A methodological proposal for estimating indirect disability transition rates from national cross-sectional healthy surveys: an application to Brazil from 1998 to 2003

Abstract

This paper proposes a new method to estimate disability transition rates from national cross-sectional health surveys. The proposed method estimates age-specific transition rates from cross-sectional data according to well-documented longitudinal age-specific health transition rates of other populations, used as standards, and the proportion of health and unhealthy individuals by age, reported in cross-sectional datasets. In order to estimate healthy life expectancy, this paper makes use of most recent Brazilian health survey data The preliminary results indicate that the estimated disability transition rates are consistent with the current literature. Moreover, the estimated parameters for the simple model specification seem to produce very reliable results. In 1998, 2003 and 2008 the estimated life expectancy – with and without any disability – do not show significant statistical differences from other estimates, produced by other methods. A second exercise will be conducted by estimating the parameters including covariates: sex, race and education and to estimate differentials in healthy life expectancy.

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Introduction

Changes in mortality and morbidity patterns are responsible for increases in life expectancy and reductions in the variability of age at death in Brazil (Gonzaga, Queiroz and Machado, 2008). Those changes follow a similar pattern as observed in the developed countries (Wilmoth and Horiuchi, 1999) and can be explained by an improvement in living conditions that reduced the number of deaths caused by infectious diseases, leading to an increase in the participation of non-infectious diseases as the main causes of deaths and a change in the age pattern of mortality (Schramm et al, 2004). At the same time, one can observed a decline in the mortality rates of the elderly population leading to an increase in the oldest age at death (Horiuchi and Wilmoth, 1998; Campos and Rodrigues, 2004). They also suggest that this phenomenon is still under way, in Brazil, and one could expect further decline in the mortality rates at older ages.

If people are living longer, including at older ages, serious doubts exist about the overall health conditions of the population. In more developed countries there is a debate about compression of morbidity hypothesis and alternative views on the association between mortality, morbidity and population health (Manton, 1982; Olshansky *et al*, 1991; Crimmins and Beltran-Sanchez, 2011). A good indicator for analyzing those hypotheses is one that could measure the implication of both mortality and health changes.

Despite the limitations in constructing an ideal measure of health, healthy life expectancy (HALE) has been the most common indicator used in healthy and morbidity compression studies (Nusselder, 2003). However, to produce good estimates of HALE it is usually necessary to have individual age-specific transitions by health status and death during a period of reference. This information is used as input to calculate multi-state life tables. However, in most developing countries, for example in Brazil, an important drawback in estimating age-specific healthy transition rates or probabilities is the absence of public available data on health conditions and longitudinal surveys. In most of developing countries, estimates of HALE use the Sullivan method, but it has some questionable assumptions and/or significant data requirements that make their use limited (Romero, et.al, 2005; Camargos, et. al, 2008).

To solve those limitations on traditional methods to estimate HALE in the absence of health conditions longitudinal surveys, Guillot and Yu (2009) proposed a new approach called Intercensal Method. The method makes possible to recover a multistate transition framework by using age-specific proportions of "healthy" individuals at two successive, independent cross-sectional health surveys together with information on general mortality. In order to apply the Intercensal Method one needs to make the assumptions that age-specific transition rates are well described by exponential functions at ages 60 and above.

In this paper, we present an alternative methodology to estimate disability transition rates by using information from only one national cross-sectional healthy survey and a standard function for age-specific disability transition rates. The proposed method estimates indirect or implicit age-specific transition rates from cross-sectional data according to well-documented longitudinal age-specific health transition rates of other populations, and the proportion of health and unhealthy individuals by age, reported in cross-sectional data for the country of interest.

Data and Methods

Methods

The method we proposed in this paper estimates age profiles for the transition rates implied in cross-sectional surveys based on an age profile of a standard population, based on longitudinal surveys, and proportions of individuals by health status by age, from the cross-sectional surveys of the country of interest. Therefore, it is expected that the proposed method can be used in any population that has any survey with information from health conditions from cross-sectional studies.

In most developing countries, and for a series of developed countries, studies of HALE are based on the Sullivan method. However, despite its usefulness, one of the major limitations of the Sullivan method, with regard to the analysis of trends in the indicator refers to the violation of the assumptions of stability of measures of incidence and homogeneity in the risk of death in the time interval considered for analysis. The method we propose, unlike the Sullivan method, allows the simulation of cohorts of active and disabled individuals, incorporating heterogeneity in the risk of death for each cohort and allowing the construction of multistate life tables for estimation of active life expectancy.

Intuitively, the method works as follows: we assume that information about the health status of individuals are available to make possible the construction of a variable indicating a state of health, for example, if the individual is considered active or functionally disabled at age x. In this case, it is reasonable to assume that the observed proportion of active individuals at age x + n is a function of the proportions of active and disabled individuals at age x, exposed to different types of risks (competitive) in the interval (x, x + n-Δ), where Δ is as small as possible. That is, the observed proportion of active individuals at age x + n is a function of the proportions of active and disabled individuals at age x, exposed to transition rates between two transient states (active / disabled) and the mortality risks for each state between ages x and x + n.

