CENTRE DE RECHERCHE EN DÉMOGRAPHIE ET SOCIÉTÉS, UCL

CONTRÔLE DE LA CENSURE INFORMATIVE EN POPULATION OUVERTE : APPLICATION AUX DONNÉES D'OBSERVATOIRE SUR LA MORTALITÉ ADULTE

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Starting point

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- Do health outcomes as measured in local populations really reflect **local health risks**?
- How do local health information systems (e.g. HDSS) reflect **exposure of mobile populations** to different environments and also to different health care systems?
- How does **migration disturb** our analysis of local population health risks?

Methodological Background

"*An individual who is censored at c should be representative of all those subjects with the same values of the explanatory variable who survive to c*"
(Cox and Oakes, 1984)

- **Independence assumption**: attrition and event are independent of each other (e.g. time at survey = non-informative censoring)
- **Attrition through in- and out-migration** in Health and Demographic Surveillance System (HDSS)
- **Informative censoring** if migration related to respondents' health (selective left- and right-censoring)

Ordinary survival framework

- *T* is the variable of interest, called the time to event or lifetime, with unknown distribution function *F*
- C is the random right-censoring time with arbitrary d.f. *G*
- *T* and C are assumed to be mutually independent

Partially informative censoring framework

- T is the variable of interest, called the time to event or lifetime, with unknown distribution function F
- C_0 defines ordinary censoring with d.f. G_0
- C_{-1} defines informative censoring with d.f. G_{-1}
- T and C_{-1} are NOT assumed to be mutually independent

Proposed solution: Two-Stage Equation Model

- Inspired by the 2SLS (two-stage least square) model to control for selection bias in cross-sectional data
  - Use **I**nstrumental **V**ariables (i.e. **IV** explain selection but not the event)
- 1st stage: Out-migration (Cox 1972)
  - Results do not differ much from Béguy et al. (2010)
- 2nd stage: Competing causes of death (Fine & Gray 1998)
  - Equivalent to Cox model, use "cumulative incidence function" instead of hazard function
  - Do not make the (wrong) hypothesis of independence between competing risks (causes of death)

Controls for observed and unobserved heterogeneity in migration

- Observed heterogeneity
  - Relative migration propensity
    = log (relative cumulative hazard function)
  - Computed on known migration determinants
- Unobserved heterogeneity
  - Captured through (standardized) deviance residuals
    (= observed versus predicted probabilities)
  - Computed on unknown migration determinants

Two-Stage Equation Model: control for selection bias due to observed heterogeneity

- Selection (out-migration) Cox model equation
  (C_{-1} = informative censoring = out-migration):

$$\lambda_{C_{-1}|Z(t)}\left(t\middle|z(t)\right) = \lambda_{C_{-1}0}(t)exp^{z(t)\beta}.$$

- Main (mortality) equation:

$$\lambda_{T|x(t)}(t|x(t)) = \lambda_{T0}(t)exp^{x(t)\beta+\Lambda_{-1}(t)\alpha}$$

where log(relative cumulative hazard function)
represents out-migration propensity
by time *t*:

$$\Lambda_{-1}(t) = log\left\{\frac{\sum_{j=1}^{N}\lambda_{C_{-1}|Z(t)}\left(t\middle|z(t)\right).I\left(C_{-1j}\leq t\right)}{\sum_{j=1}^{N}\lambda_{C_{-1}}(t).I\left(C_{-1j}\leq t\right)}\right\}$$

To note: $Z = X + V$, with V a vector or instrumental variables (i.e. that explain the selection but not the event, e.g. data collection or calendar effects)

Two-Stage Equation Model: control for selection bias due to unobserved heterogeneity

- Martingale residuals from selection (out-migration) model:

$$M_{-1,i} = \delta_{-1,i} - \exp\left(\mathbf{z_i}(t)\hat{\beta}_{-1}\right).\Lambda_{-1,base}\,(t_i)$$
$$-\infty < M_{-1,i} \leq 1$$

- Deviance residuals (Therneau et al. 1990) from selection model:

$$D_{-1,i} = sign\left(M_{-1,i}\right)\left[-2\left\{M_{-1,i} + \delta_{-1,i}\log\left(\delta_{-1,i} - M_{-1,i}\right)\right\}\right]$$
$$-\infty < D_{-1,i} < +\infty$$

