United Nations
Educational, Scientific and
Cultural Organization

UNESCO
INSTITUTE
FOR
STATISTICS

Information Paper N. 36
April 2017

open
access

The effect of varying population estimates on the calculation of enrolment rates and out-of-school rates

UNESCO

The constitution of the United Nations Educational, Scientific and Cultural Organization (UNESCO) was adopted by 20 countries at the London Conference in November 1945 and entered into effect on 4 November 1946. The Organization currently has 195 Member States and 10 Associate Members.

The main objective of UNESCO is to contribute to peace and security in the world by promoting collaboration among nations through education, science, culture and communication in order to foster universal respect for justice, the rule of law, and the human rights and fundamental freedoms that are affirmed for the peoples of the world, without distinction of race, sex, language or religion, by the Charter of the United Nations.

To fulfil its mandate, UNESCO performs five principal functions: 1) prospective studies on education, science, culture and communication for tomorrow's world; 2) the advancement, transfer and sharing of knowledge through research, training and teaching activities; 3) standard-setting actions for the preparation and adoption of internal instruments and statutory recommendations; 4) expertise through technical cooperation to Member States for their development policies and projects; and 5) the exchange of specialized information.

UNESCO Institute for Statistics

The UNESCO Institute for Statistics (UIS) is the statistical office of UNESCO and is the UN depository for global statistics in the fields of education, science, technology and innovation, culture and communication.

The UIS was established in 1999. It was created to improve UNESCO's statistical programme and to develop and deliver the timely, accurate and policy-relevant statistics needed in today's increasingly complex and rapidly changing social, political and economic environments.

Published in 2017 by:

UNESCO Institute for Statistics
P.O. Box 6128, Succursale Centre-Ville
Montreal, Quebec H3C 3J7
Canada

Tel: +1 514-343-6880
Email: uis.publications@unesco.org
http://www.uis.unesco.org

ISBN 978-92-9189-208-2
Ref: UIS/2017/ED/TD/6/REV.1
DataLink: https://doi.org/10.15220/978-92-9189-208-2-en

Table of contents

List of figures

List of tables

Introduction

Enrolment rates are calculated by the UNESCO Institute for Statistics (UIS) from a combination of i) enrolment figures provided by Member States; and ii) population estimates from the UN Population Division. Using different population estimates in the calculation can result in varying enrolment rates and out-of-school rates. Moreover, the biennial revisions of UN population estimates have a direct effect on estimates of the rate and the number of out-of-school children, both past and present. If an accurate estimate of the population of a country is difficult to ascertain, determining the exact rate and number of out-of-school children within such country becomes a challenging task.

Primary, lower secondary and upper secondary out-of-school rates are key thematic indicators of the UN Sustainable Development Goal 4 (SDG 4), which aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." Precise estimates for these indicators are essential so as to ensure that initiatives seeking to increase enrolment are directed at the correct target groups, and in order to guarantee that investments in the education sector are effective and efficient.

The present work, therefore, entails an in-depth analysis and comparison of enrolment estimates, as well as of the rate and number of out-of-school children (OOSC) for primary and lower secondary school cohorts, followed by an explanation of observed differences and recommendations for improved assessment of school participation.

The **expected contributions** of this paper are as follows:

- The improved interpretation and better comprehension of enrolment rate differences between primary and secondary school age children, as explained by varying population estimates;
- An increased understanding of the reliability of out-of-school estimates derived from data pooled from differing sources; and
- Suggestions for a more efficient use of data for policy planning at the national level.

In particular, this **technical note** addresses the following analysis, pertaining to the case of Brazil:

- Discrepancies between enrolment figures and population estimates (in addition to the analysis of trends within attendance rates calculated from household survey data as compared to enrolment data from administrative sources);
- Differences between varying sources of population estimates (e.g. projections of United Nations Population Division, UNPD; Brazilian Institute of Geography and Statistic, IBGE; household survey) and the effect of their variation on indicator values (e.g. net enrolment rate, out-of-school rate); and

This analysis further assesses such data along distinct age groups of children and adolescents: those of primary age; those of lower secondary age; all individuals of both primary and lower secondary age; and per single year of age. Officially, Brazil has not these levels of education, but it is still common for educational data to be analyzed along these lines, since they align with the same divisions as found in the ISCED classifications.

The technical note also includes recommendations on how to calculate more precise enrolment and attendance rates in Brazil by using more reliable sources of data.

1. Sources of population estimates: Demographic census, projections, PNAD

1.1. Population census

While many developed countries rely on administrative data to evaluate population dynamics, demographic censuses serve as the main source of data for developing countries. The immense size of Brazil's population, the extensiveness of its territory, and its rooted social inequalities make the national census the most reliable data source for measuring and estimating Brazil's current age structure, fertility and mortality rates, and migration trends. Furthermore, "population censuses constitute the principal source of records for use as a sampling frame for surveys, during the intercensal years (ten years in Brazil), on such topics as the labor force, fertility, and migration histories" (UN, 2008:12). In this regard, Brazil carries out an annual household survey, but still relies on censuses for sampling design, population projections, and interpolations.

The Brazilian Demographic Census meets the requisites outlined in *Principles and Recommendations for Population and Housing Censuses* (UN, 2015), including individual enumeration, universality within a defined territory, simultaneity, and defined periodicity. The Brazilian census collects statistics for virtually all the core topics suggested by the UN[1] and performs its recommended tabulations, and to a great extent it has improved the international compatibility of the census through the use of common definitions and classifications. Such data are essential to UN Sustainable Development Goal 4, which seeks "inclusive and equitable quality education and lifelong learning opportunities for all", by means of derived indicators that monitor the socioeconomic situation of a population.

However, there are several regions throughout Brazil in which population counting is notably difficult, namely the nation's largest urban centers, and remote, low-density areas such as the Amazon Basin. Attempts to remedy this problem are not simple, given that post-enumeration assessment of under-

1 The topics listed in the *Principles and Recommendations for Population and Housing Censuses* (UN, 2015) are grouped under nine headings: "Geographical and internal migration characteristics", "International migration characteristics", "Household and family characteristics", "Demographic and social characteristics", "Fertility and mortality", "Educational characteristics", "Economic characteristics", and "Agriculture" (p.188).

coverage from a sample can be quite expensive. Since 1970, IBGE has conducted a post-enumeration survey known as the "*Pesquisa de Avaliação*" (Evaluation Survey), which evaluates the quality and level of coverage of the census data. For the 2000 Census, the Evaluation Survey assessed a sample of 1,354 census tracts, 301,230 households, and 1,168,494 people (0.7% of the total population of Brazil). For the 2010 Census, this sample was expanded to include 4,000 census tracts, and saw a confidence level of 95%[2]. Unfortunately, IBGE has yet to release the results of this survey, and there is no present coverage estimate for the 2010 Census.

In 2010, IBGE introduced methodological and technological innovations that sought to improve the collection of census data, among which were the adoption of GPS-enabled handheld devices for gathering data and the introduction of an online alternative to the traditional paper questionnaire. Most notably, the 2010 Demographic Census updated the Territorial Base and the National Address Register. This update, along with the use of GPS-enabled equipment, allowed for the geo-referencing of household units in rural areas, as well as for the improved management of the pace and geographic coverage of the fieldwork conducted by census-takers. Such innovations should, in theory, increase coverage, given that they are able to incorporate sparse rural regions into the census that were previously known for their high degrees of under-coverage.

IBGE's Evaluation Survey, conducted in order to test census coverage and content error, estimated the degree of under-coverage for each of the decennial rounds of censuses (with the exception of the 1991 Census) 1980-2000 censuses, with estimates ranging from 1.8% in 1980 (the lowest) to 3.6% in 1991 (the highest); the under-coverage of the 2000 Census fell between the two at 3.0% (IBGE, 2008: 15).
In addition, in 1996, IBGE carried out the first "Population Count," which sought to collect population data across all households nationwide, between two census rounds. The 2007 Population Count, however, surveyed a smaller sample of households[3].