In the absence of another competing risks, the proportions of people who are active (in good health) in the age interval $x+n$ is a function of the exposition to the following risks at the age x: transition rates from active to disabled, transition rate from disabled to active and mortality of active and disabled. If one consider single years of age (i.e. n equals to 1), the proportion of active people at age interval $x+n$ could be written as the following (Eq. 1):

$$\pi(x+1) = \pi(x)e^{\left\{-\left[e^{\lambda}M_x(a,dead)+e^{\gamma}M_x(a,d)\right]\right\}} + \left[1-\pi(x)\right]e^{\left\{-\left[e^{\varphi}M_x(d,a)+e^{\theta}M_x(d,dead)\right]\right\}}\varphi M_x(d,a) \tag{1}$$

where:

$\pi\,(x+1)$: proportion of people from cross-section survey who are active at age x+1;
$\pi(x)$: proportion of people from cross-section survey who are active at age x;
$1-\pi\,(x)$: proportion of people from cross-section survey who are disabled at age x;
$M_x(.)$: standard transition rates from active to dead (*a,dead*), from active to disabled (*a,d*), from disabled to active (*d,a*) and from disabled to dead (*d,dead*);
$\lambda,\ \gamma,\ \varphi e\theta$: parameters that transform the standard rates $M_x(.)$ at Brazilian implicit transition rates;

If one can estimate $M_x(.)$ by using a longitudinal survey from anoter population, as a standard, the parameters $\lambda,\ \gamma,\ \varphi$ and θ on equation 1 transform the standards transition rates into implicit study population rates.

In order to apply Equation 1, we make the following assumptions:

a) Only one transition occurs per age interval;
b) All transitions should occur at the end of the interval (i.e. x, $x+n-\Delta$, where Δ is going to be as small as possible);
c) The age patterns for age-specific of the studied population transition rates are similar to the standards transition rates.

In order to apply this method all functions $M_x(.)$ need to be estimated from a longitudinal survey that has the same health conditions information we have on the population of interest. The strategy is to assume that the age structures of the transition rates, implied in sectional studies are similar to that of the standard population. Thus, if the model of Equation 1 fits the data well, it is expected that the coefficient estimates for the parameters λ (lambda), γ (gamma), φ (psi) and θ (theta), multiplied by the respective transition rates $M_x(a, m)$, $M_x(a, i)$, $M_x(i, a)$ and $M_x(i, m)$, will return the transition rates implicit by the observed proportions of the study population.

A possible computational limitation in estimating the parameters λ, γ, θ and φ can be imposed by the number of observations in the model, available only if there is only one point in time. For example, if the age range in which the objective is to estimate the rates implied transition comprises single ages from 60 to 95 years, the model has 36 observations and 4 parameters to be estimated. The computational procedure can be made more complex if one is interested in producing estimates for sub-population groups.

But, if the study population has consecutives cross-sectional surveys one can pool the data in order to improve the estimation procedure. Then, we can make each parameter as a function of covariates such as sex, education and race. However, adding covariates on Eq. 1 could increase the complexity of the estimation process. For example, if there is interest in estimating sex-specific implied transition rates; the number of parameters must be multiplied by 2 (an intercept and a slope). For the case of Brazil, we use data from three (3) PNADs and including in the model a variable for each year in order to identify changes in transitions rate over time. In this case, one needs to estimate 3 x 4 parameters in the model.

Complex computational procedures, such as optimization techniques for solving systems of equations (Guillot& Yu, 2009), can be used for estimating the parameters of Equation 1. However, in order to simplify the estimation process, we chose to use the adjustment procedure for nonlinear regression available in STATA ®. The command "nl" STATA ® uses an iterative Gauss-Newton methods modified to estimate the parameters of a nonlinear function using least squares. With the interactive version of the command, you can write the function directly from the command line. The Gauss-Newton method, also known as a method of linearization, is a particular case of the least square method (Myers, 1990). This method uses a Taylor series expansion to approximate non-linear regression model with linear terms. Then applies OLS to estimate the parameters. Iteration of these steps leads to a solution for the estimation of parameters in non-linear regression (Myers, 1990).

Data

In order to apply the proposed method and estimate healthy life expectancy, we make use of Brazilian Cross-sectional Household Surveys (PNAD) from 1998, 2003 and 2008 and two longitudinal Healthy Surveys form Latin America: Mexican Health and Aging Study (MHAS), 2001 and 2003, and Puerto Rican Elderly: Health Conditions (PREHCO), 2002/2003 and 2006/2007. We use Mexico and Puerto Rico as standards to estimate HALE and health transitions in Brazil. In relation to Guillot and Yu (2009), our method can be estimated using a single year of data for the population of interest and allows studying health status differential, for education and other variables of interest.

