Estimating death rates in complex humanitarian emergencies using the network method

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Joint with: Dennis Feehan (UC Berkeley), Saeed Rahman (Reach Initiative), Christina Kay (Reach Initiative), Joeri Smits (Reach Initiative), Steve Ahuka (University of Kinsasha)

Motivation for study

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- How do you best estimate death rates in **humanitarian emergencies**?
- We can't use conventional methods
  - Civil war, earthquake, etc.

We still need new methods....

Emerg Themes Epidemiol. 2007; 4: 9. PMCID: PMC1904216
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Wanted: studies on mortality estimation methods for humanitarian emergencies, suggestions for future research

Working Group for Mortality Estimation in Emergencies ⊠[1]

Author information ▸ Article notes ▸ Copyright and License information PMC Disclaimer

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Overview of Network Survival Method

$$M_\alpha = \frac{D_\alpha}{N_\alpha} \tag{1}$$

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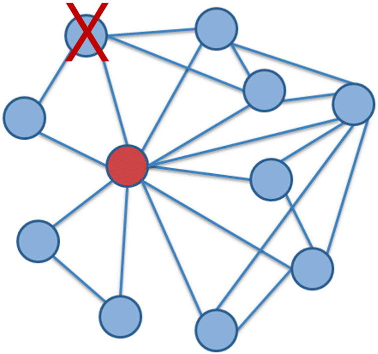
- D_α is the number of deaths
- N_α is the person days of exposure

Insights from social networks



People can report valuable information about mortality among their social network

Network survival method

$$\widehat{M}_\alpha = \frac{D_\alpha}{N_\alpha} \tag{2}$$

$$= \frac{\sum_{i \in s} w_i \; y_{i,D}}{\sum_{i \in s} w_i \; d_i \; E_i} \tag{3}$$

where

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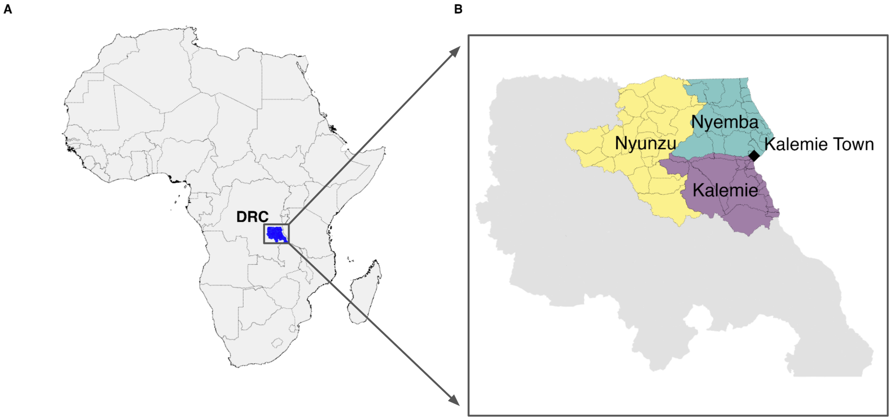
- $\sum_{i \in s} w_i \ d_i \ E_i$ is the (weighted) total amount of exposure reported on in respondents' personal network

