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Do adult health outcomes in urban population reflect local health risk? A matched cohort analysis of migration effects in Ouagadougou, Burkina Faso

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ABSTRACT

Background Selective migration may affect health indicators in both urban and rural areas. Sub-Saharan African urban areas show evidence of both negative and positive selection on health status at outmigration. Health outcomes as measured in urban populations may not reflect local health risks and access to health services.
Methods Using the Ouagadougou Health and Demographic Surveillance System and a migrant follow-up survey, we measured differences in health between matched non-migrants and outmigrants. We applied Cox and competing risks models on migration and death.
Results Controlling for premigration health status, migrants who moved out of Ouagadougou have higher mortality (HR 3.24, 95% CI 1.23 to 8.58) than non-migrants and migrants moving to other Ouagadougou areas. However, these effects vanish in the matched sample controlling for all interactions between death determinants. These and other results show little evidence that migration led to higher mortality or worse health.
Conclusions Health outcomes as measured in Ouagadougou population do reflect local health risks and access to health services despite high migration intensity. However, neither the hypothesis of effect of health on migration nor the hypothesis of negative effect of migration on health or survival was confirmed.

Strengths and limitations of this study

- ► Longitudinal analysis of migration and mortality at community level.
- ► Follow-up study combined with posterior random matching.
- ► Use of mobile phone interview to save on data collection costs.
- ► Use of bootstrap effect size to evaluate the significance of HR.
- ► Loss to follow-up due to non-systematic collection of mobile phone numbers.

BACKGROUND

Selective migration may impact health indicators in both urban and rural areas. Migrants may be selected on health, leading to the 'healthy migrant' effect often attributed to new migrants, or on the contrary to 'unhealthy migrant' effect often attributed to return migrants.[1] Such selection could lead to an urban health advantage if the healthy migrate in and unhealthy migrate out. Comparison between urban and rural sites in Burkina Faso showed positive selection on health for rural-urban migrants, adaptation to non-migrants' higher level of mortality after some years of urban residence due to exposure to the risk factors of non-communicable diseases and no negative selection of return-migrants to rural areas on health.[2] The analysis by Lankoande and Sié suggests that in Burkina Faso, the rural-urban selection effect supersedes the urban-rural selection and adaptation effects, leading to a net urban health advantage.

In sub-Saharan African urban areas, the general health advantage may be due to selection at entry and due to another selection mechanism characterising migration processes, largely overlooked so far: negative selection at outmigration. There is increasing evidence that, when sick, poorer migrants return to their places of origin to get care.[3–5] The phenomenon may be substantial in African cities where a large proportion of residents were born in rural areas; here the return of sick and poor migrants to their place of origin could result in seemingly good overall indicators of urban health. Conversely, as in Burkina Faso where migrations to urban areas are usually more permanent and often involve the whole household, sick migrants may prefer to stay in urban areas due to better access to treatment and social support in urban areas.[2] The estimated contribution of migration to the general urban health advantage may depend on whether one considers morbidity or mortality.

Table 1 Sample size for the quantitative data

	N	%
Migrants non-matched	47	9.46
Migrants matched	450	90.54
Total migrants	**497**	**100.00**
Migrants without contact number	89	19.78
Migrants with contact number	361	80.22
Total migrants matched	**450**	**100.00**
Migrants with contact number but failed to contact	116	32.13
Migrants successfully contacted (a+b)	245	67.87
Migrants alive (a)	*215*	59.56
Migrants deceased (b)	*30*	8.31
Total migrants with contact number	**361**	**100.00**

Considering the above, can we be certain that health outcomes as measured in urban populations do reflect local health risks and access to health services? Such an interrogation is the starting point of the present study, which examines the relationship between health and migration in Ouagadougou, the capital of Burkina Faso. Using Health and Demographic Surveillance System (HDSS) and data from an adult migrant follow-up survey in five informal and formal settlements in Ouagadougou, the main aim is to measure differences in health between current and former adult residents, hereafter called non-migrants and outmigrants. The objectives are to identify the health determinants of migrating out of the HDSS and to evaluate the impact of migration on health and survival after migration. Our first hypothesis is that outmigration from Ouagadougou HDSS is selective on good health (healthier people outmigrate more). The second hypothesis is that migration out of Ouagadougou negatively impacts migrants' health due to the exposure to less favourable health conditions in the destinations compared with Ouagadougou.