The health supplements of PNAD collected information on two modules: health characteristics and physical mobility of residents. Information on health included questions on morbidity and self-reported diseases. For morbidity, PNAD collected information on: a) self-perceived health, b) information on activities not performed for health reasons in the past two weeks, indicating which activities, how many days left to carry out such activities and why c) it had been bedridden for the past two weeks and the reason d) self-reported diseases. The MHAS is a prospective panel study nationally representative of adult and older individuals. The first interview was conducted in 2001 and a second wave was applied in 2003. The data collected provided a substantial amount of sociodemographic, health, functional and cognitive performance and anthropometric measures. The sample consists of individuals 50 years or older, characterized by a high prevalence of communicable and non-communicable diseases, income inequality and health and certain predominance of extended families that work generally as institutions that promote social capital, human and financial (Kohler &Soldo, 2004). The Puerto Rican Elderly: Health Conditions (PREHCO) is a representative sample of the population aged 60 or older living in private households, whether or not capable physically and mentally (Palloni et al, 2005). In addition to addressing general characteristics of the population aged 60 and over residing in Puerto Rico, provides other information, such as: health, household characteristics, intergenerational transfer, functional status, work history and sources of income, migration characteristics of childhood, health insurance, utilization and access to health services, abuse, marital history, sexuality and anthropometric measurements.

Regarding the question about activities of daily living, both in the PREHCO and MHAS as the respondent was asked whether, because of health problems, had difficulty performing certain activity. The activities included in both questionnaires were: walking, bathing, eating, lying down or getting up from the bed and using the toilet. The response categories considered in MHAS and PREHCO were: yes, no, can not, does / does not apply. There was a low frequency of responses classified as unable or does / does not apply in the two surveys (around 0.30% in all activities). Thus, we decided to consider only the categories of responses classified as yes or no to the construction of the indicator of disability in research. For PNAD, since it considers three activities combined into a single issue (eating, bathing, toileting), we chose to use the same three activities to build the indicator of disability in databases. Therefore, the respondent was classified as functionally incapacitated if he had answered yes to at least one of these activities. Table 1 presents a summary of the information and the process used to construct a disability indicator on each survey.

Table 1 - Compatibility of information about ADL databases PNAD, MHAS and PREHCO

From PNAD:			From MHAS and PREHCO:		
Do you have difficulty with eating, bathing or using the toilet?	Recoding		Do you have difficulty with:	Recodificação	
1 - Not sucssed	Yes	Disabled	1 - eating? 2 - bathing? 3 - using the toilet?	Yes at least one Daily	Disabled
2 - Have great difficulty					
3 - Have less difficulty					
7 - Not have difficulty	Not	Active		Not at all Daily	Active

Source: 1998, 2003 and 2008 National Household Surveys (IBGE, 2011); Mexican Health and Aging Study (MHAS, 2011) and e Puerto Rican Elderly: Health Conditions (PREHCO, 2011).

Results

We use the information about activities of daily living to perform personal activities (ADL) from those Brazilian cross-sectional household surveys in order to construct a functional disability indicator. Then we get the proportion of active and disabled people by single age from Equation 1. The $M_x(.)$ patterns were fitted from Mexican Health and Aging Study (MHAS) and Puerto Rican Elderly and Health Conditions (PREHCO). Both have two waves with similar information on ADL (see Table 1). We use these informations in order to estimate a functional disability indicator and get adjusted disability transition rates that were used as standards on Equation 1.

The Brazilian and Mexican epidemiological transitions have some similarities. In the both countries there was overlap of stages of epidemiological transitions (Brevis et al; 1997; Chaimowicz, 1997). Nevertheless, considering that the period of analysis in Brazil (from 1998 to 2008) comprise the two years when the longitudinal survey in Mexico were applied (2001 and 2003), the proportion of disabled people in Brazil are very similar to those in Mexico (Table 2).

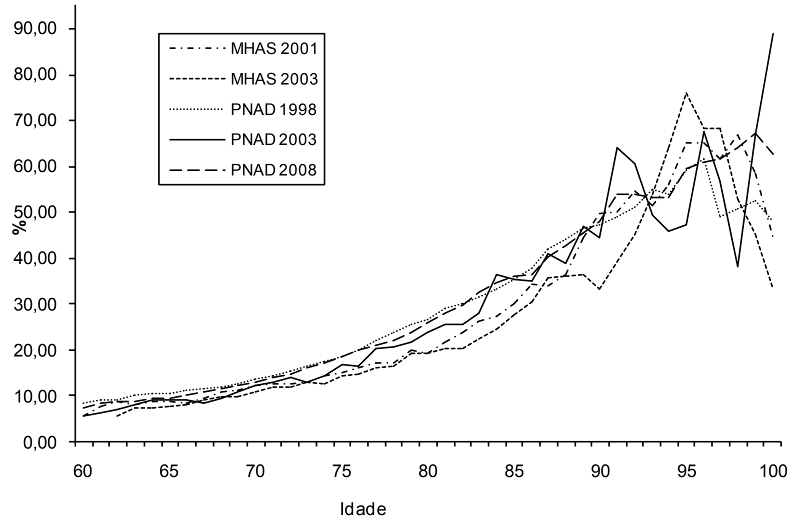
The Figure 1 shows the age pattern of the proportions of people with disability according to information from Brazilian and MHAS surveys at yours respective years. The greater variability in the Mexican data is probably due to the smaller size of the sample. According to the proportions in the Figure 1, there seems to be a similarity in the pattern of age proportions. These results suggest that the transition rates by age, to be based on information obtained from MHAS, may present as an appropriate standard to be used in the proposed method for the analysis of the Brazilian case. We do not make similar comparisons between Puerto Rican and Brazilian disability proportions, but we decide to keep the Puerto Rican standard in order to see how the method works by using different standards.

