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Women who have undergone abortion in the city of Rio de Janeiro, Brazil: application of a Bayesian hierarchical model

Natália Santana Paiva

Daniel Antunes Maciel Villela

Leonardo Soares Bastos

Francisco Inácio Bastos*

* Presenting author

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Introduction

The World Health Organization defines induced abortions as those initiated by deliberate action with the intention of terminating the pregnancy.

Induced abortions are often performed by persons without the minimum necessary skills or in locations that fail to comply with the most basic medical and hygienic standards, or both, thus characterizing unsafe abortions and posing avoidable risks to the woman’s health and life.

The high incidence of induced and often unsafe abortions is still a public health problem and one of the principal indices in reproductive health.

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Introduction

The global rate of unintended pregnancy was 62 (90% CrI [59;72]) per 1,000 women 15 to 44 years of age (2010/14,) and 56% (90%CrI [53;60]) of all unintended pregnancies ended in abortion during the same period (data from 2018).

Brazil, within a broad set of more than 65 countries, has quite restrictive laws on induced abortion.

Studies have shown that unsafe abortion is a common event in the reproductive life of Brazilian women, even in the context of illegality.

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Introduction

In the context of stigmatization and/or criminalization, nationwide studies have used indirect techniques to estimate unsafe abortions based on secondary data from Health Information Systems with the application of correction factors developed in the 1990s by the Alan Gutmacher Institute.

An alternative methodology (**Network Scale-up; NSUM**) for estimating the size of hard-to-reach populations has been employed in various public health settings both in international and Brazilian studies.

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The study aimed to estimate the number of women who had undergone induced abortion in the city of Rio de Janeiro in the year 2011.

This article takes an innovative approach in Brazil by applying a Bayesian hierarchical model based on indirect information from the contact networks of randomly selected participants from the general population to estimate the of number of women who have undergone abortion.

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Material and Methods

Study design

This study is a subproject of a broad national survey (2011/2): “Profile of crack cocaine users in the 26 state capitals, Federal District, 9 metropolitan areas, and Brazil (the latter term corresponding to all other municipalities and the rural areas)”, developed by the Oswaldo Cruz Foundation (FIOCRUZ), whose main objective was to estimate crack cocaine consumption and which also covered a series of other public health issues, such as induced abortion, illegal drug use in general (except marijuana [cannabis]), female sex work, etc.

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Material and Methods

Study design

The data collected in the national household survey allow estimating the size of hard-to-reach populations, for example women who have undergone induced abortion in the city of Rio de Janeiro in the year prior to the interview, using the network scale-up method (NSUM).

This household survey included questions about 20 subpopulations whose sizes were known in advance, or so-called "countable populations", as well as on subpopulations with unknown sizes, to generate estimates of their sizes. The current study's question was, "How many women do you know who have undergone induced abortion in the last 12 months?".

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Material and Methods

Study design

Since NSUM is based on the social network of each participant from the general population, it uses indirect information from the participant’s contact network concerning the subpopulations with known sizes to estimate the degree of the individual’s contact network.

The social network’s degree is the individual’s total number of contacts, according to the definition of “knowing someone” adopted in the study.

The study was approved by the IRB of National School of Public Health (#CAAE 84961418.4.0000.5240).

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Material and Methods

Hierarchical model

We assume that Y_i follows a binomial distribution (discrete, relatively short tail) with parameters δ_i and θ

$$Y_i \mid \delta_i, \theta \sim Binomial(\delta_i, \theta)$$ for *I =1 ,2,...,n*

<u>Notation</u>

Y_i ➔ Number of women who had undergone an abortion in the previous 12 months living in the city of Rio de Janeiro known by the participant *i*

δ_i ➔ Represent the degree of the contact network of individual *i*

θ ➔ The proportion of the target subpopulation in the general population in the city of Rio, estimated with indirect information on the contacts of the individuals selected in the survey