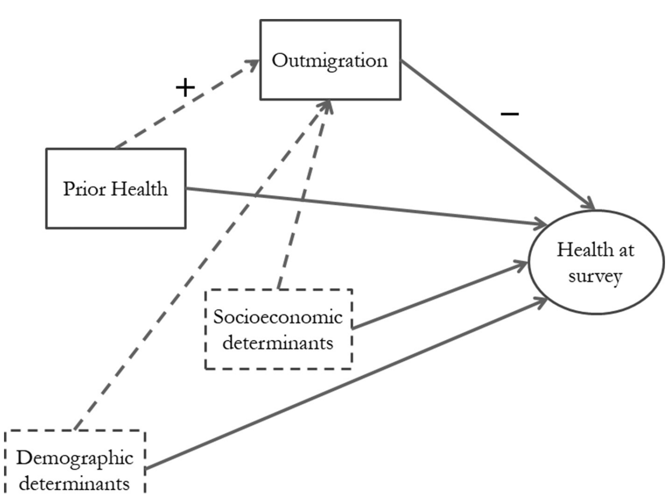

Figure 1 Conceptual model relating outmigration and health.

CONTEXT AND DATA SOURCES

Our study took place in Ouagadougou, the capital of Burkina Faso, in the Sahel region of West Africa. Its population increased from 0.7 million people in 1996 to 1.5 million in 2006,[6] and estimated at 1.9 million in 2012.[7] Between 1996 and 2006, Ouagadougou's population growth rate was estimated at 7.6% per year.[6] A breakdown of this growth showed a net migration rate of +4%.[8] Returnees from neighbouring Côte d'Ivoire and the persistence of internal migration are the basis for this high immigration to Ouagadougou.[8] For many Burkinabe youth, employment and social mobility opportunities are numerous in cities and in Ouagadougou in particular.

The study uses data collected in the Ouagadougou HDSS (also called *Observatoire de Population de Ouagadougou* (OPO) hereafter) set up in October 2008 by the *Institut Supérieur des Sciences de la Population*, University of Ouagadougou. It is located in two planned districts (Kilwin, Tanghin) and three informal settlements (Nonghin, Polesgo, Nioko II) of Ouagadougou.[9]

As of December 2015, the population under surveillance was estimated at 88 678 residents of whom 54 535 were aged 15 years or over. The backbone of the HDSS is the follow-up of the population through the registration of all demographic events (pregnancies, births, unions, migrations and deaths) and other information concerning schooling, housing, unions, employment, living standards, health, etc. This system is ideal for the identification of migrants. A migration is defined as change of residence in or out of the study area for >6 months. In this HDSS, the immigration rate is almost equivalent to the emigration rate, averaging 103 per 1000 persons-years over the period from 2010 to 2015. The crude death rate is estimated at 4.3 per 1000 persons-years, and to 4.4 per 1000 among adults aged 15 years and over.

In 2010, a health survey was conducted in the HDSS area between February and June. The representative sample included 2357 adults aged 15 years and over, distributed across 1699 households.[9]

To assess the link between migration and health, two additional surveys were conducted. The first was a qualitative pilot study conducted in 2015 which aimed to contribute to the development of a typology of migration streams, to understand subjective perceptions of the relationship between health and migration and to prepare questionnaires for the main study. This qualitative study used a combination of focus groups and in-depth interviews, in Ouagadougou and also in Boussé, a small town located 57 km from Ouagadougou, and three villages surrounding Boussé, all situated in the Kourweogo