Table 2–Brazilian and Mexican Health Conditions (1998, 2001, 2003 and 2008)

Health Conditions		1998	2001	2003	2008
Brazilian	Active	84.5	-	86.4	84.7
	Disabled	15.5	-	13.6	15.3
Mexican	Active	-	86.4	85.9	-
	Disabled	-	13.6	14.1	-

Source: Brazilian cross-sectional household surveys (IBGE 1998, 2003 and 2008) and Mexican Health and Aging Study (MHAS 2001 and 2003).

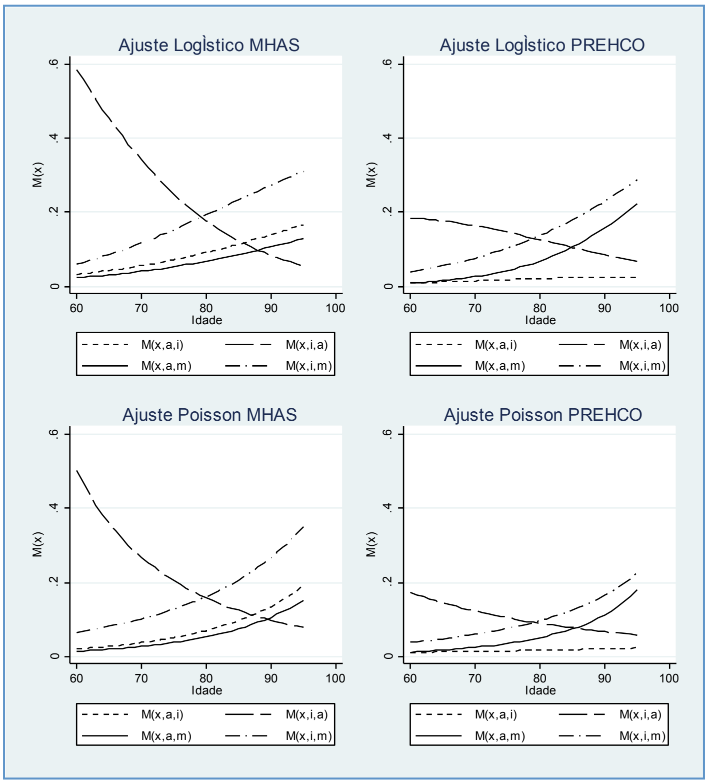
Figure 1–Proportion of people with disability by age, Brazil (1998, 2003 and 2008) and Mexico (2001 and 2003)



Source: MHAS (Mexican Health and Aging Study) and Brazilian cross-sectional household surveys (PNAD).

Figure 2 presents preliminary results on fitting disability transition rates from MHAS and PREHCO are presented in Figure 2. For both populations the age-specific transition rates follows similar patterns as those presented in literature (Lièvre, Brouard & Healthcote, 2003; Guilot & Yu, 2009). The age-specific transition rates from disabled to active decreases after age 60. The age-specific transition rates from active and disabled to death increases after age 60. One can see a different path for the transition rates from active to disabled estimated from PREHCO. Those rates increase very slowly with age. Despite of similarities on the transition rates patterns between MHAS and PREHCO, one can see remarkable differences on the level of the functions even using the same model to fit the functions. For that reason we decide to use both pattern to estimate the parameters in Equation 1.

Figure 2– Age-specific disability transition rates fitted by Logistic e Poisson models, Mexico (2001-2003) e Puerto Rican (2002/2003-2006/2007)



Source: Mexican Health and Aging Study (2001-2003), Puerto Rican Elderly: Health Conditions (2002/2003-2006/2007) and PNAD (1998, 2003, 2008).

Possible problems seem to prevent identification of the parameters λ and γ, related to transitions, to be properly estimated, which means that seems to exist a unique combination of parameters, which allow the adjustment of the model. Using MHAS as a standard, probably the model cannot distinguish the effects of age patterns of two transitions because they are very similar functions (see Figure 2). In the case of PREHCO a possible source of the problem of identification may be the lack of variability in the rates of disability transition pattern for age.

Several attempts were made in order to solve the identification problem by applying new restrictions to the model. We reformulated Equation (1) in order to reduce the number of parameters to be estimated. The reformulation consists of an equation to adjust the proportion of individuals with disability at age x+1 $(1-\pi(x+1))$ and then, with the estimated parameters in this equation, a second equation to adjust the proportion of people active at age x+1 $(\pi(x+1))$.