IBGE's Population Counts are ideal for updating current population estimates and establishing a new benchmark for population projections. Estimated under-coverage rates for the Population Counts in 1996 and 2007 were 4.9% and 3.4% respectively. However, IBGE has not published figures for the under-coverage rate of the 2010 Demographic Census. IBGE has affirmed that in terms of the evaluation of age structure and sex of the Brazilian population, the 2000 Census had the best coverage

---

2 IBGE did not publish the size of the sampled population. See: http://www.cepal.org/celade/noticias/paginas/3/45123/brasil_cobertura.pdf

3 The 1996 Population Count functioned essentially as a census, in the sense that it attempted to cover each unique household across the country. Nevertheless, the questionnaire utilized for the survey was simplified. In 2007, due to budgetary constraints, the Population Count covered only municipalities with less than 170,000 inhabitants along with 21 additional selected municipalities. 129 municipalities were not surveyed, corresponding to a mere 3% of all Brazilian municipalities but over 40% of the nation's total population.

of all recent censuses, *most notably for children* (IBGE, 2013). Although there has yet to be a formal coverage evaluation for the 2010 Census, a comparison of the 2010 Census and the IBGE population projection for 2010 may serve as a proxy for the under-coverage level.

Other demographic techniques may be used to evaluate under-coverage, but these too have flaws. In order to evaluate the adequacy of census data for the measurement of school participation, the next section analyses the aforementioned issues that arise with the use of census data and their implications for population estimates. The discussion will address a common procedure used to evaluate the expected levels (the size of the population) and the age structure by sex, known as "intercensal consistency".

1.2. *The Pesquisa Nacional por Amostra de Domicílios* (PNAD)

The other most important source of population estimates in Brazil is the household survey "*Pesquisa Nacional por Amostra de Domicílios* (National Household Sample Survey)", often abbreviated to PNAD. The PNAD has a large sample size and investigates a wide range of socioeconomic characteristics within households and for the *de facto* populations within them. After 2011, the PNAD shifted from annual administration to shorter periods of reference (three months) with improved sample representativeness. In October 2011, this new "Continuous PNAD" was implemented on a trial basis across 20 metropolitan regions and their capital municipalities, an Integrated Region of Development, five capital cities, and a Federal Unit. From January 2012 onwards, the Continuous PNAD was deployed throughout Brazil and became a permanent feature within IBGE databanks[4]. Accordingly, and echoing the period of interest for the present study, the following analysis takes into account PNAD data from 2012, 2013, 2014 and 2015.

The Continuous PNAD aims to produce indicators for monitoring quarterly fluctuations and medium- to long-term changes in work force characteristics, as well as to collect additional information pertinent to research and the socio-economic development of Brazil, such as educational data. The survey is distributed to a probabilistic sample of households derived from sample census tracks, thus ensuring the adequate representativeness of the results for the various geographical units it entails: the nation as a whole; the five Brazilian macro-regions; the 27 Federal Units; and metropolitan regions together with capital municipalities.

Each quarter, the Continuous PNAD samples roughly 211,000 households in approximately 16,000 census tracks, encompassing more than 560,000 individuals. The increased number of municipalities and census- and household-sectors surveyed in the Continuous PNAD affords constant gains in the precision of the estimates, most notably in less populous Federal Units and rural areas.

---

4 All materials are available on: http://www.ibge.gov.br/home/estatistica/indicadores/trabalhoerendimento/pnad_continua/

The Continuous PNAD demanded a larger sample size, as it was needed to estimate "the total number of unemployed individuals ages 14 and older", a key indicator that requires a predetermined precision level. However, to produce the quarterly information of the Continuous PNAD, a smaller survey, entailing basic demographic data of household residents (civil status, sex, age, race, and education), is administered in 100% of the households surveyed each quarter. The larger sample employed in all trimesters make Continuous PNAD one of the best data source to evaluate education. Nevertheless, there is no set day of the year for which the weights of such annual estimation are calibrated. For the purpose of compatibility, the subsequent analysis utilizes the second quarter of each year, given the proximity of this date to the date of both IBGE and UN WPP projections (July 1), and Educational Census, as well.

In order to improve the quality of the PNAD's estimates, the initial results of the survey are then calibrated according to the total population estimates from the latest IBGE Projection (2013 Revision). The weights for the Continuous PNAD are adjusted so that, when calculating the total population of varying geographic entities (for example, the total population of 6- to 14-year-olds in a Brazilian Federal Unit, metropolitan area, or the whole of Brazil), the estimate aligns with IBGE population projections. For this stage in the weighting process, only the total population figure is used for calibration; that is, there are no adjustments by sex, age, or rural and urban differences. Therefore, when using the expansion factor (the weight factor) of the PNAD, the total population of each geographic unit is the same as that of IBGE's population projections for the same region, whereas population *by age bracket* – that is, the data required for this study – differs.

Once the weights have been defined, they are applied to the data to generate the final results. The key findings of interest are the representative populations for each geographic unit (for example, the number of 6- to 14-year-olds who attend school), certain ratios and percentages (for example, matriculation rates), and the difference between indicators over time.

1.3. Population projections

The aforementioned sources of demographic information are fundamental to the population projections, because they are prepared based on the components of population dynamics (mortality, fertility, and migration), reported in Population Censuses, Household Sample Surveys, and derived from administrative records of births and deaths.

In terms of population estimation, the main demographic component that affects the school age population is fertility, because it directly affects the size of the youngest cohorts in a short span of time; children and adolescents present low mortality rates in contemporary Brazil[5]; and, at the national level, Brazil is relatively "closed" to international migration.

The demographic transition in Brazil began after the decline of mortality rates in the 1940s. In the two decades that followed, the population growth rate reached its all-time maximum, at around 3.0% per year. The mid-1960s saw the onset of fertility decline, and later the initial stages of an irreversible decrease in growth rates. The rapid pace of fertility and population growth rate decline represented the greatest source of uncertainty in population projections. By the turn of the century, fertility in Brazil had fallen below replacement level, and its decline remained the most ambiguous component in demographic calculations. In regards to the effect of uncertain fertility data on population projections, contemporary studies on fertility behavior suggest that there are certain fertility shifts that traditional measures fail to reveal, and that slight changes in fertility levels can have great impact within low fertility settings (Miranda Ribeiro, et all, 2013). While other demographic components affect projection outputs as well, fertility is more pertinent to estimates of the target school-age population. These issues will be addressed in the next subsections.

Similar to the UN WPP (United Nations World Population Prospects, 2015 Revision), the IBGE population projections seek to ensure intercensal consistency, which means to ensure that the projected population, based on estimates for fertility, mortality and migration derived from an initial census, matches the enumerated population of the subsequent census. The 2000 Census population served as a baseline for the latest official IBGE projections (2013 Revision). The projections were then revised after back-surviving cohorts from the 2010 Census, and then projecting from the 1990 Census population, so as to optimize overall intercensal cohort consistency. The method used by both IBGE and the UN to formulate intercensal consistency and projections is known as the Cohort Component, the most common technique for producing national-level population projections worldwide.

As explained by George *et al.* (2004):

> "The cohort-component method divides the launch-year population into age-sex groups (i.e., birth cohorts) and accounts separately for the fertility, mortality, and migration behavior of each cohort as it passes through the projection horizon. It is a flexible and powerful method that can be used to implement theoretical models or serve as an atheoretical accounting procedure. It can provide in-depth knowledge on population

---

[5] According to the UN (2015), in 2010-2015, the Brazilian crude birth rate was around 15 births per 1,000 individuals, and the number of births – both sexes combined – was 15,369,000. The number of deaths for the 0-4 age group was 378,000 (24 deaths under five per 1,000), and a net number of only 16,000 migrants for the same period (zero rate). See: https://esa.un.org/unpd/wpp/DataQuery/ (accessed in July 2016).

dynamics. Also the cohort-component method can accommodate a wide range of assumptions and can be used at any geographic level — from the world as a whole down to nations, states/provinces, counties, and subcounty areas" (p. 571).

The following details the methodology of the Cohort Component method and its implications for the case of Brazil:

1) Establish the launch-year population and calculate the number of persons who survive to the end of the projection interval (five years in the case of IBGE and the UN WPP). The application of age-sex-specific survival rates to each age-sex group in the launch-year population is required.

   As net migration is essentially null for Brazil as a whole, its impact on the projections is insignificant. In Brazil, male survival rates due to deaths caused by violence are an object of concern. However, this is not the case for the female population. Hence, survival rates of the female population aged 15-49 (childbearing age) are not a significant source of error. Mortality rates have been relatively low and accurate for young women. Furthermore, the level of under-coverage of the female population is much lower than that of the male population (IBGE, 2013).

2) Calculate the number of births occurring during the projection interval. This is accomplished by applying age-specific birth rates (the number of live births occurring within a particular age group of women per year) to the female population aged 15-49 for each five-year age group. This procedure is key for analyzing the school age population born between 2000-2010. The estimate of Total Fertility Rates (TFR) is crucial at this point, as it is the first step for determining age-specific fertility rates. The TFR is the total number of children a woman could potentially have had if she had experienced the average (regional or national) age-specific fertility rate corresponding to each period of her reproductive life.