Table 2 Determinants of migration in 2010–2014

Variable	PYAR (%)	M1 SHR (95% CI)	P value	M2 SHR (95% CI)	P value
Sex					
Male	*45.64*	Ref.		Ref.	
Female	*54.36*	1.549*** (1.285 to 1.869)	0.000	1.558*** (1.287 to 1.886)	0.000
Age group (years)					
<20	*11.60*	Ref.		Ref.	
20–29	*24.47*	1.062 (0.837 to 1.346)	0.622	1.050 (0.826 to 1.333)	0.691
30–39	*16.07*	0.965 (0.699 to 1.331)	0.826	0.954 (0.691 to 1.316)	0.773
40–49	*7.90*	0.686 (0.435 to 1.082)	0.105	0.684 (0.429 to 1.091)	0.111
50–64	*26.96*	0.572** (0.391 to 0.837)	0.004	0.655 (0.409 to 1.048)	0.078
65+	*13.01*	0.814 (0.502 to 1.320)	0.404	0.956 (0.540 to 1.694)	0.878
Marital status					
Never married	*22.75*	Ref.		Ref.	
Married	*63.50*	0.458*** (0.349 to 0.602)	0.000	0.457*** (0.349 to 0.599)	0.000
Divorced	*1.22*	1.320 (0.610 to 2.854)	0.481	1.329 (0.615 to 2.871)	0.470
Widowed	*12.52*	0.472** (0.301 to 0.742)	0.001	0.466*** (0.297 to 0.732)	0.001
Education					
None	*56.15*	Ref.		Ref.	
Primary	*17.23*	1.139 (0.901 to 1.439)	0.277	1.138 (0.901 to 1.438)	0.278
Secondary+	*21.32*	1.143 to (0.903 to 1.446)	0.266	1.147 (0.907 to 1.450)	0.254
Missing	5.30	3.401** (1.562 to 7.404)	0.002	3.302** (1.478 to 7.376)	0.004
Occupation					
Employer/self-employed	*31.44*	Ref.		Ref.	
Employee	*13.38*	1.327* (1.015 to 1.735)	0.038	1.334* (1.021 to 1.744)	0.035
At school/trainee/ inactive	*37.78*	0.930 (0.715 to 1.210)	0.589	0.929 (0.715 to 1.208)	0.584
Unemployed	*12.62*	1.262 (0.963 to 1.654)	0.091	1.273 (0.973 to 1.664)	0.078
Missing	*4.77*	0.526 (0.223 to 1.238)	0.141	0.535 (0.222 to 1.288)	0.163
Standard living					
Poor	*41.75*	Ref.		Ref.	
Middle	*47.73*	0.886 (0.739 to 1.063)	0.193	0.880 (0.733 to 1.056)	0.169
Rich	*10.44*	1.042 (0.784 to 1.384)	0.777	1.021 (0.768 to 1.359)	0.884
Missing	*0.09*	0.000*** (0.000 to 0.000)	0.000	0.000*** (0.000 to 0.000)	0.000
Settlement type					
Planned	*55.77*	Ref.		Ref.	
Informal	*44.23*	0.975 (0.802 to 1.185)	0.801	0.979 (0.806 to 1.191)	0.835
Hypertension					
No	*88.80*			Ref.	
Yes	*11.13*			0.974 (0.675 to 1.403)	0.886
Obesity					
No	*77.94*			Ref.	
Yes	*22.06*			1.228 (0.955 to 1.577)	0.109
Abdominal obesity					
No	*86.49*			Ref.	
Yes	*13.51*			0.777 (0.552 to 1.093)	0.147

Continued

Table 2 Continued

Variable	PYAR (%)	M1 SHR (95% CI)	P value	M2 SHR (95% CI)	P value
N subjects		2354		2354	
N censored		1648		1648	
N deaths		126		126	
N migrations		580		580	

Fine and Gray competing risks model with death as competing event.
Missing values (coded 99) are kept in the regression for the sake of controlling for potentially non-random missing values in some variables. The HR for these missing values should not be interpreted.
*P<0.05, **p<0.01, ***p<0.001.
PYAR, person-years at risk; Ref., reference; SHR, Sub-Hazard Ratio.

province whence many Ouagadougou HDSS residents originate.

The second, quantitative, survey conducted between April and May 2016 aimed to estimate the effect of health status on migration and to assess the impact of migration on adult mortality and health. The sampling identified individuals aged 15 years and over who were interviewed during the 2010 health survey and had emigrated between 2010 and 2014. These migrants were matched with non-migrants with similar characteristics (see 'Methods' section). The health survey covered both migrants and matched non-migrants who survived through to 2016.

Seven characteristics were used for matching: sex, 5-year age group, level of education (none, primary, secondary and higher), marital status (single, married, divorced or widowed), type of neighbourhood (planned/informal), employment (inactive, unemployed, salaried, self-employed or learner) and standard of living (low, medium, high). The standard of living here is a proxy used by the OPO, and constructed on the basis of household assets.[10] The method of deterministic recode linkage (using 'reclink' command of Stata) was used for matching. Only non-migrants with matching scores >65% were selected. Of the 497 migrants identified, it was not possible to match 47 migrants (9.46%) and the other 450 migrants were matched with non-migrants on the basis of the characteristics of the migrant at the time of migration (table 1). The analysis of the risk of a non-match (online supplementary annex 1) shows that the bias is mainly against migrants with missing data for education and occupation (who represent around 11% of migrants), as well for young female migrants below 20 (15.2% of all migrants), and marginally against richer migrants (12.2% of migrants) and divorced migrants (only 0.8% of migrants). The biases implies that the overall migrant mortality might be overestimated (young women and richer inhabitants presumably die less than average), although the analysis of the migration effect on mortality in the matched sample will be marginally impacted since we control for the same variables. However, we cannot exclude that the non-matched migrants may have different unobserved characteristics than the matched migrants. For the selected non-migrants, the matching score is >90% for 92% of non-migrants, and 57% of selected non-migrants have a matching score of 100%.