Assuming that all the individuals who move from active to disabled, do so at the beginning of the age interval, individuals who move from the active state to the disable state would be unable to survive the entire range age as disabled. Thus, since no transition occur from disable to active among those who have made the transition from active to disabled at the beginning of the interval, there is one less parameter to be estimated, namely the parameter related to the transition from active to death. The equation for the proportion of people with disability at age x +1 becomes:

$$1-[\pi(x+1)]=[1-\pi(x)]e^{\{-[e^{\theta}M_x(i,m)+e^{\varphi}M_x(i,a)]\}} + \pi(x)e^{\gamma}M_x(a,i)e^{\{-e^{\theta}M_x(i,m)\}} \tag{2}$$

To estimate the parameter λ absent in Equation (2), a second equation, which determines the proportion of active people at age x+1 $(\pi(x+1))$, can be defined as follows:

$$\pi(x+1)=\pi(x)e^{\{-[e^{\lambda}M_x(a,m)+e^{\gamma}M_x(a,i)]\}} + [1-(x)]e^{\varphi}M_x(i,a)e^{\{-e^{\lambda}M_x(a,m)\}} \tag{3}$$

The first component of the right-hand side of Equation (3) is exactly equal to that of Equation (2). The change occurs in the second component of the right side, where the proportion of people with disability at age x $(1-\pi(x))$ is not exposed to the risk of mortality in people with disability, $M_x(i,m)$. If all transiting state unable to make active at the beginning of the interval, the only risk to which they are exposed refers to the death of people in the active state, $M_x(a,m)$.

In order for the parameters of equations (2) and (3) to be consistent, since the proportions of active and disabled people at age x +1 are expressed in terms of the proportions of active and disabled people at age x, it is necessary to hold constant, in the estimation of Equation (3), the parameters already estimated in Equation (2).

Even with the proposed change in the estimation procedure, the identification problem in the estimation of some parameters by the method of nonlinear regression STATA remained unsolved. In the case of MHAS, it seems that the fact that there are three curves that increase with age introduces some difficulty in estimating the parameters associated with these curves. The proposed developed by equations (2) and (3) was trying to delete one of these curves and enable the setting. However, in Equation (3), we observed that the two curves that increase with age remained in the equation and were the most similar (see Figure 2).

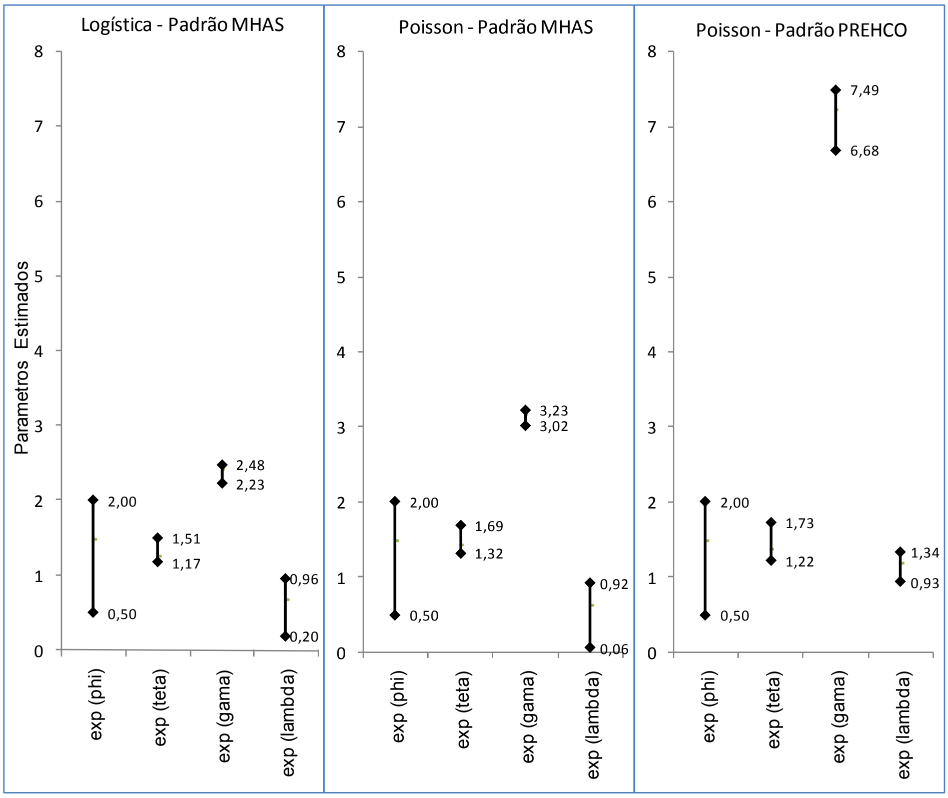
We proposed an alternative solution. We estimate the parameters θ (theta) and γ (gamma) in Equation (2) fixing the value of φ (phi), which indicates how sensitive are the estimates of theta and gamma to changes in the value of φ . Probably, the transition from disabled to active was very rare among elderly and with little variation between countries. This fact justifies the choice of φ and to test the sensitivity of the estimates of the other parameters in Equation (2).