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Material and Methods

Hierarchical model

We also assume that X_{ik} (contacts) follows a binomial distribution with parameters δ_i and π_k

$$X_{ik} \mid \delta_i, \pi_k \sim Binomial(\delta_i, \pi_k)$$ for *I = 1,2,…,n* and *k = 1,2,…,K*

Notation

X_{ik} ➔ Number of contacts known by the participant *i,* residing in the city of Rio, from **subpopulation *k***

δ_i ➔ Represent the degree of the contact network of individual *i*

π_k ➔ Prevalence of subpopulation *k* in the city of Rio and is previously known

The study considered K subpopulations of previously known sizes (e.g. bus drivers, bank employees, foreigners). The information on subpopulations with known sizes was used to estimate the degree of the survey participants’ networks.

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Hierarchical model

Thus, the likelihood, $L(\theta, \delta_1, \ldots, \delta_n; y_i, x_{ik})$ can be written as

$$L(\theta, \delta_1, \ldots, \delta_n; y_i, x_{ik}) = p(y_i \mid \delta_i, \theta) \times p(x_{ik} \mid \delta_i, \pi_k)$$

Where:

$p(y_i \mid \delta_i, \theta)$ is the probability density given for Thus, the likelihood, $L(\theta, \delta_1, \ldots, \delta_n; y_i, x_{ik})$ can be written as **women**

$p(x_{ik} \mid \delta_i, \pi_k)$ is the probability density given for $X_{ik} \mid \delta_i, \pi_k \sim Binomial(\delta_i, \pi_k)$ **contacts**

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Material and Methods

Hierarchical model

The number of women who had undergone an abortion in the city of Rio de Janeiro in the 12 months prior to the interview is

$$N_Y = N \times \theta$$

Where:

N ➔ Size of the population in the city of Rio (IBGE Census 2010)

θ ➔ The proportion of the target subpopulation in the general population of the city of Rio in the year 2011, estimated with indirect information on the contacts of the individuals

Cumulative incidence of women aged 15-49y who had undergone an abortion in the city of Rio in the 12 months prior to the interview. ➔

$$\theta_Y = \frac{N_Y}{POP_{M15-49}} \times 1000$$

➔ Size of the population of women aged 15-49y living in the city of Rio (Census 2010)

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Model's self-validation

<u>Objectives:</u>

i) To verify whether the model is able to reasonably predict the size of any unknown population;

ii) To assess whether the proposed model is able to appropriately handle uncertainty;

iii) To verify whether there is a pattern of underestimation vs. overestimation of the target estimates for the hard-to-reach populations based on the Bayesian hierarchical modeling in NSUM.

"leave-one-out format"

20 known populations can used to self-validate the model

19 known populations are used to estimate the removed one

This process is repeated until all the subpopulations are estimated as if they were unknown

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Results

Table 1: Self-validation of the Bayesian hierarchical model using indirect information on social networks in the city of Rio, Brazil: true prevalence (%), estimated prevalence (%), and respective 95% CrI, and relative error

continues

Subpopulation with known size	True prevalence (%)	Estimated prevalence [a] (%)	95% CrI[b]	Relative error [c]
Bank employees	0.40	0.91	(0.84;0.97)	-0.56
Women under 20 years of age who gave birth in the last 12 months	0.99	1.73	(1.64;1.82)	-0.43
Women 20 years and older who gave birth in the last 12 months	0.16	1.24	(1.17;1.32)	-0.87
Mothers who received the Bolsa Família (cash transfer) benefit	2.75	1.96	(1.87;2.06)	0.40
Bus drivers	0.52	1.17	(1.10;1.25)	-0.56
Persons 15 years or older who cannot read or write (“illiterate”)	2.29	0.84	(0.78;0.90)	1.73
Women with four or more children (here - living biological children)	3.48	2.07	(1.97;2.17)	0.68
Foreigners	1.10	1.20	(1.13;1.28)	-0.08
Women who married in civil ceremonies in the last 12 months	0.44	0.50	(0.44;0.55)	-0.12
Men who married in civil ceremonies in the last 12 months	0.44	0.45	(0.41;0.50)	-0.02
Women over 70 years of age	4.25	4.55	(4.41;4.70)	-0.07
Men over 70 years of age	2.31	3.47	(3.35;3.61)	-0.33