Case Study: Democratic Republic of the Congo



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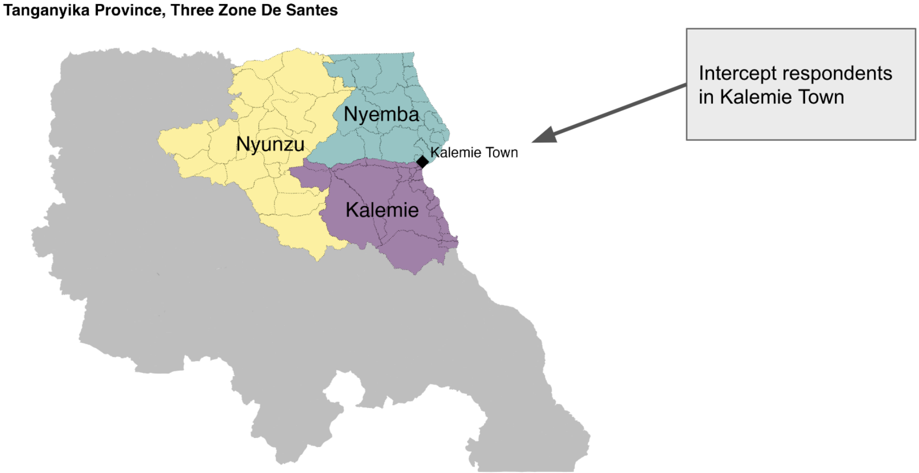
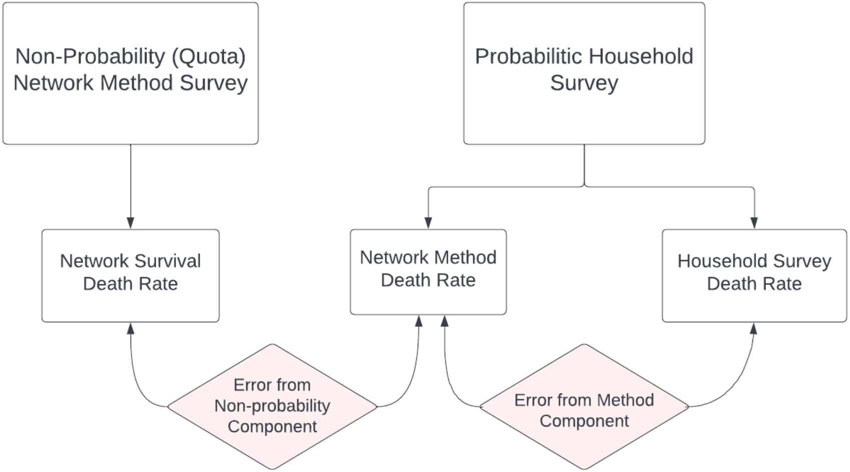


Study design



Key design question – how do we pick a network tie?

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- Too small a network: we need a much bigger sample size (e.g, parents, siblings)

Formative research (qualitative)

- **Goal**:
  - What deaths can respondents report on accurately?
  - What reference date and reporting window should we chose?
- 8 focus groups + 20 individual interviews

Group	Age	Gender	Location
1	<45	Male	Urban
2	<45	Female	Urban
3	<45	Male	Rural
4	<45	Female	Rural
5	45+	Male	Urban
6	45+	Female	Urban
7	45+	Male	Rural
8	45+	Female	Rural

Best option — kin and neighbor networks

Module	Group	Notes
Neighbor	Respondent's Household	
Neighbor	1st Closest Neighbor Household	
Neighbor	2nd Closest Neighbor Household	
Neighbor	3rd Closest Neighbor Household	
Neighbor	4th Closest Neighbor Household	
Neighbor	5th Closest Neighbor Household	
Kin	Respondent's Grandchildren	
Kin	Respondent's Children	
Kin	Respondent's Siblings	
Kin	Respondent's Cousins	
Kin	Respondent's Aunts/Uncles	
Kin	Respondent's Parents	
Kin	Respondent's Grandparents	

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- Quota sample by geographic region + gender (non-probability)

Data Collection

Interviews conducted at transit hubs such as markets, ports, taxi stations, health clinics, etc.

Informed consent on paper form, survey administered on smartphone

Quota sample: Interviews by month (N = 2,650)

Month	Kalemie	Nyemba	Nyunzu
March	203	198	200
April	201	203	202
May	216	221	232
June	228	237	204

Note: All respondents report on deaths since January 1st, 2023

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  - Sampling frame was constructed from population data from the Ministry of Health
  - Primary sampling units at the village level
- The household survey asked detailed information about deaths occurring within their household after January 1st, 2023

Quota sample re-weighting strategies - 3 different scenarios

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1. No weights (rely on quota design)
2. Poststratification weights (age, gender, geography only)
3. Inverse probability weights (requires high-quality reference sample)

Inverse probability weights

Fit a model to estimate inclusion probability:

$$w_i = \frac{1}{\hat{P}(S_i = 1)} \tag{4}$$

where w_i is a weight define as the the inverse probability of being included in the sample $(S_i = 1)$.

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$$\begin{aligned}\text{logit}(\text{Pr}(\text{inclusion} = 1|\mathbf{X})) = &\beta_0 + \beta_{\text{(gender)}} + \beta_{\text{(age class)}} + \beta_{\text{(gender}\times\text{age\_class)}} + \beta_{\text{(hh size)}} \\ &\beta_{\text{(radio)}} + \beta_{\text{(bed)}} + \beta_{\text{(wall material)}} + \beta_{\text{(modern fuel type)}} + \\ &\beta_{\text{(hh count age 0–4)}} + \beta_{\text{(hh count age 5–17)}} + \beta_{\text{(hh count age 18+)}}\end{aligned} \tag{5}$$

Blended estimates - combined neighbor and kin estimates

$$\underbrace{\widehat{M}}_{\text{Blended Estimate}} = \underbrace{\theta\widehat{M}^A}_{\text{Weighted Estimator A}} + \underbrace{(1-\theta)\widehat{M}^B}_{\text{Weighted Estimator B}} \tag{6}$$

where θ is a weight $\in [0, 1]$.