Figure 3 shows the sensitivity tests of the estimated parameters θ, γ and λ based on the values set for φ based on three adjusted models: Poisson (by using PREHCO, MHAS) and Logistic (by using MHAS). One can check that gamma, the parameter which reflects the effects of the transition from active to disabled, being perhaps the most important parameter for this study is not very sensitive to changes in φ when using the MHAS standard regardless if the adjustment was made by Logistic or Poisson models. The same is true for the estimates of θ. Although the values of λ show some sensitivity to changes in φ for the purpose of inference, it is verified that changes in φ from 0.5 to 2.0 generate changes from 0.20 to 0.96 in the case of logistic fitting and from 0.06 to 0.92 in the case of Poisson adjustment for the parameter λ. That is, it is possible to provide solutions to the equations (2) and (3) based on some interval defined for φ. In the case of using PREHCO-standard, although estimates of the parameters θ and λ do not vary much from the values set for φ, the estimates for γ (gamma) are very discrepant compared with those obtained when using the standard MHAS.

Figure 4 shows the results by considering the logistic estimated coefficients based on the MHAS pattern. Besides the similarities in the patterns of mortality and morbidity between Brazil and Mexico, two more reasons justifying this choice. First, compared to PREHCO standard, the estimates based on MHAS pattern are less sensitive to φ fixed values. Second, compared to Poisson estimates, the fitted coefficients by logistic regression keep all on the interval (-1; 1) – see figure 3. Then, the inflation factor given by exp [coefficients] was not excessively high. On the other hand, being less strict, we conclude that estimates by Logistic and Poisson models are reasonable pattern in order to estimate the Brazilian implicit transition rates. The results show that the implicit estimated disability transition rates in Brazil are consistent with the literature (figure 4). Moreover, the estimate parameters for a simple model specification (without covariates) seem to produce very reliable results.

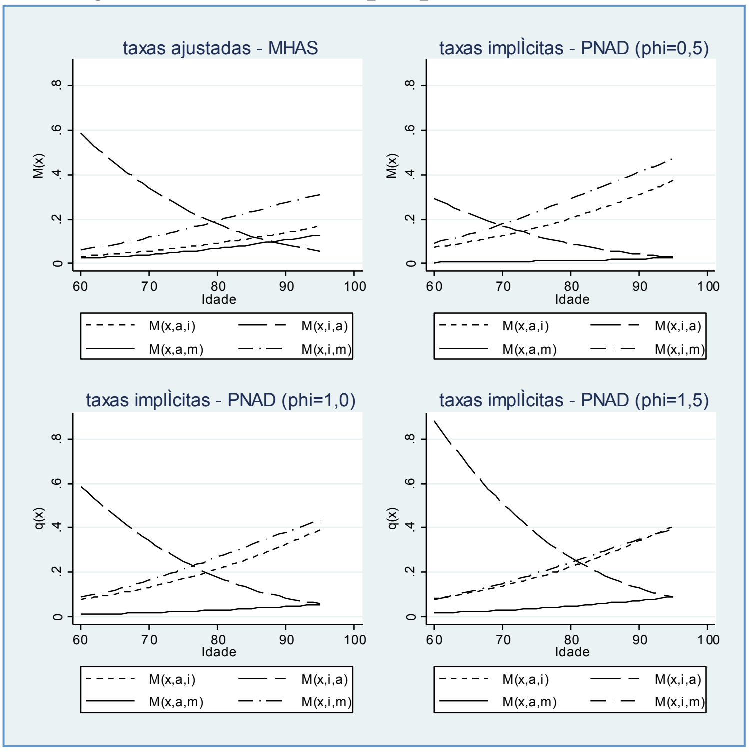
Estimates of total life expectancy (LE), active life expectancy (ALE) and functional disability life expectancy (DLE) to the total population of Brazil, based on annual implicit transition rates of disability at PNAD, according to the patterns shown in Figure 4 for each fixed value of φ, are shown in the Table 3. The Multistate Life Table method was used to estimate the LE and their components (ALE and DLE). The root of the life table (l_0) was distributed according to the observed proportions of active and functional disability people in the PNAD Brazilian cross-sectional surveys. In order to compare the results we also estimated LE, ALE and DLE base on the Mexican transition rates (the results are shown on the table 3).

Figure 3 – Variability on the estimates of the θ, γ e λ parameters related to fixed values to φ parameter, Brazil, 1998, 2003 e 2008



Source: Mexican Health and Aging Study (2001-2003), Puerto Rican Elderly: Health Conditions (2002/2003-2006/2007) and PNAD (1998, 2003, 2008).

