96)
SES quintiles	Richest	2,716 (15.15)	2,136 (27.81)	661 (31.12)	5,513 (19.88)
	2nd quintile	3,549 (19.79)	1,608 (20.93)	398 (18.74)	5,555 (20.03)
	3rd quintile	3,627 (20.23)	1,498 (19.50)	368 (17.33)	5,493 (19.81)
	4th quintile	3,972 (22.15)	1,293 (16.83)	346 (16.29)	5,611 (20.23)
	Poorest	4,066 (22.68)	1,146 (14.92)	351 (16.53)	5,563 (20.06)
Year moved to Gauteng	After 2009		1,543 (19.74)	673 (31.14)	2,216 (22.21)
	2005-2009		1,242 (15.89)	589 (27.26)	1,831 (18.35)
	1995-2004		2,524 (32.28)	519 (24.02)	3,043 (30.49)
	1985-1994		1,290 (16.50)	217 (10.04)	1,507 (15.10)
	Before 1985		1,219 (15.59)	163 (7.54)	1,382 (13.85)

The prevalent morbidities in Gauteng province

The overall prevalence of hypertension and diabetes was 15.5% (95% CI: 15.1-15.9), 11.2% (95% CI: 10.8-11.6), respectively (**Table 2**). The prevalence of hypertension and diabetes was higher among non-migrants.

Table 2: Prevalence of hypertension and diabetes

Characteristics	Hypertension % (95% CI)	Diabetes % (95% CI)
Overall	15.5 (15.1 - 15.9)	11.2 (10.8 - 11.6)
Age group years		
18-27	11.3 (10.5 - 12.1)	8.4 (7.7 - 9.1)
28-37	8.7 (8.1 - 9.4)	6.3 (5.7 - 6.8)
38-47	11.8 (11.0 - 12.6)	9.0 (8.3 - 9.7)
48-57	21.1 (19.9 - 22.5)	14.6 (13.5 - 15.8)
58-67	32.2 (30.3 - 34.1)	21.4 (19.7 - 23.1)
68+	39.8 (37.5 - 42.2)	30.5 (28.3 - 32.7)
Sex		
Male	12.1 (11.5 - 12.7)	10.1 (9.6 - 10.6)
Female	18.5 (17.9 - 19.1)	12.1 (11.7 - 12.7)
Migration status		
Non-migrant	16.8 (16.3 - 17.4)	12.6 (12.1 - 13.1)
Internal migrant	14.4 (13.7 - 15.2)	9.7 (9.1 - 10.4)
External migrant	8.1 (7.1 - 9.4)	5.1 (4.3 - 6.2)

Note: % = percentage, 95%CI = 95% Confidence Interval

The effect of migration status on hypertension and diabetes

The effect of migration status on hypertension and diabetes based on analysis of multilevel logistic regression models is presented on **Table 3.** Three models were fitted, the first model only included the individual or household factors, the second model included ward factors and the final model included all factors. Compared to non-migrants, internal migrants and external migrants in the final model had reduced odds of self-reporting hypertension with the OR of 0.86 (95% CI: 0.78-0.95) and 0.60 (95% CI: 0.49-0.75) respectively. Being a migrant was also associated with lower risk of diabetes with OR of 0.84 (95% CI: 0.75-0.94) and 0.53 (95% CI: 0.41-0.68). While there was a reduction in the variance between the null and full models and ICC vary for both outcomes. There was substantial residual between-ward variance in

hypertension and diabetes with median odds ratio of 1.31 and 1.14 respectively as presented in the final model.

Table 3: The effect of migration status on the most prevalent morbidities

Characteristics	Null Model	Model 1[a] OR (95% CI)	Model 2[b] OR (95% CI)	Model 3[c] OR (95% CI)
Hypertension				
Migration status				
Non-migrant		1.00	1.00	1.00
Internal migrant		0.85 (0.77-0.95)	0.90 (0.83-0.97)	0.86 (0.78-0.95)
External migrant		0.59 (0.48-0.74)	0.52 (0.44-0.61)	0.60 (0.49-0.75)
Random Effects				
Between-ward variance (SE)	0.25 (0.050)	0.15 (0.035)	0.10 (0.023)	0.08 (0.021)
ICC	0.07	0.04	0.03	0.02
MOR	1.61 (1.46-1.76)	1.45 (1.33-1.57)	1.35(1.26-1.44)	1.31 (1.22-1.40)
Diabetes				
Migration status				
Non-migrant		1.00	1.00	1.00
Internal migrant		0.84 (0.75-0.94)	0.77 (0.70-0.84)	0.84 (0.75-0.94)
External migrant		0.51 (0.40-0.66)	0.41 (0.37-0.50)	0.53 (0.41-0.68)
Random Effects				
Between-ward variance (SE)	0.05 (0.014)	0.04 (0.015)	0.02 (0.007)	0.02 (0.011)
ICC	0.02	0.01	0.01	0.00
MOR	1.24 (1.17-1.31)	1.22 (1.13-1.30)	1.13 (1.07-1.19)	1.14 (1.06-1.22)