3) Add the number of births (differentiated by sex) to the rest of the population. Since significant gender preference is not present in Brazil, the sex ratio between boys and girls is of minimal concern. Furthermore, mortality rates have a smaller effect than fertility shifts on population projections of children. According to IBGE (2013), infant mortality rates decreased from 135.0 deaths per thousand live births in 1950 to 15.0 in 2013 (as seen in footnote 4, infant mortality plays a minor role.).

Considering the three components of the projection methodology, unique to the context of Brazil, fertility is the primary source of error for population estimates of children aged 0-9 in the year 2000 (the launch-year for the projection) and for subsequent projection intervals.

a) Declaration and underreporting in fertility

Fertility is the most important demographic component considered in this paper, given that primary and lower secondary age groups in Brazil have witnessed low infant and child mortality rates since the 2000s[6]. Furthermore, given that Brazil's net international migration is currently near zero, its pool of internal migrants does not witness much variation. Nevertheless, migration may affect population projections of the country as whole, seeing as Brazilian Federal Units are subject to interregional flows (Rigotti, 2006; Rigotti et al., 2013, because projections in Brazil are calculated first at the state level, and later summed to decipher the national population. Thus, overall migration is fixed (zero international migration), but rates vary locally between states. As a result, the greater the rate of internal net migration and the greater the population of a state, the larger the effect will be on an overall population projection for the entire country. However, in contemporary Brazil, net migration between states has been gradually decreasing, and its impact on demographic growth is rarely above 3% of the total population[7] for recent five-year intervals. In Brazil's most populous states, net migration rates are near zero (Rigotti, 2013).

Therefore, changing fertility rates have the greatest potential to alter the size of the youngest cohorts in the short term, thus affecting estimates of out-of-school and enrolment rates. Seeing as Brazil has not had a Population Count since the 2010 census, fertility rate estimates are increasingly uncertain because of the lack of recent data on the number of women of reproductive age.

Indeed, Brazil is in an advanced stage of its demographic transition, and it is a prime example of the complexity of population forecasting. According to Andreev, Kantorová, and Bongaarts (2013: 6):

> "Countries with projected population growth that is near zero represent a complex interplay of demographic components. In Brazil, for example, nearly zero population growth is expected between 2010 and 2100. The nearly zero population growth is due to the compensation of a population increase because of a young population age structure and expected mortality reductions with total fertility below replacement".

In general, fertility variation is the largest cause of changes in population growth at the country level. Brazil can be classified within a group of countries characterized by a population wherein "young age structures contribute towards population increase, but the projected total fertility below replacement has a larger impact thus producing an overall population decline" (Andreev, Kantorová, Bongaarts, 2013: 12).

[6] See footnote 4.

[7] Such dynamic occurs in only three states, among the least populous of Brazil.

Although projection assumptions are key to forecasting the size and age structure of a population, understanding the current discrepancies between enrollment figures and population estimates first requires an in-depth evaluation of the fertility baseline.
In general, the results of fertility questionnaires within most censuses have fundamental problems, as pointed out by the UN (1983):

> "The most important error in the number of children reported is due to omission. Women tend to omit some of their live-born children, particularly those living in other households and those who have died, with the result that the proportion omitted tends to increase with age of mother" (p. 28).

The estimate of the TFR to be used in the projections requires a correction of the errors in the number of children reported due to omission. The IBGE uses Brass-type methods based on the comparison of period fertility rates and reported average parities. These methods usually require two types of information on fertility: all children ever born at one point in time (the census date), and age-specific fertility rates referring to a recent period of interest;[8] defined, in Brazil, as the last twelve months before the census.

The most familiar Brass-type method is the P/F ratio:[9]

> "...a consistency check for survey information on fertility. Information on recent fertility is cumulated to obtain measures that are equivalent to average parities. Lifetime fertility in the form of reported average parities by age group, P, can then be compared for consistency with the parity equivalents, F, by calculating the ratio P/F for successive age groups" (UN, 1983: 32).

Considering that information on all children ever borne is frequently distorted by omission in developing countries, the P/F ratio method adjusts the level of observed age-specific fertility rates (the current fertility at the time of the census – the "F" term in the ratio), which presumably represent the true age pattern of fertility, so as to be consistent with the level of fertility calculated by the average parities of women in age groups lower than ages 30 or 35 (the "P" term in the ratio, referring to the number of live births that a woman has had in her lifetime). The latter figures are often deemed more accurate than the former, as they entail only minor memory errors and more stable age-specific rates

---

8 For details, see: United Nations, Department of International Economic and Social Affairs (1983). Indirect techniques for demographic estimation, Population Studies, no.81 (Chapter 2).

9 According to the UN (1983: 302): "Cumulated fertility: an estimate of the average number of children ever borne by women of some age x, obtained by cumulating 'age-specific fertility rates' up to age x: also often calculated for age groups"... "Children ever born(e): number of children ever borne alive by a particular woman: synonymous with 'parity'. In demographic usage. Stillbirths are specifically excluded".

when compared to those figures reported at older ages of the reproductive period. Despite fertility decline being due mainly to the increased use of contraception at older ages, the P/F ratio method yields valid results when information pertaining to younger age groups (normally 20-24) is utilized instead (UN, 1983: 32), so long as it is assumed that the fertility of younger women has not changed substantially in the preceding decade; otherwise, their lifetime fertility would not be consistent with cumulative current fertility rates. The next section attempts to contextualize and discuss the reliability of these technical assumptions, and elaborate on debates surrounding contemporary fertility in Brazil.

b) Fertility shifts in contemporary Brazil

Castanheira and Kholer (2015) argue that the P/F Brass Method used by IBGE to adjust for presumed underreporting at birth is no longer suitable for modern Brazil. Instead, improvements in civil registration now allow for the estimation of more reliable fertility rates, which are much lower than those estimated by Brass Method.

Another misconception is the assumption of constant fertility. As Carvalho (1985) explains, Brazilian fertility rates in past decades withered among women further along in their reproductive years; the estimation of fertility rates in this period was therefore not affected by this change, seeing as the adjustment technique of the Brass Method relies on statistics from younger reproductive age groups.

However, several demographers (Rosero-Bixby et al., 2009; Rios-Neto and Miranda-Ribeiro, 2015) have now found empirical evidence of a modern trend of fertility postponement, which would eviscerate the assumptions that underlie the P/F Method. From 2000 to 2010, there was a significant decline in fertility rates for women aged 15-24 and a marked increase in the number of young, childless women, resulting in an increasingly aging structure of fertility.

In Brazil, the P_2/F_2 ratio – that is, the parity of women ages 20-24 divided by the accumulated fertility rates of the 15-19 and 20-24 age groups – was once recommended for adjustment. However, in modern Brazil, the fertility of younger cohorts has declined, and thus parity for the 20-24 age group is higher than the simulated parity from current accumulated fertility. The result is an adjustment that is increasingly overestimated, growing from a factor of 1.10 in 2000 to 1.19 in 2010 (Castanheira and Kholer, 2015: 3):

> "Brazil is therefore likely to have attained below-replacement fertility earlier more than is indicated by the official TFR estimates, and the decline of fertility is likely to have progressed further than is commonly believed" (Castanheira and Kholer, 2015: 1).

Despite the unsuitable conditions in countries with fast fertility decline, the Brass Method continues to be used in Latin America:

> "Brazil, together with Colombia, Peru, Venezuela, and Ecuador are one of these countries in Latin America and the P/F Brass method is used to calculate their official TFR and as input in population projections. We therefore believe that recent fertility declines in several Latin American countries have progressed further than is indicated by official TFR estimates and related UN WPP analyses, with important implications for the assessment of future trends in population size and aging". (Castanheira and Kholer, 2015: 2)

In a situation of relatively low child mortality and fertility rates, like that of contemporary Brazil, a high level of imprecision in birth registration is not expected. It is comparatively easy for today's parents to recall the date of birth for only a couple of living children, as opposed to for many more children, both alive and dead, as was the case in decades past. In addition, the design of Brazil's census questionnaire improved in 1991, and now asks census respondents for the month and year of their last birth, a more precise gauge for measuring current fertility.

An overestimation of fertility levels would engender serious implications for population projections. Thus, other available sources of fertility data must be compared with the Brass P/F Method results from the census. Brazil has two different birth registries: the Civil Registry and SINASC (Live Births Information System). While the former derives its data from notaries and is collected and distributed by IBGE, the latter dataset is managed by hospitals. If a child is born at home, the health unit or the notary public must send a record of the birth to the Civil Registry. Ultimately, birth estimates from SINASC end up being greater than those of the Civil Registry due to late registration.