Figure 4– Brazilian annual age-specific implicit disability transition rates estimated according to fixed values for phi parameter and Mexican pattern



Source: Mexican Health and Aging Study (2001-2003), and PNAD (1998, 2003, 2008).

The results on Table 3 show that there are no major variations the total life expectancy (LE) at age x base on the three fixed values of φ. Variations on ALE or DLE depend on the combination in terms of the level of disability, mortality and recovery transition rates imposed by the φ values. An important contribution of this new approach is the possibility in estimating a confidence interval of the total life expectance and their components as we can see on table 3.

On the period between 1998 and 2008 the LE at Brazil, based on the population and deaths registers, ranged from 19.9 to 21.9 years. Probably the low estimate of LE in Brazil, based on the new method, is due in part to the higher level of mortality over 80 years in the total mortality rate implicit in the National Household Survey (PNAD). Another portion of the difference may be due to a probable underestimation of the parameter λ, reflecting the effect of mortality of active people.

Table 3 – Estimated life expectancy (LE), active and disabled life expectancy (ALE and DLE) for both sex on Brazil (1998, 2003 e 2008) and Mexico (2001/2003)

age	Total Life Expectancy (LE), Active and Disabled Life Expectancy (ALE and DLE)				
	LE	ALE	DLE	% ALE	% DLE
			Mexico		
60	16.8	14.2	2.6	85%	15%
70	11.5	8.9	2.6	78%	22%
80	7.6	5.1	2.5	67%	33%
90	4.8	2.5	2.3	53%	47%
			Brazil (= 0,5 and 95% C.I)		
60	16.5 (12.9; 19.1)	12.0 (9.3; 13.9)	4.5 (3.5; 5.2)	73%	27%
70	10.0 (7.6; 11.9)	6.2 (4.6; 7.5)	3.7 (3.0; 4.3)	63%	37%
80	5.9 (4.5; 7.0)	3.0 (2.1; 3.7)	2.9 (2.3; 3.3)	51%	49%
90	3.0 (2.5; 3.4)	1.2 (0.8; 1.4)	1.8 (1.7; 2.0)	39%	61%
			Brazil (= 1,0 and 95% C.I)		
60	16.9 (14.0; 19.6)	13.0 (10.8; 15.1)	3.9 (3.2; 4.6)	77%	23%
70	10.6 (8.5; 12.6)	7.1 (5.7; 8.5)	3.4 (2.8; 4.0)	67%	33%
80	6.2 (5.0; 7.4)	3.4 (2.7; 4.2)	2.8 (2.3; 3.2)	55%	45%
90	3.1 (2.7; 3.5)	1.3 (1.0; 1.6)	1.8 (1.7; 2.0)	42%	58%
			Brazil (= 1,5 and 95% C.I)		
60	16.4 (14.0; 19.0)	13.0 (11.1; 15.0)	3.4 (2.9; 4.0)	79%	21%
70	10.5 (8.7; 12.4)	7.4 (6.1; 8.8)	3.1 (2.6; 3.6)	70%	30%
80	6.3 (5.2; 7.5)	3.6 (2.9; 4.4)	2.7 (2.3; 3.1)	57%	43%
90	3.2 (2.8; 3.6)	1.3 (1.1; 1.6)	1.8 (1.7; 2.0)	42%	58%

Source: Mexican Health and Aging Study (2001-2003), and PNAD (1998, 2003, 2008).

In order to verify the applicability of the new method, we compared our estimates with the others in the literature. We show on table 4 some published and selected results for estimates of total, active and disabled life expectancies to Brazil from 2005 to 2012. The four published studies were selected based on the following criteria: a) results for the total population of Brazil, b) some degree of similarity of the used indicators and c) data sources and reference year.

The only one that uses data from the 2008 National Household Survey, of those presented in Table 4, on their estimates are those presented by Nepomuceno (2012), which used Guillot and Yu method. The results for healthy life expectancy are similar to our average estimates. However, the estimates produced there are valid for the periods between the PNADs 1998, 2003 and 2008. While the estimates produced in this paper take into account the pooled data from 1998, 2003 and 2008. The intercensal method estimates the age pattern of transitions linking the proportions of active at age x at time t, the proportions of active subjects of age x + n at time t + n, whereas the method proposed in this paper relates to the proportion of active individuals at age x to the proportions of active individuals with disability and age x+n. This means that if there is only one cross-sectional, and the parameters of the equations (2) and (3) were correctly estimated, the method proposed here would enable the estimation of transition rates implied by considering only a cross-sectional, which would not be possible with applying the census method proposed by Guillot & Yu.

The next steps consist estimating the parameters on the equations (2) and (3) using dummies for sex, education, race and years of PNAD as covariates Since adding covariates on the equations (2) and (3) means to increase considerably the number of parameters to be estimated, it is important to develop and consider alternative ways to obtain more robust estimates of these parameters.