[a] Prevalence’s posterior mean; [b] 95% credibility interval; [c] *relative error = (true prevalence – estimated prevalence / estimated prevalence*

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conclusion

Subpopulation with known size	True prevalence (%)	Estimated prevalence [a] (%)	95% CrI[b]	Relative error [c]
5th to 8th grade students in private schools	3.06	2.51	(2.40;2.62)	0.22
Private secondary school students	1.16	1.85	(1.76;1.95)	-0.37
Public secondary school students	3.45	4.38	(4.24;4.53)	-0.21
Secondary and primary private schoolteachers	1.58	1.53	(1.44;1.61)	0.03
Secondary and primary public schoolteachers	2.35	2.34	(2.23;2.45)	0.00
Girls under 5 years of age	2.85	4.33	(4.19;4.48)	-0.34
Boys under 5 years of age	2.92	4.08	(3.95;4.23)	-0.28
Widows/widowers (men or women whose last spouse died and who did not remarry)	5.93	1.83	(1.74;1.92)	2.24

[a] Prevalence's posterior mean; [b] 95% credibility interval; [c] *relative error = (true prevalence – estimated prevalence / estimated prevalence*

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Figure 1: Self-validation of the Bayesian hierarchical model in the city of Rio: true prevalence versus prevalence's posterior mean (bar = 95%CrI).