After matching datasets, we obtained from relatives and neighbours a mobile phone number for each migrant. These telephone 'contact numbers' were collected between July 2015 and March 2016. Of the 450 migrants matched with non-migrants, telephone contact numbers were obtained for 361 (table 1). Interviews for both migrants and non-migrants were conducted by telephone and data recorded on tablets. In total, 245 migrants (or their relatives) out of the 361 were successfully found using phone contact numbers, of whom 30 had died (table 1). Despite high failure to contact the migrants (45.9% of 450 matched migrants), the analysis of the risk of a non-contact (online supplementary annex 2) shows that there is no evidence of bias (none of the covariates show a significant p value). Failure to contact seems therefore fairly random, although we cannot exclude that the non-contacted migrants may have different unobserved characteristics than the contacted migrants.

Death data between 2010 and 2016 were collected through the routine HDSS data collection for non-migrants and through the follow-up survey for outmigrants (ie, outmigrants who died after their migration). The 2010 and 2016 health questionnaires included aspects of both physical and mental health, the latter represented primarily by depression. The qualitative pilot study suggests that a range of other mental health conditions, including epilepsy, were associated with outmigration from Ouagadougou. First, such conditions are seen as better treated by traditional and religious healing more frequently found in rural areas, and second people with mental health problems were often sent back to the village for family care. These other aspects of mental health are not captured in the following analyses.

METHODS

Our conceptual framework is outlined in figure 1, where health is the principal outcome and outmigration the main covariate of interest. The control variables are the socioeconomic and demographic determinants. A first model will explain outmigration from OPO (relationships

Table 3 Impact of migration in 2010–2014 on death before 2016 (Cox model)

	PYAR (%)	M1 HR (95% CI)	P value	M2 HR (95% CI)	P value
Sex					
Male	*46.55*	Ref.		Ref.	
Female	*53.45*	0.606** (0.418 to 0.879)	0.008	0.610** (0.420 to 0.887)	0.010
Age group (years)					
<20	*10.21*				
20–29	*23.28*	1.117 (0.197 to 6.347)	0.901	1.166 (0.205 to 6.643)	0.863
30–39	*15.78*	1.444 (0.215 to 9.675)	0.705	1.507 (0.223 to 10.17)	0.674
40–49	*8.18*	6.789* (1.116 to 41.29)	0.038	6.843* (1.108 to 42.29)	0.038
50–64	*28.76*	10.58** (1.860 to 60.16)	0.008	7.732* (1.289 to 46.39)	0.025
65+	*13.78*	26.47*** (4.654 to 150.5)	0.000	18.51** (3.055 to 112.1)	0.001
Marital status					
Never married	*20.77*				
Married	*64.65*	1.769 (0.603 to 5.194)	0.299	1.753 (0.593 to 5.181)	0.310
Divorced	*1.27*	1.646 (0.382 to 7.094)	0.504	1.590 (0.367 to 6.890)	0.536
Widowed	*13.30*	2.386 (0.765 to 7.444)	0.134	2.343 (0.747 to 7.352)	0.144
Education					
None	*57.93*				
Primary	*16.64*	1.151 (0.673 to 1.969)	0.607	1.182 (0.690 to 2.025)	0.542
Secondary+	*21.09*	1.435 (0.761 to 2.704)	0.264	1.450 (0.770 to 2.732)	0.250
Missing	*4.34*	0.539 (0.129 to 2.247)	0.397	0.501 (0.118 to 2.124)	0.348
Occupation					
Employer/freelance	*32.50*				
Employee	*13.10*	1.074 (0.592 to 1.948)	0.814	1.098 (0.604 to 1.994)	0.760
At school/trainee/ inactive	*38.72*	1.200 (0.715 to 2.016)	0.490	1.203 (0.716 to 2.022)	0.486
Unemployed	*11.83*	0.552 (0.216 to 1.409)	0.214	0.570 (0.223 to 1.456)	0.240
Missing	*3.85*	1.790 (0.282 to 11.36)	0.537	2.001 (0.310 to 12.93)	0.466
Standard living					
Poor	*41.70*				
Middle	*47.87*	0.712 (0.504 to 1.005)	0.054	0.710 (0.503 to 1.002)	0.051
Rich	*10.33*	0.840 (0.467 to 1.511)	0.561	0.858 (0.477 to 1.543)	0.609
Missing	*0.10*	0.000 (0.000 to 0.000)		0.000 (0.000 to 0.000)	
Settlement					
Formal	*55.41*				
Informal	*44.59*	0.905 (0.638 to 1.283)	0.574	0.914 (0.644 to 1.296)	0.612
Destination					
No migrant	*91.73*				
Ouagadougou	*4.71*	2.804*** (1.532 to 5.133)	0.001	2.757** (1.503 to 5.055)	0.001
Out of Ouagadougou	*2.30*	4.164*** (2.156 to 8.042)	0.000	4.364*** (2.237 to 8.515)	0.000
Missing	*1.27*	1.676 (0.526 to 5.340)	0.383	1.678 (0.526 to 5.350)	0.381
Hypertension					
No	*58.36*				
Yes	*7.58*			1.672 (0.882 to 3.170)	0.115
Missing	*34.07*			1.527 (0.884 to 2.639)	0.129