  - Negative residuals = lower observed chance to out-migrate than predicted
  - Positive residuals = higher observed chance to out-migrate than predicted

Final Two-Stage Equation Model

- Determinants of mortality
- Controlling for:
  - Observed heterogeneity in out-migration risk
  - Unobserved heterogeneity in out-migration risk
- Controlling for:
  - Observed heterogeneity in in-migration risk
  - Unobserved heterogeneity in in-migration risk

$$y(t) = x(t)\beta + \Lambda_{-1}(t)\alpha_{-1} + \Lambda_{+1}(t)\alpha_{+1} + D_{-1}(t)\gamma_{-1} + D_{+1}(t)\gamma_{+1}$$

Hypotheses: expected selection effect

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	Non-violent death	Violent death
Observables, in-migration	Positive (HR<1)	Nil (HR=1)
Unobservables, in-migration	Negative (HR>1)	Nil (HR=1)
Observables out-migration	Positive (HR<1)	Nil (HR=1)
Unobservables out-migration	Negative (HR>1)	Nil (HR=1)

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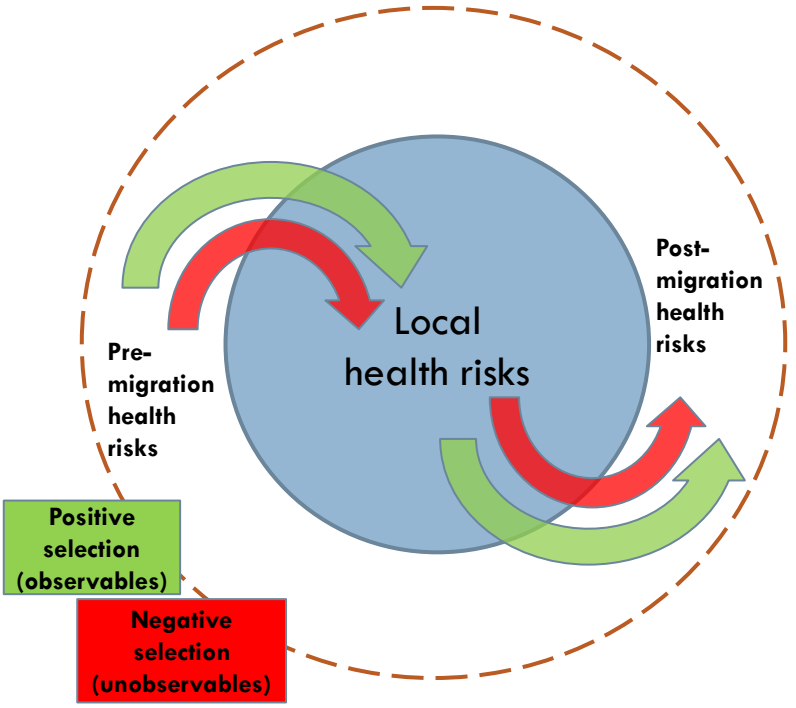

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Nairobi HDSS data

- 2004 to mid-2010 data (6 ½ years)
- Almost 100,000 lived in the HDSS (aged 15-79)
- 1927 died in the HDSS in 2004-2010 (aged 15-79)
- High circular migration of adults (15+) in slums:
  - More than 26% annual in- and out-migration rate
- Eliminate first 6 months after in-migration
  - 4-month minimum duration criteria for residence
  - No risk of dying/out-migrating during those first 4 months

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Covariates in Nairobi HDSS Data

- Time-invariant covariates
  - sex, ethnicity, slum area, education
- Time-varying covariates (TVC)
  - duration of residence, year, post-election (dec-2007) period
- TVC specific to migration model (=instruments)
  - notice of demolition (eviction from the slums)
  - field-workers (quality of data collection)

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Cause of death data

- Non-violent deaths (66%) include chronic diseases
  - diabetes, HIV/TB, cardio-vascular, undetermined but not violent…
- Violent deaths (17%)
  - murders (e.g. political), suicide, accidents…
- Unknown causes of death (17%)