The 2010 Census requested, for the first time, the type of birth registration for each child aged 10 and under, thus allowing for an accurate estimation of under-registration. For children under the age of one at the date of the 2010 census distribution, only 2.76% births had not been registered by the Civil Registry or SINASC (Castanheira and Kohler, 2015).

Considering the multiplicity of sources available for estimating fertility, Castanheira and Kohler (2015) point out:

> "The Brazilian TFR in 2010 using the Civil Registry data is 1.65 and 93.94% of births were registered (Table 2). The correction factor for under-registration in the civil registry is, then, 1/0.9394 = 1.064, which, multiplied by the total number of births in the civil registry, results in a final TFR of 1.760 children per women. The Brazilian TFR in 2010 calculated with the SINASC data is 1.71 and its coverage is 97.25% (registries from notaries and health facilities), providing a correction factor of 1/0.9725 = 1.028, and the final SINASC TFR is then 1.761. The two adjustments provide very similar results, which

> increase our confidence in the data and estimates. These results are significantly lower than the 1.90 children per women calculated with Brass P_2/F_2 ratio from the 2010 Census data, and in greater agreement with the TFR of 1.80 resultant from the 2003-2006 PNDS, the Brazilian DHS's equivalent" (p. 8).

Other authors have tried to estimate the total fertility rate for Brazil as well. Within the context of rapid fertility decline, Schmertmann et al. (2013) proposed the use of the empirical Bayes technique to estimate smoothed, local, age-specific fertility rates, thus applying a new variation of the P/F Brass Method. When replicating this methodology, Castanheira and Kohler (2015) found a TFR of 1.91, approximately the same result as that of IBGE for 2010.

Overall, Brass's P/F technique seems to overestimate Brazil's TFR given the national context of rapid fertility decline and the occurrence of first pregnancies at an increasingly later average age. TFR affects projected population in terms of both magnitude and age structure. Utilizing the same methodology as in the United Nations World Population Prospects (UN WPP), but with a lower TFR of 1.76 (the SINASC-adjusted TFR), Castanheira and Kohler (2015) projected a national population of seven million fewer individuals, and an average age one year older, than IBGE predictions for 2050. The greater amount of time that passes from the launch-year, the larger the effect of an underestimated fertility rate on the size of the projected population, and the faster the apparent pace of population aging. On the other hand, the effect on school age cohorts occurs in the short-term, since newborns enroll in school a few years after birth. The following sections discusses the sources of population estimates in Brazil: the United Nations Population Division (UNPD) and the Brazilian Institute of Geography and Statistic (IBGE), as well as the effects of the differences between them on indicator values (e.g. net enrolment rate and out-of-school rate).

2. Comparison of the three population data sources

This section seeks to assess the size of the school age population and compare it with estimates from IBGE and the UN WPP. Thereafter, enrollment and out-of-school rate estimates from varying sources will be analyzed as well, for distinct age groups: those of primary age; those of lower secondary age; all individuals of both primary and lower secondary age; and per single year of age.

Apart from the uncertainties of fertility, the discrepancies between the 2010 Census estimates and the 2010 IBGE population projection (2013 Revision)[10] may be explained by under-coverage, which is often highly differentiated by age. The greatest known inaccuracy in Brazilian Census data is the underestimation of children, a problem that appears to be particularly grave in the 2010 Census (IBGE, 2013). In addition, having accepted the conclusion that fertility rates in Brazil are lower than the

[10] The latest version of the official IBGE Projection, revised in 2013, will be referred to as the IBGE Projection from here on.

assessments of most current estimates, this section also seeks to show the effects of differing fertility estimates on evaluations of the size of school-age cohorts. Later in this section, the population projections and PNAD estimates will be compared.

2.1 Census under-coverage and IBGE population projections

Figure 1 depicts the differences between the registered population of 0- to 19-year-olds in the 2010 Demographic Census and the IBGE projection for the year 2010. If under-coverage were fully avoided, and assumptions regarding fertility, mortality, and migration projections were accurate, there would be – unlike the actual results – no observable difference between the census counts and the population projection. After consistency checks, the 2010 projection should be a more precise population estimate than the census itself, given that it is adheres closely to intercensal demographic dynamics.

The 2010 Demographic Census counted a total of 62,923,166 individuals within the 0-19 age group, while the IBGE projection estimated 67,106,378 unique individuals in 2010, or 6.0% more. For children aged 0-9, the 2010 Census counted 28,765,533 individuals, while the IBGE projection estimated 32,733,544, or 14% more[11]. This percentage is much higher than that of Brazil's population as a whole for 2010, even after factoring in intercensal consistency, which averaged around 2% (IBGE, 2013). It is difficult to discern what proportion of the percentage derives from under-coverage, and what proportion is a result of inaccurate fertility assumptions.

Figure 1 reveals a greater discrepancy between the two estimates in the 0-4 age group than in the older cohort aged 5-9. It is reasonable to infer that the inconsistency between the 2010 Census count and the IBGE projection for the youngest cohort (ages 0-4) is primarily a result of an overestimated TFR (Total Fertility Rate) in the projection, as well as the relatively high under-coverage in the 2010 Census as a whole[12]. The primary school cohort – ages 6 to 10 in Brazil – is the age group most affected by overestimation for the current decade.

After the age of ten, incongruities between the Census data and the IBGE Projection become much less pronounced. With international net migration near zero and low levels of mortality for this age group, the principal cause of the discrepancy between the 2010 Census and the IBGE Projection for the 2010 cohort of 10- to 19-year-olds is likely to be undercounting, with an average difference smaller than 2% for the population aged 10-19.

---

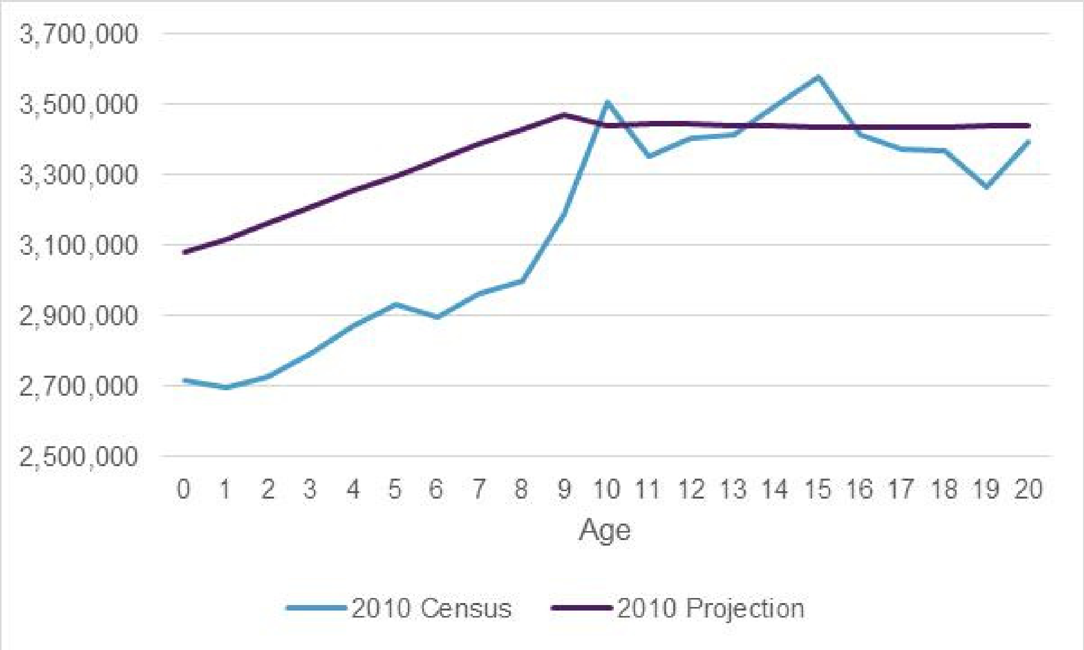
[11] At ages 10 and 15, registered census counts are above 100% of the IBGE projection; this is likely due to the fact that individuals commonly round their ages to these figures, a normal pattern of age heaping.

[12] Survival ratios and net international migration are a minor concern, since mortality levels are low in these age groups and net migration is near zero.