Continued

Table 3 Continued

	PYAR (%)	M1 HR (95% CI)	P value	M2 HR (95% CI)	P value
Obesity					
No	*85.16*				
Yes	*14.84*			0.730 (0.308 to 1.735)	0.477
Abdominal obesity					
No	*90.92*				
Yes	*9.08*			0.845 (0.318 to 2.249)	0.736
N subjects		2105		2105	
N PYAR		11932.15		11932.15	
N deaths		181		181	

Missing values are kept in the regression for the sake of controlling for potentially non-random missing values in some variables. The HR for these missing values should not be interpreted.
*P<0.05, **p<0.01, ***p<0.001.
PYAR, person-years at risk; Ref., reference.

represented with dashed lines) and the second model will explain health or mortality (continuous lines). Our first hypothesis is that outmigration is selective on good health (first model). Our second hypothesis is that outmigration has a negative impact on health due to unfavourable conditions at destination (second model).

Variables

The main outcome of the *first model*, outmigration, is measured through migration between 2010 and 2014 out of the HDSS area by destination area (within Ouagadougou non-HDSS destinations vs out-of-Ouagadougou destinations).

The main outcome of the *second model* is captured for both outmigrants and non-migrants through death and composite health indices of self-declared health condition, health limitation and self-perceived health.

For both models, the main covariates are:

High body mass index (>25), abdominal obesity and hypertension (all Boolean: 1 for yes, 0 for no) as collected in the 2010 Health Survey (HS-2010). These physical health indicators could not be collected in the follow-up phone survey. The HS-2010 did not collect mental health indicators (stress) for the whole sample but, due to language skill abilities, only for those speaking either French or Moore (the Mossi language, spoken by the majority of Ouagadougou residents) and not for those speaking only other languages. Therefore, the analyses are limited to physical health indicators. Analyses on the subsample of French and Moore speakers (two-thirds of the total sample) show no effect of the stress variable in any of the models (results not shown).

Demographic indicators: sex (male, female); age group (<20, 20–29, 30–39, 40–49, 50–64, 65+ years); marital status (never married, married, divorced, widowed).

Socioeconomic indicators: education (none, primary, secondary+); standard of living (poor, middle, rich); type of settlement (planned, informal).

For all these covariates, missing values are identified by a separate indicator but are not interpreted for both models. Missing values are included to control for any association of missing value with other covariates in their effect on migration or on death. For the second model (mortality), outmigration is added as the main explanatory variable. Only the last migration (when the individual ceased to be an OPO resident) is taken into account. Outmigrants who returned to the HDSS in the 2010–2014 period are considered as 'always resident', a simplification that has little consequence since there are only 21 return migrants.

Lastly, a *variant of the second model on the paired sample* was limited to surviving outmigrants and their matches. This variant on health outcomes includes only the outmigration event and the 2010 physical health indicators as covariates.

Statistical analyses

To test the healthy migrant hypothesis, a competing risk model[11] was used with two categories for the dependent variable: migration out of the OPO and death in the OPO (ie, before migration). Not accounting for mortality as competing risk would bias the analysis of outmigration in relation to health status. The analysis time is the time between the 2010 survey interview date and the date of migration, death or 2016 interview.

To test the negative impact of outmigration, a Cox model is used on death with migration as the independent (time-varying) variable of interest and other variables as control variables. The date of death for outmigrants could not be reliably collected from proxy respondents but was approximated as the median date between migration and the 2016 survey date.