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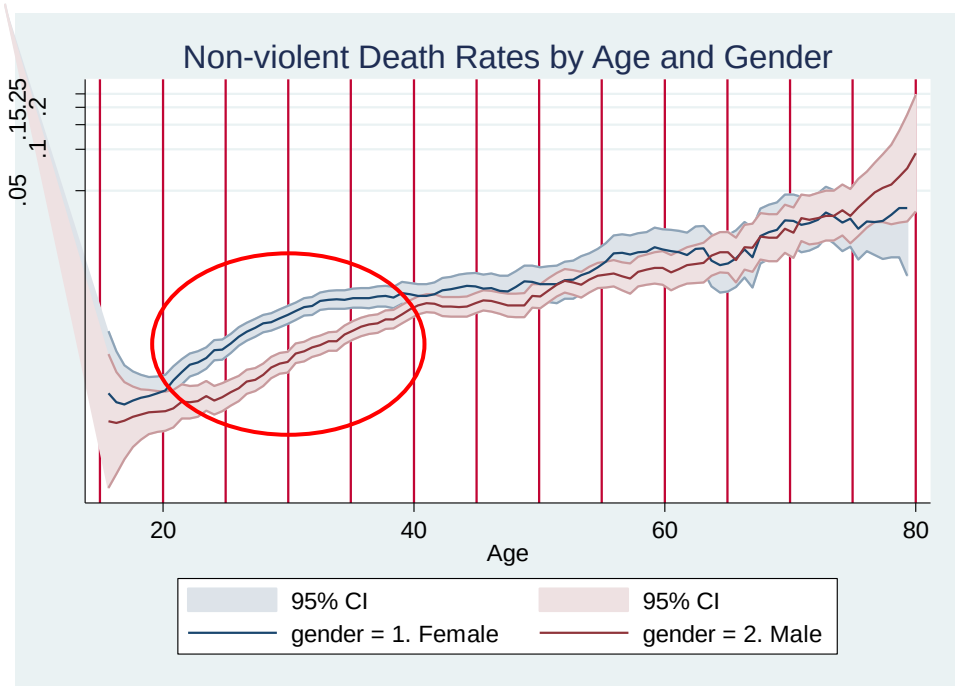
Unusually high female mortality in Nairobi slums

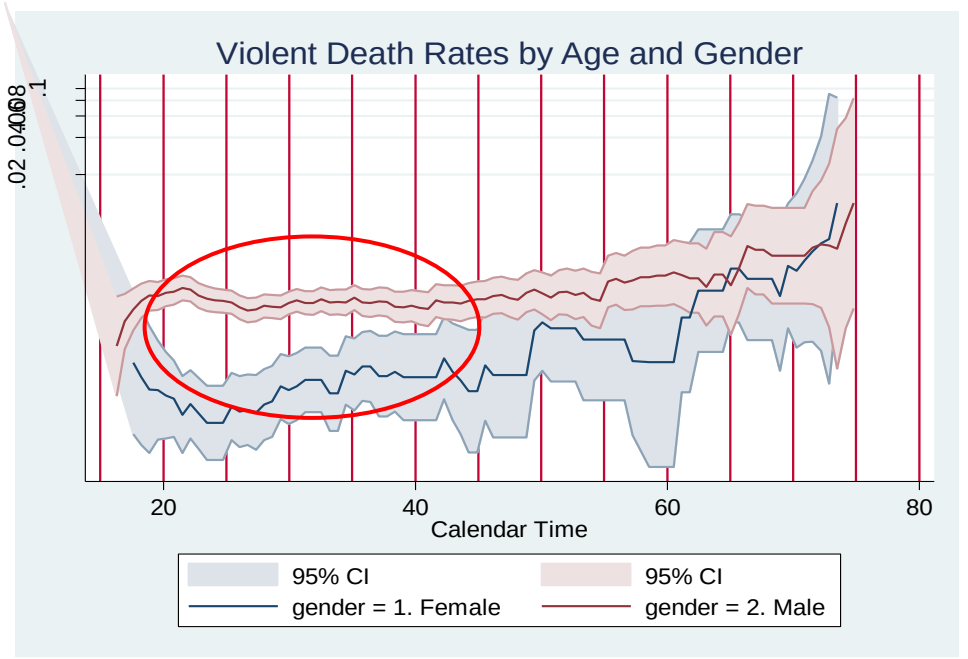
Nairobi HDSS:

- 45q15 (15-60)
  - 334‰ [CI: 312 – 356] for males
  - **375‰** [CI: 342 – 410] for females
- E15 (15-80)
  - 15+49.3=64.3 year old [CI: 63.5 – 65.1] for males
  - 15+48.6=**63.6** year old [CI: 62.6 – 64.7] for females

WHO for Kenya:

- 45q15 (15-60)
  - 358‰ for males
  - 282‰ for females
- E15
  - 15+49.2=64.2 year old for males
  - 15+53.0=68.0 year old for females


Non-violent Death Rates by Age and Gender
.05
.1
.15
.2
.25
20
40
60
80
Age
95% CI
95% CI
gender = 1. Female
gender = 2. Male


Violent Death Rates by Age and Gender
.02
.04
.06
.08
.1
20
40
60
80
Calendar Time
95% CI
95% CI
gender = 1. Female
gender = 2. Male

Regression results: observed heterogeneity in out-migration

Out-migr. propensity	Male	Female
Non-violent death	0.95 (0.80 - 1.12)	0.80*** (0.69 - 0.93)
Violent death	0.95 (0.81 - 1.12)	0.94 (0.61 - 1.46)

- Lower risk of non-violent death **in HDSS** associated with high out-migration propensity for **females**

⇒ Non-violent mortality in HDSS would have been **higher** for females without out-migration

Regression results: observed heterogeneity in in-migration

In-migr. propensity	Male	Female
Non-violent death	0.96 (0.89 - 1.05)	1.19*** (1.08 - 1.31)
Violent death	0.92** (0.86 - 0.99)	1.01 (0.75 - 1.36)

- Unexpected higher risk of non-violent death **in HDSS** associated with high in-migration propensity for **females**

⇒ Non-violent mortality in HDSS would have been **lower** for females without in-migration

- Unexpected lower risk of violent death **in HDSS** associated with high in-migration propensity for **males**

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Regression results: unobserved heterogeneity in out-migration

Deviance residuals	Male	Female
Non-violent death	1.06*** (1.02 - 1.10)	1.07*** (1.04 - 1.11)
Violent death	1.01 (0.95 - 1.07)	1.08 (0.94 - 1.24)

- Higher risk to die **in HDSS** if higher-than-predicted risk to out-migrate
  - ⇒ Conditional on not having done a migration yet
- Effect for **both males and females**

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Regression results: unobserved heterogeneity in in-migration

Deviance residuals	Male	Female
Non-violent death	1.43*** (1.29 - 1.58)	1.62*** (1.48 - 1.77)
Violent death	1.59*** (1.39 - 1.82)	1.23 (0.80 - 1.89)

- Higher risk to die **in HDSS** if higher-than-predicted risk to in-migrate
- Effect for **both males and females**
- **Unexpected effect on violent death for males**

Hypotheses: evidence of selection effect for females

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	Non-violent death	Violent death
Observables in-migration	Negative	Nil
Unobservables in-migration	Negative	Nil
Observables out-migration	Positive	Nil
Unobservables out-migration	Negative	Nil

Too few cases of violent deaths for females

Hypotheses: evidence of selection effect for males

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	Non-violent death	Violent death
Observables in-migration	Nil	Positive
Unobservables in-migration	Negative	Negative
Observables out-migration	Nil	Nil
Unobservables out-migration	Negative	Nil

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Conclusions: expected results

- **High migration contribution** (Chi2: F=44.1%; M=26.5%)
- Confirmed negative selection by **unknown determinants of migration** :
  - Evidence that they are **health-related** (migration motivated by bad health, or associated with risk taking, violence or exposure to health risks)
  - Unobserved determinants are **more important than observed ones** to explain mortality in HDSS
  - Also confirmed for **violent death for males,** thus identifying a sub-population of men in the slums who take up (illegal) activities or adopt (risky) behaviour that expose them to violent deaths

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Conclusions: unexpected results

- **No bias in other determinants**
- **Higher selection by in-migration** than by out-migration
- **Positive selection almost absent for males**
  - Non-significant evidence for non-violent deaths
  - Unexpectedly positive for violent deaths
- **Negative selection by in-migration for females**
  - Combined with positive selection by out-migration = high risks of dying of non-violent death
  - Explain rather high female-to-male mortality in Nairobi slums (≠ Kenya)

Merci pour votre aimable attention!