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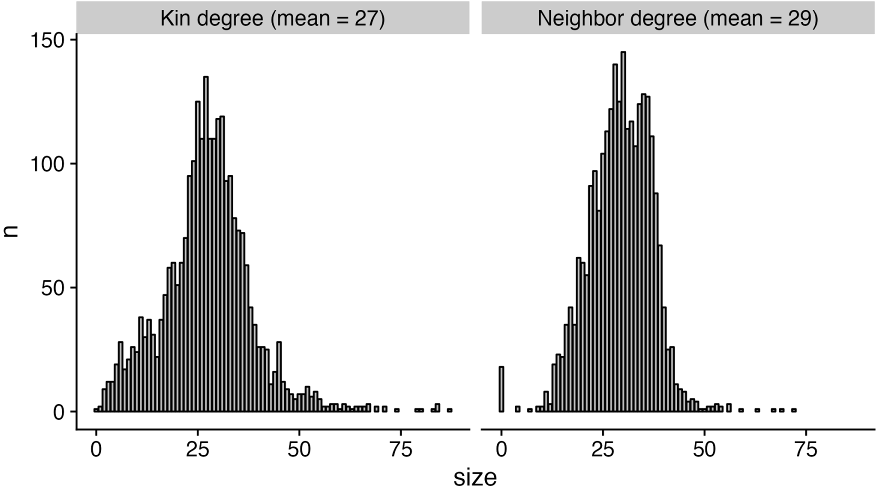
where θ is a weight $\in [0, 1]$.

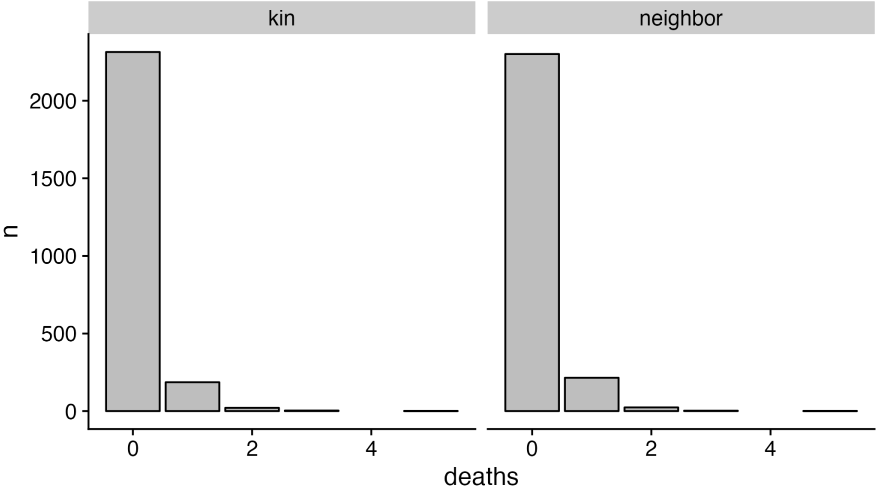
We can pick the optimal $\theta^\star$ to minimize mean squared error:

$$\theta^\star = \frac{\sigma_B^2 - \frac{\sigma_{AB}}{2}}{\sigma_A^2 + \sigma_B^2 - \sigma_{AB}}, \tag{7}$$