A variant of this second model is performed on the matched sample using traced migrants and their matches.

Because migration is not a random event, its effect on death may be confounded by other covariates. Therefore, a matched sample is a way to control for the sociodemographic determinants of migration, and their complex interactions, in order to focus on the migration effect on death. Matches are randomly chosen on the basis of seven characteristics (as measured in 2010). Matching on known characteristics does not totally prevent mismatch on unobserved characteristics associated with both migration and health, such as genetic or behavioural dispositions, but chance that migrants and their non-migrant pairs share unobserved characteristics is higher with random matching. The applied Cox model controls for correlated variance within pairs of migrants and non-migrants (StataCorp 2017).

Lastly, this second model is tested by using health outcomes (and not death) from the data collected on outmigrants and their non-migrant matches who survived to 2016. As in the previous paired model, correlated variance within pairs is controlled for.

All effects are interpreted through HRs. An effect of migration in both models will indicate an impact of migration on death or health. After controlling for objective health status as measured in 2010, a persisting effect of migration would indicate that the impact of health is postmigration. On the contrary, a diminished effect of migration after controlling for initial health status would indicate that the health conditions prevailing before migration explain survival or health outcomes more than the migration event. Health measures are obviously endogenous to mortality (ie, a health condition might lead to death). The comparison of models with and without health variables is not actually to explain death by health but to determine whether the higher risk associated with migrant status for the whole sample is explained by premigration health conditions.

The significance of the HR will not be evaluated through p value but through the effect size that accounts for both α, the risk of false positive and statistical power, that is $1-\beta$, the risk of false negative, as suggested by Halsey *et al*[12] to allow for more robust interpretation of regression results. We applied a 5% threshold for both α and β. The effect size is computed a posteriori for the Cox model. We used bootstrap replication method (10 000 replications) to obtain the 95% CI of the effect size for a given dependent (ie, death) risk estimate and SD of the independent variables of interest (ie, outmigration within Ouagadougou or out of Ouagadougou). For the matched sample, the replications are not done on individuals but on clusters of paired migrants and non-migrants. An HR with p value >0.05 but situated below the 95% CI of the effect size is considered non-significant. It is considered relevant (but not conclusive) if within the 95% CI of the effect size. The HR is conclusively significant if situated above the 95% CI of the effect size.

Patient and public involvement

The study did not involve patients.

RESULTS

Health determinants of outmigration

Among the respondents of the HS-2010, 24.6% (580/2354) outmigrated from the OPO between the survey in 2010 and the last 2014 round of OPO routine data collection. Among the migrants to destinations outside Ouagadougou, 25% migrated abroad and 75% to smaller urban centres or rural areas of Burkina Faso. Only 40% of these outmigrants returned to a previous place of residence.

The effects of non-health determinants on outmigration do not differ between the two regressions in table 2, one without health covariates (M1) and the other with health covariates (M2). This gives credence to the assumption that health determinants do not correlate with non-health determinants. The regression with health covariates shows that none of the health indicators have an effect on outmigration.

Impact of outmigration on survival

The first regression in table 3 (M1) shows that migration status is significant and migrants who moved out of Ouagadougou have higher mortality (HR 4.16) than those moving to other Ouagadougou areas (HR 2.80). However, these HRs are within the 95% CI of the effect size (3.59–5.26 for out-of-Ouagadougou areas and 2.63–3.67 for other Ouagadougou areas, respectively, computed with bootstrap SEs). In other words, the estimated HRs are relevant but not reliably significant under the conditions of 95% statistical power, $p<0.05$, and 10% correlation between migration and other covariates. In addition, the difference between the HR for the two destinations is not significant. Overall outmigration is detrimental to survival but there is not enough statistical power to conclude on the significance of this effect for either of the two destinations.

In the second regression using objective health measures as additional covariates (table 3, M2), the migrant status effect is maintained. None of the health variables are significant. The migration effect on mortality seems therefore independent of premigration health status.