Table 4 – Estimated life expectancy (LE), active and disabled life expectancy (ALE and DLE) for both sex on Brazil (1998, 2003 e 2008) and Mexico (2001/2003)

Authors	Total, active and disabled life expectancies at age 60					Observations:
	LE	ALE	DLE	%ALE	%DLE	
Romero et al (2005):						
Both sex	20.6	15.4	5.2	74.7	25.3	Source: Pesquisa Muncial de Saúde (2003). Foi utilizado um indicador de incapacidade com base em limitações de atividades.
Male	19.0	14.9	4.2	78.1	21.9	
Female	22.0	15.8	6.3	71.6	28.4	
Camargos et al (2008b):						Source: PNAD (2003). Aplicou-se o método de Sullivan utizando indicadores de incapacidade de acordo com o grau de severidade. No grau severo de incapacidade o indicador utilizado foi semelhante ao desta tese.
Male	19.1	16.5	2.6	86.1	13.9	
Female	22.1	18.1	4.0	81.7	18.3	
Guedes et al (2011):						
1998:						
Male	18.5	17.0	1.5	91.9	8.1	Sources: PNAD (1998 e 2003). Aplicou-se o método de Sullivan utilizando o mesmo indicador de incapacidade utilizado nesta tese.
Female	21.3	18.9	2.4	88.7	11.3	
2003:						
Male	19.1	17.6	1.5	92.1	7.9	
Female	22.1	19.6	2.5	88.7	11.3	
Nepomuceno (2012):						
1998/2003:						
Both sex	16.9	12.4	3.8	76.6	23.4	
Male	15.2	12.3	2.9	80.9	19.1	Source: PNAD (1998 e 2003). Aplicou-se o método Intercensal (Guillot & Yu, 2009) utilizando o mesmo indicador de incapacidade utilizado nesta tese.
Female	17.2	12.8	4.4	74.5	25.5	
2003/2008:						
Both sex	16.3	12.3	4.0	75.6	24.4	
Male	15.3	12.1	3.3	78.8	21.2	
Female	17.2	12.7	4.7	73.0	27.0	
Results from the new method for both sex:						
Lower						
= 0,5	12.9	9.3	3.5			
= 1,0	14.0	10.8	3.2			
= 1,5	14.0	11.1	2.9			
Mean						Resuts from table 3. We have pooled the data from 1998, 2003 and 2008 PNAD.
= 0,5	16.5	12.0	4.5			
= 1,0	16.9	13.0	3.9			
= 1,5	16.4	13.0	3.4			
Upper						
= 0,5	19.1	13.9	5.2			
= 1,0	19.6	15.1	4.6			
= 1,5	19.0	15.0	4.0			

Source: Mexican Romero et al (2005); Camargos et al (2008b); Guedes et al (2011) e Nepomuceno (2012).

Discussion

Estimates of healthy life expectancy in order to analyze trends in the health status of a population requires knowledge of the age pattern of rates or transition probabilities between health states and death, between two or more time points, thus enabling using the life table method to construct the multistate indicator.

In the absence of such rates or probabilities, under the assumption that the characteristics under study are stable over time, the Sullivan method has emerged as the primary tool for estimating HALE. However, despite its usefulness, one of its major limitations, with regard to the analysis of trends in the indicator refers to the violation of the assumptions of stability of measures of incidence and homogeneity in the risk of death in the time interval considered for analysis.

For countries that do not have longitudinal data to estimate the rates or transition probabilities, some new approaches have been proposed in order to reduce the bias in the estimates of HALE due to violation of the assumptions adopted by the Sullivan method. Noteworthy is the intercensal method, proposed by Guillot& Yu (2009) that reproduces a multistate structure and enables the estimation of HALE in the presence of heterogeneity of risk of death.

The method proposed in this paper, unlike the Sullivan method, allows the simulation of cohorts of active and disabled people, incorporating heterogeneity in the risk of death for each cohort and allowing the construction of multistate life tables for estimation of active life expectancy. For this, the method estimates the age structure for the transition rates implicit in cross-sectional surveys based on a standard age for the transition rates between health states and death from nationally representative longitudinal surveys and other populations, and proportions of healthy and unhealthy by age, from cross-sectional surveys.

Difficulties in implementing the original proposal of the method led to a reformulation and simulations in order to enable more robust estimates of the parameters. As a result, the rates implied transition of disability by age, estimated by the new method are consistent with those presented in the literature. Moreover, estimates of HALE for the total population in 1998, 2003 and 2008 are consistent with those produced by other methods.

A possible differential method proposed here in relation to traditional methods and the intercensal method, which also estimates the age pattern of transitions of disability, is the possibility of a multivariate analysis of trends in the HALE. However, limitations related to the estimation of the parameters in the presence of covariates of interest hinder the multivariate indicator. The limitations encountered in the implementation of the proposed method should serve as a stimulus for new reformulations of the equations and assumptions adopted. In this sense, the difficulties encountered in the application of the method can serve as a basis for a research agenda in finding the most appropriate solutions. Such an agenda should be considered in order to make the method more easily replicable in other populations, as well as Brazil, lack of adequate information to monitor trends in healthy life expectancy of the population.

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