If the underlying assumptions of the projections are correct, the differences between the census counts and the demographic projections for ages ten and under are evidence of significant under-coverage. For example, dividing the population aged 10-14 in the 2010 Census by the population aged 0-4 in the 2000 Census results in a ratio of 1.05, a figure that should be impossible to attain in a country with negligible international net migration. This figure implies the existence of a minimum benchmark for under-coverage of 5% within the 0-4 age group in 2010, an assumption supported by the fact that IBGE acknowledges a lower-than-average coverage rate for the 2010 Census (IBGE, 2013: 9). Given that the IBGE projection adjusted the original population count of individuals aged 0-9 upwards by 14%, fertility rate assumptions may have the effect of overestimating this population by up to 9% (if under-coverage were a mere 5%). This statistic could equate to a maximum figure of 2.6 million children under 10 years old.

However, as the following section shows, there is considerable disagreement regarding fertility rates in Brazil, thus leaving the degree of under-coverage in the 2010 Demographic Census highly uncertain.

Figure 1. Brazil: 2010 demographic census and 2010 IBGE projection



Source: IBGE 2010 demographic census and IBGE projection (2013 revision)

To arrive at the figures above, IBGE utilizes the Cohort Components Method to project the population of each of the 27 Brazilian Federal Units, and later uses the sum of these figures to obtain its estimate of the Brazilian population in its entirety.

Figure 2 reveals that the relative differences between populations gathered from census data and figures derived from projections for the population aged 0-19 vary considerably by region. São Paulo, Brazil's largest state in terms of population size and boasting one of the nation's highest population densities, exhibits both the highest relative figures and the greatest absolute difference, an unexpected result in light of the state's notably accurate birth and death records, and its continuous and gradual decline in internal net migration rates (Rigotti, 2006, Rigotti et al., 2013). Considering these factors, such discrepancies should not be attributed to overestimated fertility or net internal migration rates, nor to underestimated mortality levels in São Paulo state. Given the predictable population behavior of São Paulo, one does not expect serious problems in the population projection. Therefore, it is more likely that the difference between the 2010 census and population projection for the same year is due to an under-coverage higher than in previous versions of the census.

On the other hand, some states with smaller populations and lower population densities, such as Roraima, Amapá, and Rondônia, present significant relative differences as well. These Amazonian states likely suffer from some of the highest under-coverage rates in the country. Projection assumptions in these states are also more likely to be erroneous. Civil administrative registers in these three states are also known for their high levels of underreporting, and it is difficult to assess net migration in these states, due to a relatively intense and unstable population mobility.

The Northeastern state of Rio Grande do Norte also falls within the group of Federal Units with small populations and large discrepancies between census and projected population figures. If the difference between a projected population and the individuals counted by a census can be considered a proxy for under-coverage, then the low-density areas of Brazil, along with some of its most populous states (São Paulo and Bahia) and largest urban centers, are the regions where this problem is most acute.

Even the analysis of certain Federal Units with relatively small differences, such as the Amazonian states of Pará, Mato Grosso, and Acre, deserves caution. Most of their population is distributed throughout regions wherein households are difficult to enumerate because of remoteness, and thus these states are known for their high rates of under-coverage and errors in accurate age declaration. Age declarations, as well as birth declarations, are known to be erroneous in remote states, due to lower levels of education or mis-identification by an extended family member (ex. a grandfather attempting to identify the age of all of his grandchildren). In remote areas, it is not unusual for a respondent to omit mention of a child or declare a child's age erroneously. The socioeconomic and spatial heterogeneity within all five Brazilian macro-regions (North, Northeast, Central-West, Southeast, South) indicates the pervasiveness of census under-coverage nationwide.

This selection of states demonstrates the difficulty in ascertaining definitive trends of population undercounting or false projection assumptions in Brazil. However, the Southern states of Paraná, Santa Catarina, and Rio Grande do Sul offer alternative perspectives. These states are among the most developed in Brazil, possessing accurate civil registers and reaching a more advanced stage within the demographic transition, and as such demonstrating more stability in terms of demographic dynamics. These favorable conditions afford greater reliability to the formulation of projection assumptions. Assuming that the assessment of future population behavior is easier to predict in these three states, and therefore more accurate, any observable difference between the 2010 Census data and IBGE projections is primarily due to under-coverage. Figure 2 illustrates the range of the percentage of difference between the two sources – from 6% to 8% – in Brazil's Southern region. The mid-point of this range of percentages (7%) serves as a reasonable estimate of the average under-coverage rate of the 2010 Brazilian census, a figure admittedly higher than that of the 2000 Census (IBGE, 2013). If this assumption is true, roughly half of the 14% difference between the enumerated population aged 0-9 in the 2010 Census and the population for the same cohort estimated by the IBGE projection can be explained by under-coverage. The remaining proportion would then be explained by overestimated fertility. The following section addresses this issue.

2.2 Overestimated fertility and population projections

When evaluating school age populations, the use of five-year age group intervals is necessary for interpolation procedures to achieve successful disaggregation of age groups into single, unique ages. The intervals emphasized are ages 6-10 (primary school) and 11-14 (lower secondary).

a) 2015 UN WPP and IBGE projections

The consequences of overestimated fertility rates for assessing enrollment and out-of-school rates are similarly apparent. With the 2015 UN WPP and IBGE TFRs calculated as 1.90 and 1.97 respectively for the 2005-2010 period[13], both the number of children in the youngest age groups and the size of the out-of-school population are overestimated, while net enrollment rates are underestimated. For the 2010-2015 period, TFR estimates were calculated at 1.82 and 1.79 for UN WPP and IBGE respectively.

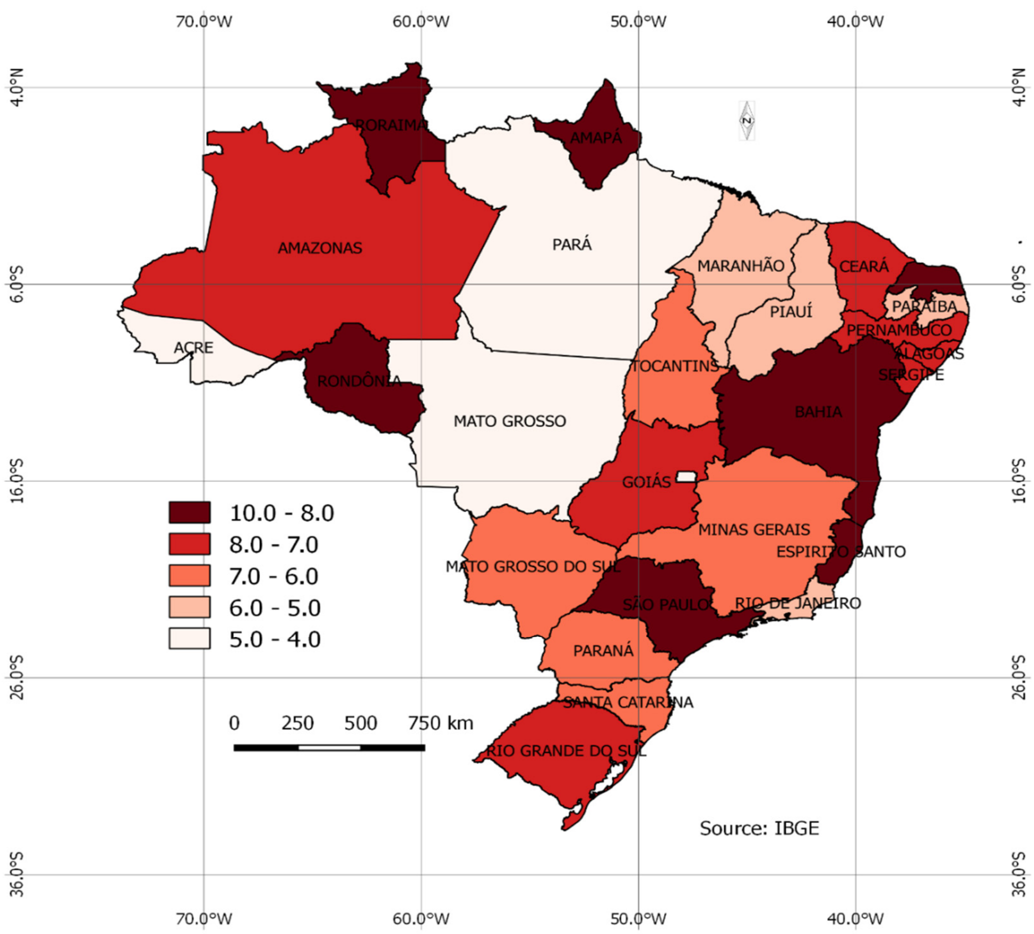
Table 1 shows the results of both projections. While the figures for each of the two sources are similar, the size of the 0-4 age group is estimated as larger by IBGE in 2010 and by the UN WPP in 2015, in accordance with their respective calculated TFRs.