With the matched sample, the regression shows (table 4, M1) a non-significant difference between non-migrants and migrants to other Ouagadougou areas but significant difference with migrants out of Ouagadougou (HR 2.63, $p<0.05$). This significance remains the same in the regression including health variables (table 4, M2). This means that the effect of migration is independent from premigration health status. Effect size computation for out-of-Ouagadougou migration shows that the estimated HR is well below 3.37, the lower range of the 95% bootstrap CI of the effect size (computed with 95% statistical power, $p<0.05$, and, due to matching, no correlation between migration and other covariates). Under the same conditions, the sample would have to be at least two-thirds bigger (1365 instead of 822) to get an estimated HR of 2.63 that would satisfy both 95% statistical power and p value <0.05. In addition, the analysis of the surviving matched sample for

Table 4 Impact of migration in 2010–2014 on death in 2016 (Cox model, matched sample on seven variables)

	PYAR (%)	M1 HR (95% CI)	P value	M2 HR (95% CI)	P value
Sex					
Male	*50.93*	Ref.		Ref.	
Female	*49.07*	0.731 (0.420 to 1.273)	0.268	0.700 (0.386 to 1.268)	0.239
Age group (years)					
<20	*14.70*	Ref.		Ref.	
20–29	*33.11*	1.704 (0.127 to 22.85)	0.687	1.624 (0.120 to 21.92)	0.715
30–39	*15.09*	2.042 (0.074 to 56.25)	0.673	1.804 (0.066 to 49.63)	0.727
40–49	*5.98*	10.183 (0.387 to 268.2)	0.164	8.855 (0.333 to 235.7)	0.193
50–64	*19.17*	18.151 (0.725 to 454.4)	0.078	12.49 (0.453 to 344.2)	0.136
65+	*11.95*	37.515* (1.662 to 846.6)	0.023	23.84 (0.974 to 583.4)	0.052
Marital status					
Never married	*32.02*	Ref.		Ref.	
Married	*54.96*	1.675 (0.291 to 9.634)	0.564	1.593 (0.283 to 8.960)	0.597
Divorced	*1.13*	0.695 (0.039 to 12.24)	0.803	0.641 (0.038 to 10.88)	0.758
Widowed	*11.89*	2.293 (0.344 to 15.27)	0.391	2.239 (0.337 to 14.89)	0.404
Education					
None	*54.79*	Ref.		Ref.	
Primary	*16.16*	1.366 (0.623 to 2.996)	0.437	1.416 (0.616 to 3.254)	0.412
Secondary+	*23.55*	0.943 (0.166 to 5.357)	0.947	0.918 (0.165 to 5.103)	0.922
Missing	*5.50*	0.310 (0.086 to 1.117)	0.073	0.309 (0.079 to 1.210)	0.092
Occupation		1.011 (0.510 to 2.004)	0.974	1.052 (0.519 to 2.132)	0.888
Employer/freelance	*30.14*	0.480 (0.138 to 1.669)	0.248	0.506 (0.150 to 1.711)	0.273
Employee	*12.96*	1.184 (0.491 to 2.857)	0.707	1.251 (0.513 to 3.047)	0.623
At school/trainee/ inactive	*39.43*				
Unemployed	*12.60*	Ref.		Ref.	
Missing	*4.87*	3.388 (0.553 to 20.76)	0.187	3.348 (0.489 to 22.95)	0.218
Standard living					
Poor	*47.26*	Ref.		Ref.	
Middle	*43.39*	0.993 (0.627 to 1.573)	0.977	0.977 (0.601 to 1.589)	0.926
Rich	*9.23*	0.912 (0.335 to 2.484)	0.857	0.921 (0.327 to 2.593)	0.877
Missing	*0.12*	0.000 (0.000 to 0.000)	0.000	0.000 (0.000 to 0.000)	0.000
Settlement					
Formal	*45.72*	Ref.		Ref.	
Informal	*54.28*	0.716 (0.469 to 1.094)	0.123	0.745 (0.485 to 1.144)	0.178
Destination					
Non-migrant	*77.65*	Ref.		Ref.	
Ouagadougou	*12.82*	1.724 (0.953 to 3.119)	0.072	1.728 (0.942 to 3.171)	0.077
Out of Ouagadougou	*6.31*	2.630* (1.234 to 5.609)	0.012	2.712* (1.200 to 6.130)	0.016
Missing	*3.23*	1.232 (0.385 to 3.942)	0.725	1.242 (0.389 to 3.968)	0.715
Hypertension					
No	*69.28*			Ref.	
Yes	*6.36*			1.812 (0.679 to 4.834)	0.235
Missing	*24.37*			1.810 (0.734 to 4.464)	0.197

Continued

Table 4 Continued

	PYAR (%)	M1 HR (95% CI)	P value	M2 HR (95% CI)	P value
Obesity					
No	*87.22*			Ref.	
Yes	*12.78*			1.828 (0.544 to 6.141)	0.329
Abdominal obesity					
No	*93.45*			Ref.	
Yes	*6.55*			0.941 (0.196 to 4.509)	0.939
N subjects		822		822	
N matched		245		245	
N PYAR		4570.68		4570.68	
N deaths		89		89	