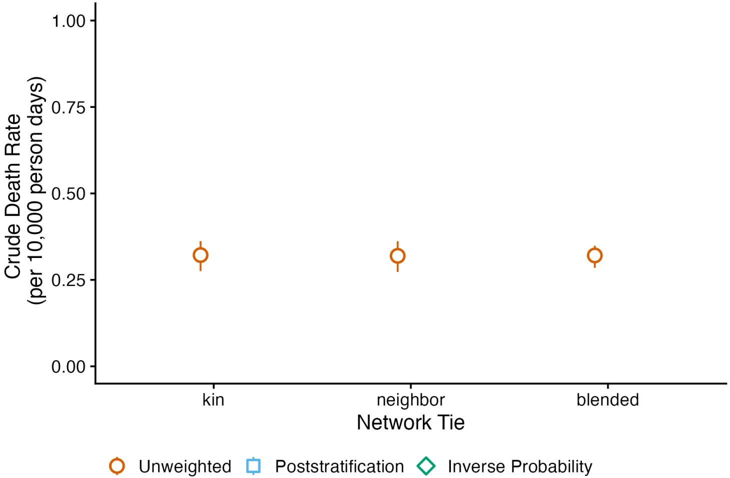
Network size – distribution



Deaths reported per interview – distribution



Non-probability network survival results



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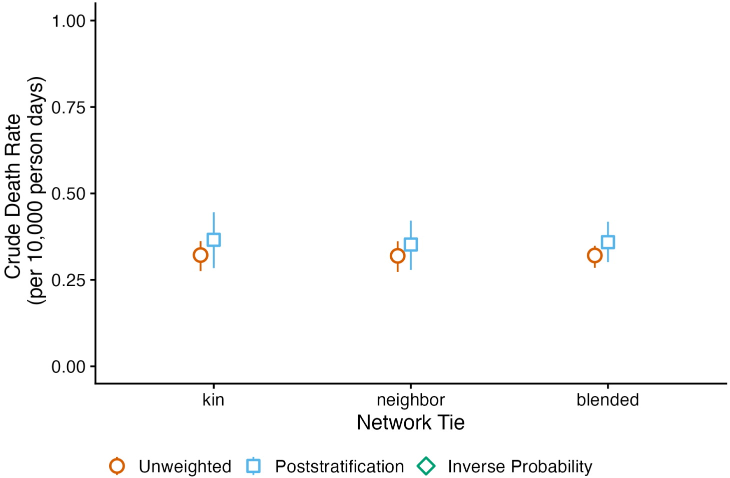

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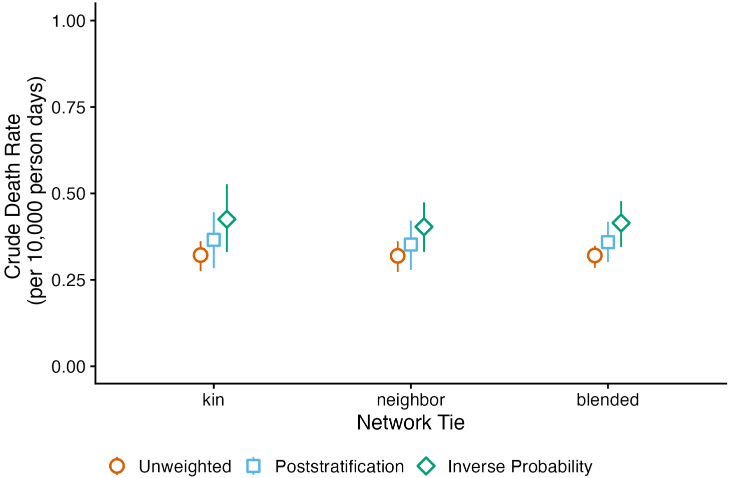
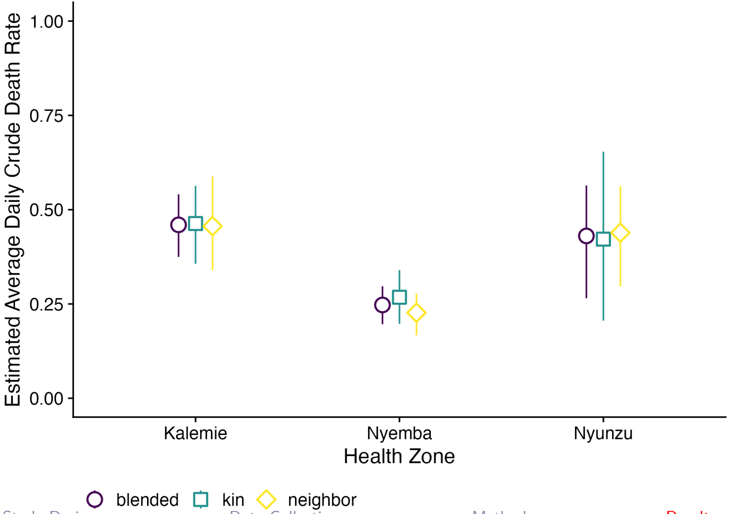
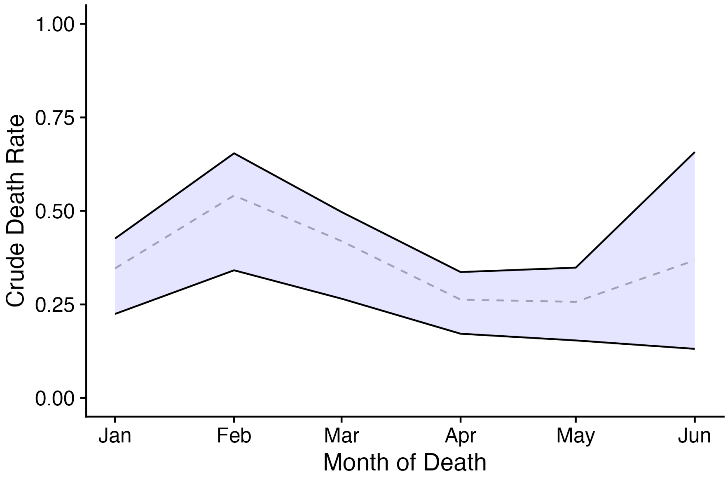