Note: OR = Odds ratio, 95%CI = 95% Confidence Interval, ICC = intraclass correlation coefficient, MOR = median odds ratio, **Model 1[a]** = the individual/HH level factors, **Model 2[b]** = the Ward level factors and **Model 3[c]** = all factors.

To further assess effect modification of age, race and SES, we ran grade-stratified analysis. The association between migration status and hypertension is significantly modified by race. For Africans, migration status (both internal and external) was associated with lower odds of hypertension, while internal and external Asian migrants have higher odds of hypertension. From the interaction assessment between migration status and race, age group and socioeconomic status, respectively were found to be effect modifiers for hypertension (**Figure 1**) and diabetes (**Figure 2**).

Figure 1: Association between migration status and hypertension, by SES, race and age group
Figure shows SES-, race-, and age group-stratified, fully adjusted ORs in hypertension and associated 95% CIs.

Figure 2: Association between migration status and diabetes, by SES, race, and age group
Figure shows SES- race-, and age group-stratified, fully adjusted ORs in diabetes and associated 95% CIs.

Discussion

The findings from this study provide important information on migration status and the prevalence of morbidities among residents of 508 administrative wards in Gauteng province from a population-based survey. The study indicates that migration status is associated with prevalence of hypertension and diabetes conditions. Internal and external migrants had lower odds of both hypertension and diabetes than people born in Gauteng province. Age, race and SES of the respondents were significant effect modifiers of the association between migration status and morbidities. The major strength of this study is that it assesses prevalence of morbidities and predictors of the most prevalent morbidities from a large population-based survey. The potential of the study was maximized and included the vulnerable population like migrants. The migrants made up 36% of the total respondents.

The most prevalent morbidities in Gauteng province were hypertension and diabetes at 15,5% and 11.2% respectively. The prevalence of diabetes in South Africa is increasing rapidly [17]. In 2009 it was approximately 9% among those aged 30 years and older [18]. Based on the population census the prevalence of diabetes was around 9% according to the International Diabetes Federation (IDF) [19, 20]. Hypertension was found to be around 14.0% for those aged 25 and older [21]. SANHANES reported slightly higher prevalence of diabetes (19.4%) and hypertension (25.7%) [10]. Hypertension and diabetes were higher among non-migrants. The migrant population is believed to keep increasing in different countries; their heterogeneity becomes apparent with respect to the differences in the prevalence of diseases [7]. Prevalence is likely to increase therefore, these findings can be used to inform future policy, planning and funding allocation to assist in controlling as well as managing different conditions [22].

Migration status was associated with prevalence of hypertension and diabetes in Gauteng province. Non-communicable diseases are the most common health problem and are the primary cause of death in many countries [23]. Research revealed that compared to native-born respondents, migrants reported better health [24]. This could be attributed to healthy migration effect, healthier individuals are more likely to migrate. This is consistent with our findings, migrants reported lower prevalence of diabetes and hypertension. Reasons for migration were not included in the questionnaire administered in the primary study; these might have a bearing on the prevalence of hypertension and diabetes among migrants in Gauteng province. Effect of migration status on health differed by age group, race and socio-economic status. Migrants might find themselves in a worse socioeconomic status, with less access to health care services, and experiencing greater linguistic and cultural barriers related to accessing health information, despite the conditions they tend to have better health profiles compared to the natives [25]. A number of studies have shown that this health advantage deteriorates over time and with successive generations [24, 26, 27]. There is a lack of studies on morbidity among migrants compared to natives [7]. This study clearly demonstrates a need for more research on migration and different morbidities.