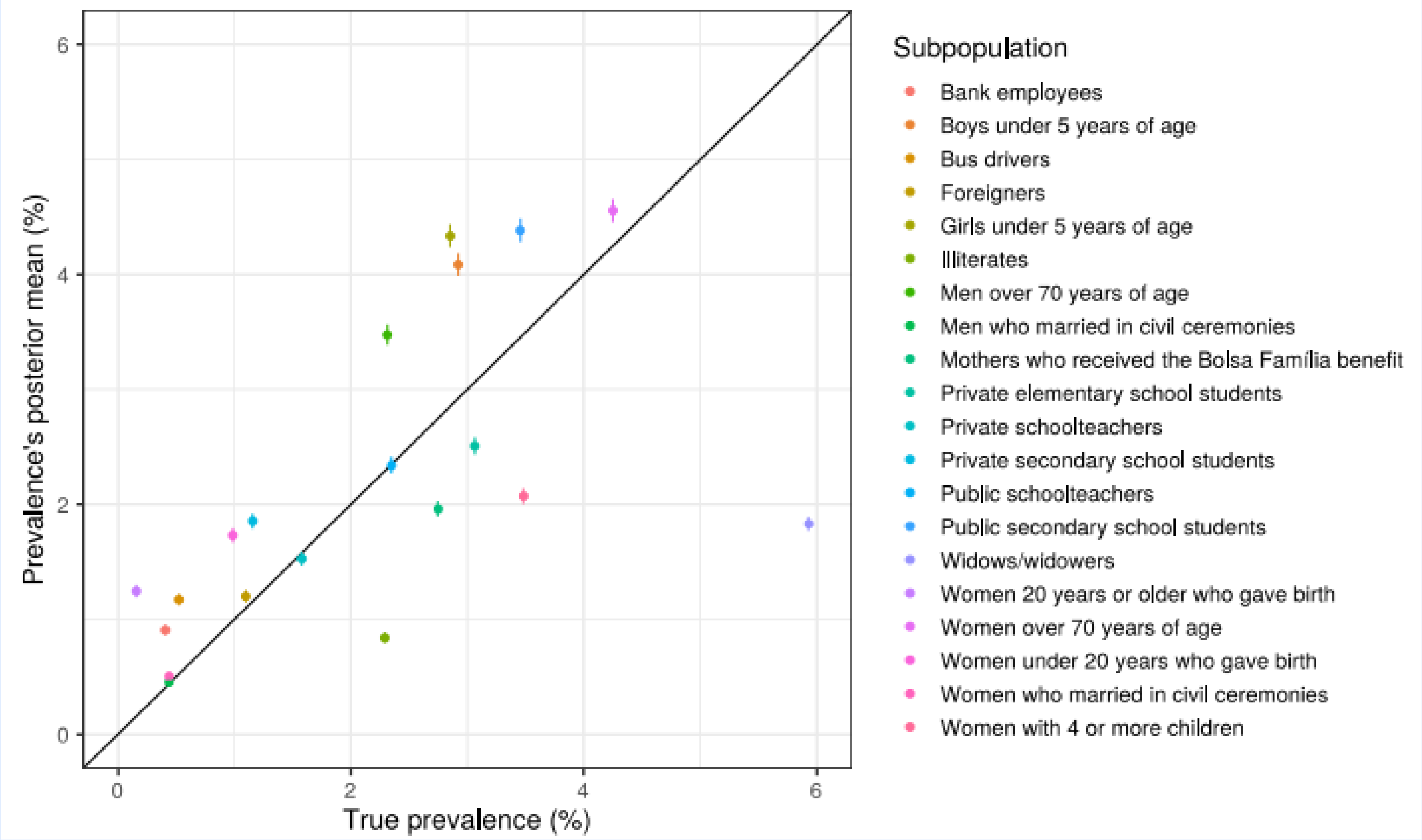

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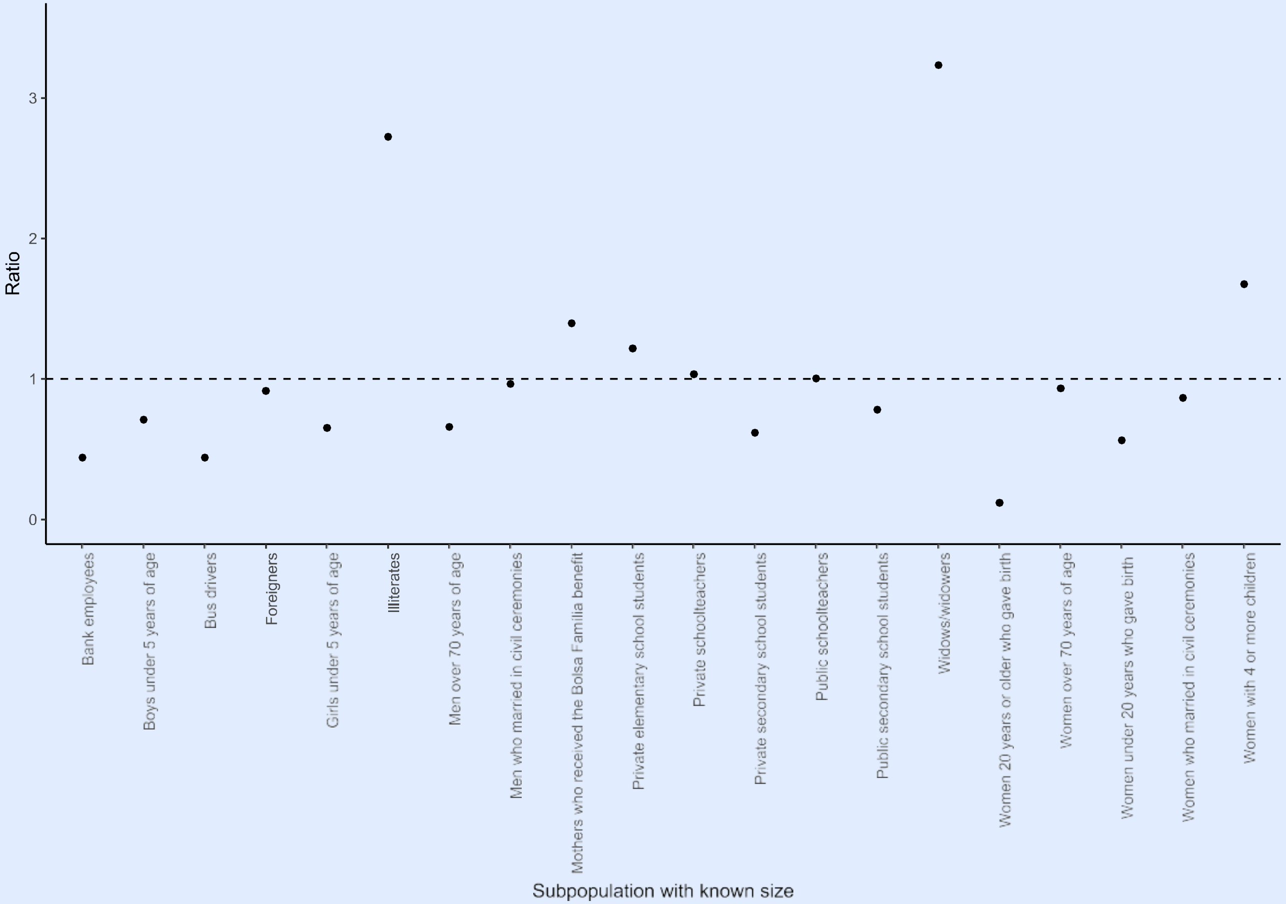
Figure 2: Self-validation of the Bayesian hierarchical model in the city of Rio: ratio between the true prevalence and the posterior mean prevalence for the 20 known subpopulations.