Frequent problems stem from the procedures to disaggregate five-year age groups into single ages within demographic studies of school-age children. The 2015 UN WPP utilizes a Beers' ordinary formula for this task, comprising two steps: first, the five-year population projection is interpolated into annual population figures, and finally, the population by single year of age is interpolated by

13 "Period estimates may be assumed to refer to the mid-point of the period concerned (e.g. the mid-point of the period 1 July 1970 to 1 July 1975 is the 1 *January* 1973)". See: https://esa.un.org/unpd/wpp/General/FAQs.aspx (accessed 7/19/2016).

applying Sprague's fifth-difference osculatory formula for subdivision of groups into fifths[14]. As pointed out by the UN (2015: 32), "it must be noted, however, that interpolation procedures cannot recover the true series of events or the true composition of an aggregated age group".

Figure 2. Brazilian federal units: Difference between 2010 demographic census and 2010 IBGE projections (%)



Source: IBGE 2010 demographic census and IBGE projection (2013 revision)

[14] See Swanson and Siegel, (2004). For details, see: Henry S. Shryock, Elizabeth A. Larmon, Jacob S. Siegel, The methods and materials of demography, Vol. 2. U.S. Dept. of Commerce, Social & Economic Statistics Administration, Bureau of the Census, 1973. United States Bureau of the Census.

Table 1. UN WPP and IBGE projections by five-year age group

Ratio between IBGE/UN WPP projections; 2010, 2015

Age Group	2010			2015		
	UN WPP	IBGE	ratio *	UN WPP	IBGE	ratio *
0-4	15 456 788	15 816 957	1,02	15 032 203	14 737 740	0,98
5-9	17 443 141	16 916 587	0,97	15 407 519	15 779 109	1,02
10-14	17 511 377	17 200 577	0,98	17 422 671	16 892 243	0,97
15-19	16 765 167	17 172 257	1,02	17 464 370	17 140 200	0,98

Source: UN (2015), IBGE (2013)

Table 2 illustrates the UN WPP and IBGE[15] projections according to level of education and corresponding theoretical age. At their greatest, differences between the two hover around 3%, depending on age group. However, these deceptively small discrepancies often hide greater disparities when broken down to single years of age.

Table 2. UN WPP and IBGE projections by school age

Ratio between IBGE/UN WPP projections, 2010, 2015

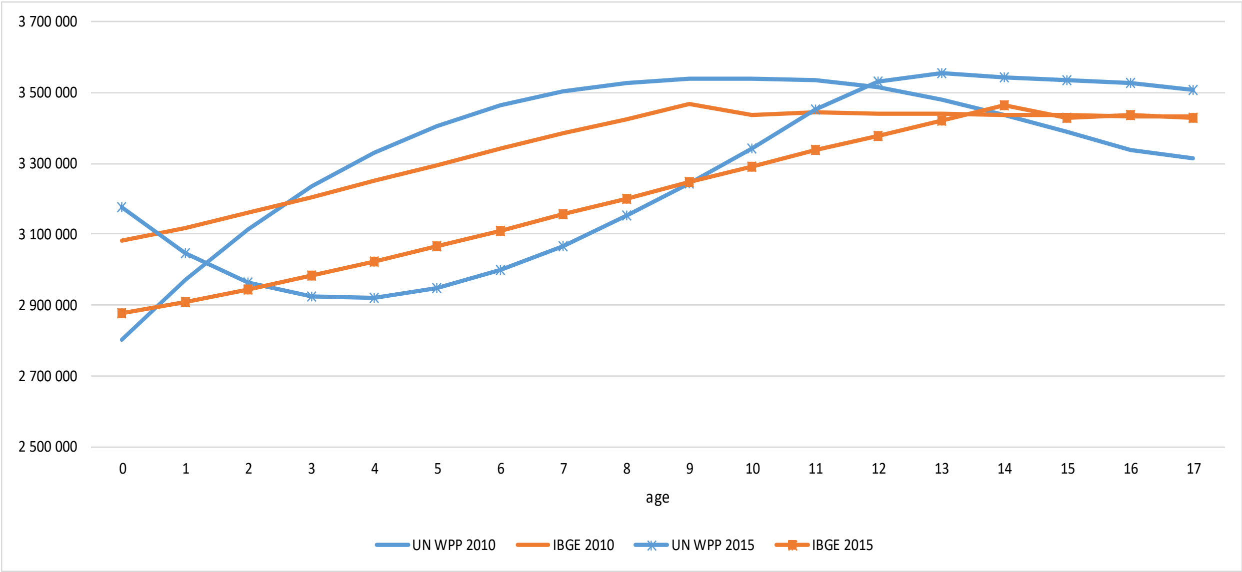
Level of Education	Theoretical Age	2010			2015		
		UN WPP	IBGE	ratio *	UN WPP	IBGE	ratio *
Primary Education	6-10	17 576 871	17 056 938	0,97	15 802 587	16 005 507	1,01
Lower Secondary	11-14	13 970 654	13 763 623	0,99	14 080 630	13 600 023	0,97
Upper Secondary	15-17	10 044 240	10 300 029	1,03	10 570 286	10 295 356	0,97

Source: UN (2015), IBGE (2013)

Figure 3 depicts the Brazilian population, aged 0-17, by single year of age, for 2010 and 2015. In contrast to the IBGE figures, the Sprague's formula used by the UN WPP presents not only a continuous oscillating curve, but also results in inverse curves, i.e. convex for about 0- to 12-years old and concave for ages 12-17 in 2015.

[15] IBGE did not state the interpolator used in their 2010 Projection (2013 Revision).

Figure 3. Brazilian population, aged 0-17, by single year of age
UN WPP and IBGE projections, 2010 and 2015



Source: UN (2015), IBGE (2013)

Depending on education level, enrollment and out-of-school rate estimates varied. For instance, the continuous sinuous shape of the UN WPP projection depicts the population aged 6-10 in 2015 as lower than that displayed in the IBGE projection by 202,920 individuals, while for the 11-14 age group the UN WPP denotes a cohort size that is greater than that of the IBGE projection by 480,607 individuals. The aggregation of the two age groups (6-14) lessens these discrepancies due to their reciprocal compensations. If aggregated in this way, the UN WPP projection would count 278,000 more individuals than the IBGE projection, a relatively small difference that amounts to less than 1%.

b) UN WPP projections using TFR (Castanheira and Kohler, 2015) and IBGE projections

The empirical evidence for the contemporary trend of fertility postponement in Brazil, as detailed by Rosero-Bixby et al. (2009) and Rios-Neto and Miranda-Ribeiro (2015), calls into question the estimates used by the UN WPP and IBGE projections, which suggest that the actual fertility levels were lower at the turn of the century. The projections for 2020 are included in this analysis so as to show the role of fertility assumptions in the long-term.

Table 3 shows the difference between the official IBGE projection and the results of the 2015 UN WPP methodology as reinterpreted by Castanheira and Kohler (2015) using a base TFR of 1.76, 1.68, and

1.64 for the periods 2005-2010, 2010-2015, and 2015-2020 respectively.[16] This is in contrast to the corresponding figures for IBGE, which were 1.97, 1.79, and 1.66 respectively [17].

Table 3. UN WPP projections reinterpreted by Castanheira and Kohler (2015) and IBGE projections by five-year age groups, 2010, 2015, and 2020

Age	2010			2015			2020		
Group	UN WPP	IBGE	ratio *	UN WPP	IBGE	ratio *	UN WPP	IBGE	ratio *
0-4	15 197 946	15 816 957	1,04	13 656 829	14 737 740	1,08	13 366 958	13 845 258	1,04
5-9	17 236 674	16 916 587	0,98	15 141 265	15 779 109	1,04	13 616 946	14 708 594	1,08
10-14	17 327 934	17 200 577	0,99	17 208 978	16 892 243	0,98	15 120 091	15 761 172	1,04
15-19	16 504 288	17 172 257	1,04	17 252 940	17 140 200	0,99	17 140 091	16 841 311	0,98

Source: UN (2015), IBGE (2013)

Given the lag of the fertility effect on cohort sizes, differences between the two projections are more apparent for 2015 and 2020. For these periods, IBGE figures are consistently larger for the youngest two age groups.