In both models, SEs are corrected for matched clusters. The seven variables used for matching are: sex, age group, level of education, marital status, type of neighbourhood, employment and standard of living. Missing values are kept in the regression for the sake of controlling for potentially non-random missing values in some variables. The HR for these missing values should not be interpreted.
*P<0.05, **p<0.01, ***p<0.001.
PYAR, person-years at risk; Ref., reference.

whom 2016 health status could be collected showed that none of the migration and health variables explain survivors' health status in 2016 (results not shown).

DISCUSSION

Our analytic results are so-called negative results, that is, they did not confirm our main hypothesis. We conclude through various methods (non-matched and matched samples, death or health outcomes) that there is not enough evidence that migration, in or out of Ouagadougou, led to higher mortality or worse health. It is worth noting that even if there was enough evidence to confirm our hypothesis, the higher mortality associated with outmigration would affect a relatively small part of the population. In a 4-year period, <8% of adults migrated out of Ouagadougou while 16% headed to other Ouagadougou destinations. The impact on underestimation of health risks in the HDSS would be negligible, even with a high impact of bad health on outmigration.

This project made use of both a health survey conducted in 2010 and of the HDSS framework to monitor deaths and outmigration between 2010 and 2016. In addition, matching was used to save substantially on follow-up costs and to control covariate interactions for counterfactual analysis. This methodology could potentially be extended in most HDSS frameworks, where surveys are conducted on a regular basis on samples.

However, it should be noted that loss to follow-up should not be underestimated, even when the constraints of face-to-face interviews are lessened by mobile phone interviews. Only 54% of the migrants could eventually be reached through mobile phone (245/450). No significant difference was found between reached and non-reached migrants on the basis of observed characteristics. However, unobserved characteristics associated with loss to follow-up may have generated a bias generated in the analysis of the migration-mortality relationship. In addition, no objective health measures could be gathered from migrants using phone interviews.

Based on these results, methodological advice for future research is to collect mobile phone numbers more systematically to make phone interview a viable alternative to prospective face-to-face interview, for both the treated and non-treated (eg, non-migrants and outmigrants after their departure). In our case, half of the lost-to-follow-up migrants could not be reached because of lack of phone contacts. This could have been reduced if we had collected phone numbers in 2010 and maintained a phone number database throughout the 2010–2015 period. Mobile phone interviews can be conducted more systematically. Most questions can be asked at a distance (especially to make routine corrections of data collection errors), while face-to-face interviews should be kept to the absolute minimum to avoid respondent fatigue and failure to meet the respondent. The proportion of respondents who refused to respond on the phone was quite low (<10%).

HDSS platforms can be used to analyse the long-term impact of health through sample follow-up, but need to use large samples. Although the HS-2010 gathered data on >2350 adults, it was not big enough considering the low prevalence of events at stake (<20%) and the loss to follow-up (around 50%). With similar figures, the sample needed to get enough statistical power should have been at least doubled to 5000 adults.

We also advise using posterior matching (ie, matching of non-treated after identification of the treated) whenever possible. Randomisation is difficult if not impossible to achieve in social sciences in general, and migration analysis in particular, and matching is a good alternative to randomisation for counterfactual analysis with longitudinal data. Random matching does not completely prevent mismatch on unobserved characteristics associated with both migration and health, but it certainly reduces the risk of misinterpretation due to differences in characteristics between treated and non-treated. We finally also advise the use of the effect size (and its 95% CI) rather than the p value to evaluate the significance of the estimated HR accounting for the sample's statistical power.

CONCLUSION

The study neither confirms the hypothesis that outmigration is selective on health nor confirms the hypothesis that migration away from Ouagadougou has a negative effect on mortality or other health outcomes. Indeed, there is no evidence of a negative effect of migration on health for survivors, and the higher mortality of outmigrants after their migration away from Ouagadougou is not supported after proper control for confounders through matching and consideration of effect size.

Therefore, measures of health and mortality in the OPO are marginally biased by migration and are therefore generalisable to similar areas in Ouagadougou. It is not worth extending the follow-up study on a larger sample of outmigrants to control for potential outmigration effect. As for our initial question, we can provisionally say that health outcomes as measured in the Ouagadougou population do reflect local health risks and access to health services despite high migration intensity.

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