Strengths and limitations

This study contributes to the knowledge on migration status and morbidities in Gauteng province, South Africa. Assessment of predicts for the most prevalent morbidities was done from a very large population based representative sample survey. Therefore, the power of the study to detect significant associations was maximized. The respondents were selected by random sampling thus both internal and external validity of the study were improved. The study included the migrant population and little research has been done on the morbidities affecting this sub-population. A wide variety of socio-demographic factors were employed to assess their association with the two most prevalent morbidities.

The morbidities were self-reported thus prevalence might be underestimated. Self-reported data can be biased by differential access to healthcare services between groups of different socioeconomic status [28]. When self-reported information was compared with medical records or clinical measurements from health examination surveys in Colorado, Netherlands and 12 countries in Europe, self-reported information underestimated the prevalence of hypertension [29, 30]. It is worth noting that the results from these studies may not be valid for the South African context. This calls for more research on migration status and morbidities, as well as validity studies of self-reported morbidities in the South African setting.

Missing data of some important health-related information, might have resulted in residual confounding because of unmeasured potential confounders.

Conclusion

Migration status is associated with the prevalence of hypertension and diabetes in Gauteng province. From the public health perspective, it is important to evaluate the prevalence of morbidities because the information can inform the development of prevention programme on a community level.

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Author contributions
Concept and design of the study: JN, Acquisition of data: JN, Analysis and interpretation of data: JN, MM, Drafting the manuscript: JN, MM, Revising the manuscript critically for important intellectual content: JN, MM and approval of the manuscript to be published: JN and MM

Disclosure statement
No potential conflict of interest was reported by the authors.

Ethics and Consent
For the primary study ethics approval was obtained from the local ethics committee and the Human Research Ethics Committee of University of the Witwatersrand. All respondents provided informed consent before data collection. The study was granted ethics clearance by the Human Research Ethics Committee of University of the Witwatersrand.

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Data sharing

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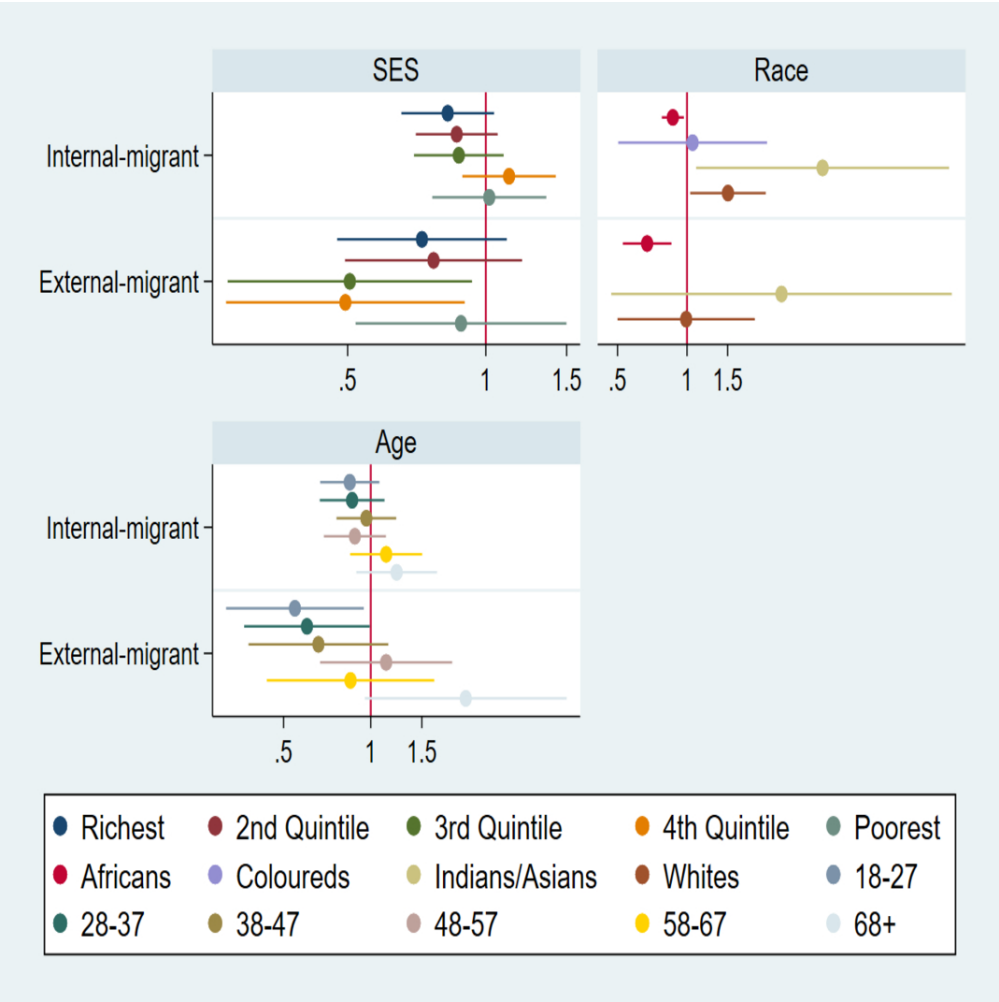