Table 4. UN WPP projections reinterpreted by Castanheira and Kohler (2015) and IBGE projections by school age, 2010, 2015, and 2020

Level of Education	Theoretical	2015			2020		
	Age	UN WPP	IBGE	ratio *	UN WPP	IBGE	ratio *
Primary Education	6-10	15 659 965	16 005 507	1,02	13 837 944	14 904 632	1,08
Lower Secondary	11-14	13 752 570	13 600 023	0,99	12 246 407	12 698 554	1,04
Upper Secondary	15-17	10 451 523	10 295 356	0,99	10 115 655	9 985 343	0,99

Source: UN (2015), IBGE (2013)

The results from tables 2 and 4 reveal the differences that arise when varying sources of population estimates are utilised, each of which features dissimilarities in fertility assumptions and a potential variance in their net enrolment and out-of-school rates. If enrolment figures for a given year remain the same, then out-of-school rate estimates should be smaller when employing the UN WPP methodology as reinterpreted by Castanheira and Kohler (2015) as opposed to when using the IBGE projections. For the year 2015, the original UN WPP projection estimates 142,622 more out-of-school

[16] The author is grateful to Helena Castanheira for sending supplemental material from: Castanheira, Helena Cruz & Kohler, Hans-Peter (2015). It is Lower Than You Think it is: Recent Total Fertility Rates in Brazil and Possibly Other Latin American Countries. Population Studies Center, University of Pennsylvania, Working Paper 15-5 URL: http://repository.upenn.edu/psc_working_papers/63

[17] IBGE figures are available by single year. The aforementioned figures are the midpoints of the five-year periods. Data accessed 6/14/2016) at: http://www.ibge.gov.br/home/estatistica/populacao/projecao_da_populacao/2013/default_tab.shtm

children aged 6-10 and 328,060 more out-of-school children in the lower secondary age bracket than the Castanheira and Kohler (2015) reassessment does.

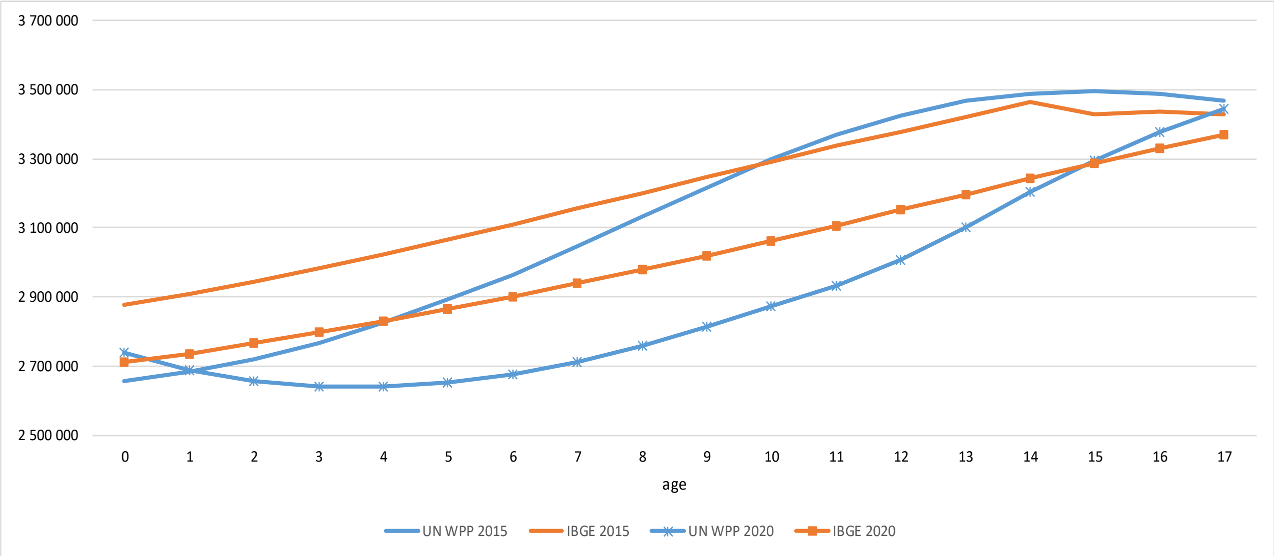
While the difference when subtracting the IBGE projection figures from the original UN WPP projection figures was 202,920 individuals for the 2015 primary education cohort, the Castanheira and Kohler reinterpretations result in a difference of 345,542 individuals. However, for the 11-14 age group, the inverse occurs, with differences of -480,606 and -152,547 individuals respectively.

Figure 4 depicts Brazil's population by single year of age for ages 0 to 17, as calculated by the 2015 UN WPP methodology reinterpreted by Castanheira and Kohler (2015) and IBGE Projections for years 2015 and 2020. So as to be coherent with the original methodology, the five-year age groups used by the UN WPP projections (see Table 3) were subdivided using Sprague's Method.

Comparing to Figure 3, the UN WPP curve for 2015 is lower, the effect of the lower TFR used by Castanheira and Kohler (2015) in their calculations. From age 10 onwards, the IBGE and UN WPP curves are more alike. Discrepancies with Figure 3 are a result of an interpolation procedure that uses adjacent age groups to interpolate into single ages[18]. Consequently, changes in fertility assumptions alter both the level of the TFR and the age-specific rates of the estimates.

Figure 4. Brazilian population by single year of age (0-17)

UN WPP Projection reinterpreted by Castanheira and Kohler (2015), Sprague's Method interpolations and IBGE projections, 2015 and 2020



Source: Castanheira and Kohler (2015), IBGE Projection (2013 Revision)

[18] See Swanson and Siegel, 2004, p. 727.

Ultimately, therefore, interpolation methodologies should be chosen carefully and in light of the level of precision required in a study. Results of the estimates used, such as out-of-school and enrollment rates, should be compared by single years of age.

2.3 Comparisons between population projections and PNAD estimates

The interpolated annual population projection also serves as the basis for weighing samples gathered in the annual national survey known as the *Pesquisa Nacional por Amostra de Domicílios* (PNAD - National Household Sample Survey). As such, projections are important not only because national surveys provide an estimate of infant and adolescent populations, but also because contain necessary information for estimating net enrollment rates and in-school populations.

Despite having being weighted to correspond to the total stock of the IBGE projection (2013 Revision), the Continuous PNAD does not merely replicate the projection population across all school-age group subdivisions. The consistency between estimates derived from the PNAD and others obtained from the administrative data of enrolments is analyzed later in this study. The trends of primary and lower secondary age group size, gathered from PNAD data and detailed in Table 5, are compared to projections by IBGE and UN WPP.

Table 5. Population aged 6-14, PNAD, IBGE and UN WPP

Age	PNAD				IBGE Projection				UN WPP			
	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
6	2 924 926	2 788 355	2 793 166	2 756 303	3 249 428	3 202 677	3 155 988	3 110 016	3 299 307	3 186 360	3 077 866	2 998 228
7	2 927 547	2 918 884	2 916 246	2 815 179	3 294 788	3 248 588	3 201 870	3 155 216	3 384 866	3 279 397	3 168 281	3 068 386
8	2 913 721	2 941 723	2 879 299	2 888 714	3 339 307	3 293 935	3 247 770	3 201 081	3 463 481	3 369 672	3 260 085	3 151 660
9	3 100 983	2 951 189	2 929 136	2 966 537	3 382 591	3 338 444	3 293 107	3 246 974	3 518 678	3 458 982	3 355 086	3 242 272
10	3 019 062	3 130 228	3 039 072	3 049 954	3 424 400	3 381 622	3 337 512	3 292 220	3 543 121	3 521 746	3 455 093	3 342 041
6-10	14 886 240	14 730 380	14 556 919	14 476 688	16 690 514	16 465 266	16 236 247	16 005 507	17 209 453	16 816 157	16 316 411	15 802 587
11	3 333 859	3 144 094	3 134 222	3 026 622	3 465 804	3 423 329	3 380 591	3 336 521	3 544 682	3 546 086	3 525 429	3 452 785
12	3 699 884	3 497 278	3 240 906	3 217 068	3 434 669	3 464 722	3 422 283	3 379 586	3 542 325	3 542 916	3 549 668	3 530 721
13	3 464 375	3 684 267	3 491 232	3 237 077	3 441 969	3 433 597	3 463 670	3 421 271	3 536 754	3 538 809	3 541 775	3 554 872
14	3 605 717	3 447 867	3 671 620	3 433 659	3 439 935	3 440 896	3 432 556	3 462 645	3 516 928	3 532 959	3 535 918	3 542 252
11-14	14 103 835	13 773 507	13 537 980	12 914 425	13 782 377	13 762 544	13 699 100	13 600 023	14 140 689	14 160 770	14 152 790	14 080 630
Total	**28 990 075**	**28 503 886**	**28 094 899**	**27 391 113**	**30 472 891**	**30 227 810**	**29 935 347**	**29 605 530**	**31 350 142**	**30 976 927**	**30 469 201**	**29 883 217**

Source: IBGE (2013), UN WPP (2015) and PNAD (2012 to 2015, 2nd trimester)

As depicted in **Table 6**, the PNAD estimates contain the lowest figures for Brazil's total population aged 6-14 across all years examined. The greatest discrepancy occurs in relation to the UN WPP estimates, which calculate 2.5 million more individuals than the PNAD dataset does for 2015. However, in general, differences do not vary significantly through the years.