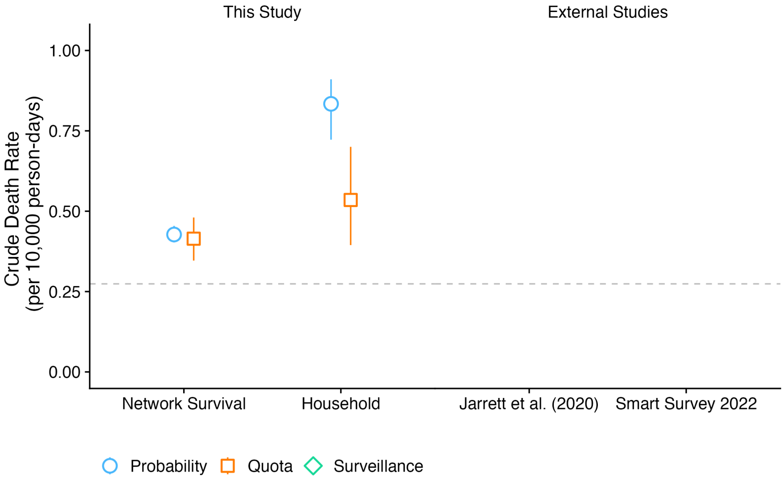
Variation across health zones



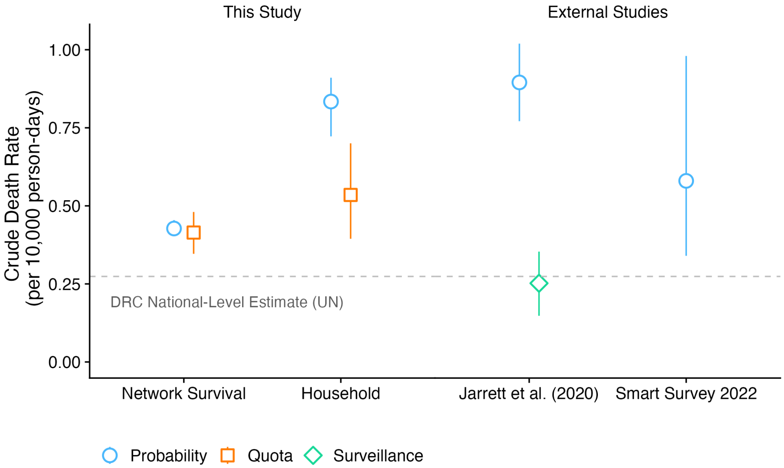
Monitoring trends over time



Full comparisons



Full comparisons + external studies



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  - We need more systematic evaluations
- Highly contextual – **requires** localized knowledge of social networks, diffusion of info about deaths, etc.

Where to next...?

- We need more **rigorous assessment** of household mortality survey and network survival method in different settings

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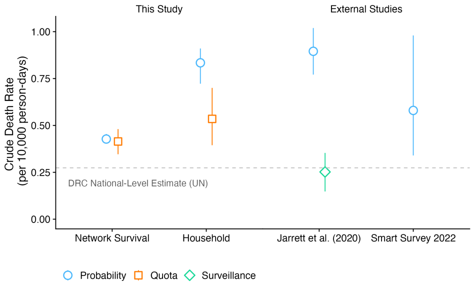
  - Surveillance sites, verification visits, etc.
- Streamlining into a "off-the-shelf" module that can easily be added onto existing surveys

Thank You

- Questions?



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