Association between migration status and hypertension, by SES, race and age group

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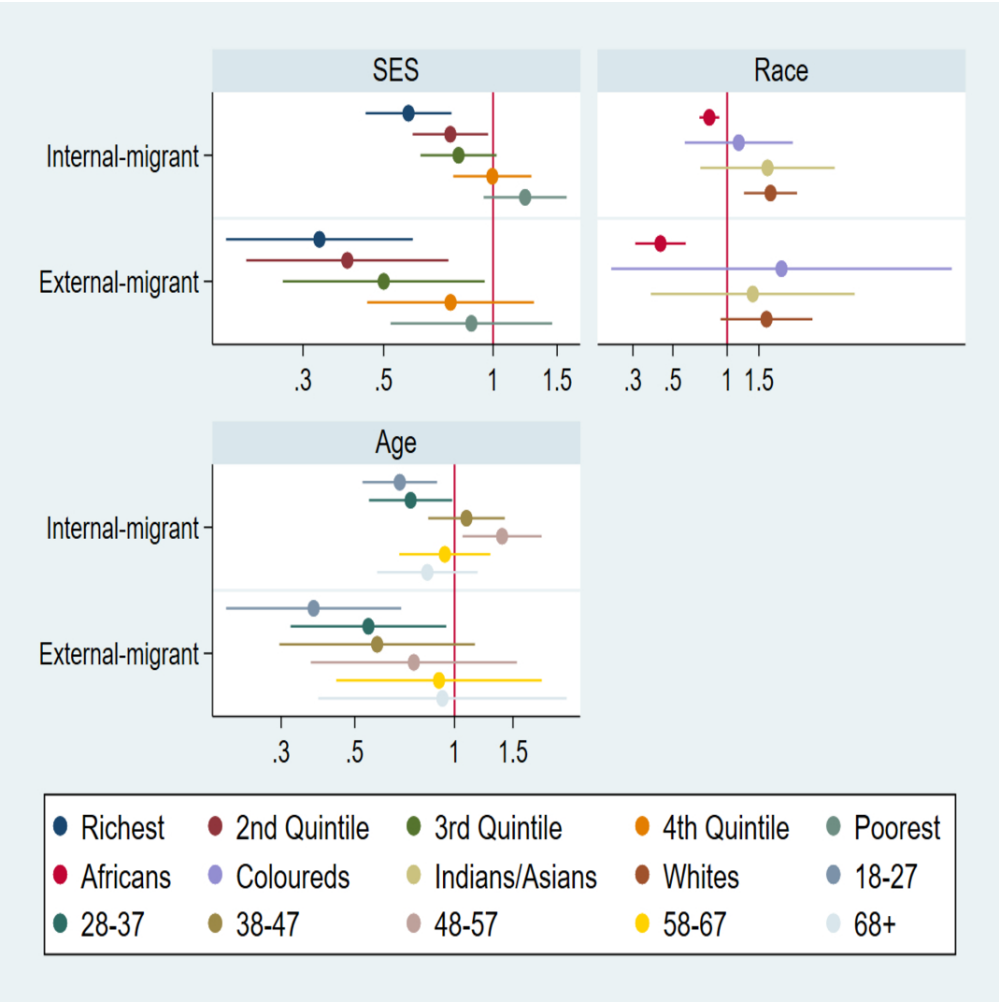

Association between migration status and diabetes, by SES, race, and age group

90x90mm (300 x 300 DPI)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

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	2
Objectives	3	State specific objectives, including any pre-specified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3
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	3
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4
		(*b*) Describe any methods used to examine subgroups and interactions	4
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
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	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	3
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	3
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	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	4
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
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	9

*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.