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Discussion

The application of Bayesian hierarchical modeling in the context of NSUM allowed incorporating uncertainty and prior information in the process of estimation

The range of induced abortions per 1,000 women aged 15-49y in Southeast Brazil in 2011 was 12-15 (Guttmacher Institute). In the city of Rio de Janeiro, the current study found a cumulative incidence of women who had undergone abortion of 7.41 per 1,000 (95%CrI [6.05; 8.96]).

The estimate of the mean annual number of unsafe abortions, based on records of hospital admissions and correction factors, reported by Martins-Melo et al. (2014) for the state of Rio was 8,700. The current study estimated that 13,025 women (95%CrI [10.635; 15.748]) had undergone induced abortions in the city of Rio de Janeiro in 2011.

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Discussion

Self-validation of the model described in this study identified a pattern of overestimation of the size of subpopulations with low prevalence rates in the general population and underestimation of the size of subpopulations with high prevalence rates in the general population, as in previous studies (Zeng et al, 2006; Salganik, 2011; Killworth, 2003).

If the target subpopulation has low social visibility, as is probably the case of women who have undergone abortion, the estimates based on indirect information from contact networks might be very low (Salganik et al (2011)

Examples of the alternatives to deal with limitation to the NSUM

- Adaptation of the "game of contacts" to estimate the social visibility of groups of drug users Salganik et al (2011).
- To use independent surveys, which allow correcting the "transmission error", lack of information in the context of social networks involving a heavily stigmatized characteristic across different strata (Ezoe, 2012).

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Discussion

Importance of the existing methodologies for estimating unsafe (or induced) abortions in Brazil

i) Use secondary data from the Health Information Systems

ii) Use of correction factors

iii) The building and maintenance of the historical series for estimating unsafe (or induced) abortions

iv) Definition of the basic parameters for comparability

However, it is necessary to update these correction factors, as there is a lag of 25 years have gone by since they were formulated to correct the estimate in Brazil

New estimation methods can help measure the event more precisely in this context of illegality and thus contribute to the formulation of appropriate health policies.