A comparison between the PNAD estimates and the IBGE projection reveal a different pattern. While in 2012 the IBGE projection exceeds the PNAD estimate by only 1.5 million individuals, the gap between the two sources increases steadily, reaching 2.3 million individuals by 2015.

Table 6. Brazil: Differences between PNAD data, the IBGE projection and the UN WPP projection for the population aged 6-10, 11-14 and 6-14, 2010 to 2015

Age Group	IBGE Projection - PNAD				UN WPP - PNAD			
	2012	2013	2014	2015	2012	2013	2014	2015
6-10	1 804 274	1 734 886	1 679 328	1 528 819	2 323 213	2 085 777	1 759 492	1 325 899
11-14	- 321 458	- 10 963	161 120	685 598	36 854	387 263	614 810	1 166 205
6-14	**1 482 816**	**1 723 924**	**1 840 448**	**2 214 417**	**2 360 067**	**2 473 041**	**2 374 302**	**2 492 104**

Source: PNAD (2012 to 2015, 2nd trimester), IBGE (2013), UN WPP (2015)

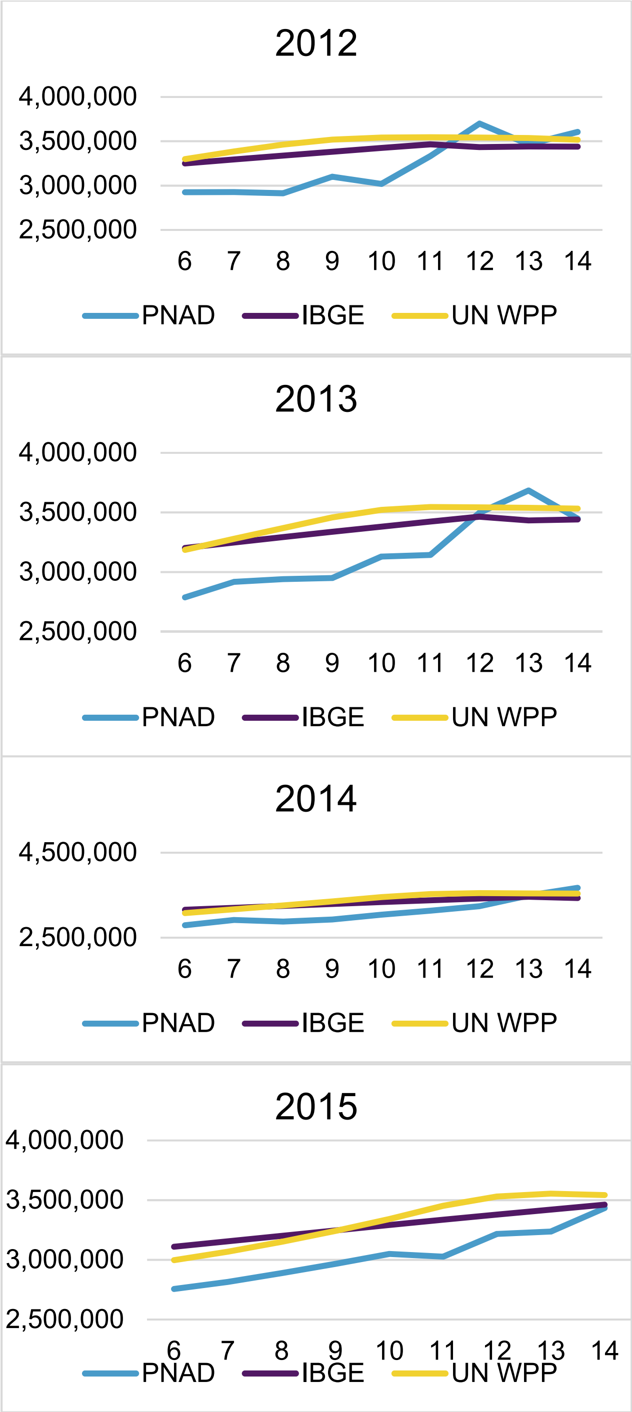
Figure 5 illustrates the erratic trend of the PNAD series, a result of the lack of interpolation procedures and a lower estimate for younger ages. The curve depicts a process of fertility decline, and suggests a TFR lower than that used in the two projections. The discrepancies between both projections and the PNAD data for the population aged 6-10 decrease throughout the years, while the opposite occurs for the 11-14 age group *(see Table 8).* If the PNAD data are correct, the trends it reveals suggest that the fertility assumptions used in both projections for the second half of the 1990s and the beginning of the 2000s (when individuals aged 11-14 were born) suffer from greater overestimation than the assumptions utilized for the second half of the 2000s (when individuals aged 6-10 were born). Thus, in accordance with the arguments of many authors cited above, the turn of the last century is a critical period for estimating TFRs to be used in population projections.

These figures reiterate the central role of projection assumptions and adjustments for census underenumeration of estimated enrolment and out-of-school rates. Depending on the figure for population used as the denominator for calculating enrolment rates, the number of out-of-school children may be overestimated by up to 2.5 million individuals *(see Section 5).*

3. Sources of enrolment data: PNAD and administrative data (educational census)

Brazil's "Educational Census" is a nationwide administrative register of educational statistics, collected from a questionnaire that is distributed every year and coordinated by Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP). INEP is the governmental institution responsible for assessing primary, secondary, and higher education in Brazil. The Educational Census collaborates with both state and municipal education secretaries, ensuring the participation of all public and private schools in the country. INEP compiles educational indicators to help formulate, implement, monitor, and evaluate educational policies at all government levels (federal, state, and local). Thus, the annual Educational Census covers all public and private schools across Brazil's numerous municipalities, registering more than 50 million enrollments each year. Since the modification of the Educational Census in 2007, when unique idenfication numbers were assigned to each student, it has been possible to follow each student's year-to-year educational trajectory; that is, statistics track whether or not a student passed or repeated a given grade, or dropped out entirely.

Figure 5. PNAD, IBGE projection and UN WPP projection for the population aged 6-14, 2012 to 2015



Source: PNAD (2012 to 2015, 2nd trimester), IBGE (2013), UN WPP (2015)

The Educational Census is the main instrument for collecting basic educational information across all levels of schooling: regular education (early childhood, primary, and secondary education); special education; adult education; and vocational education (technical courses, training courses, and professional qualification). The Educational Census collects data about schools, classes, students, professionals in the classroom, and school performance.

The information gathered by the Educational Census is used to devise a basic education plan nationwide, and to serve as reference for the formulation and implementation of public policy and educational programs, including the transfer of public resources – for meals, transportation, books, libraries, electricity, and financial resources – to a maintenance fund aimed at the further development of basic education and education professionals in Brazil (Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação - FUNDEB).

Prior to the establishment of FUNDEB, *FUNDEF* (Fundo de Manutenção e Desenvolvimento do Ensino Fundamental e de Valorização do Magistério), implemented in 1998, allowed for automated resource allocation to schools as determined by the number of students enrolled in primary and lower secondary education and registered in the consolidated data of the Educational Census for the previous year. The impact of FUNDEF on enrolment figures was immediate; the number of students enrolled in primary and lower secondary school rose from 30.5 million in 1997 to 32.4 million in 1998[19]. The notable increase in the pupil enrolments is certainly the result of both, the extra resources and requirement in the official budget. However, there is evidence that part of this enrollment increase was cases of fictitious students, that only existed in records to increase the funds allocated to the school. In spite of being highly probable, there is no reliable estimation of the amount of false enrolments. After 2007, enrolment records were no longer linked to schools but to individual students who were assigned unique identification numbers. From this date, the number of false records likely dropped sharply because fraud has become a much more difficult task. Nowadays, the legacy of FUNDEF (renamed FUNDEB) has ensured that student enrolment has become not only an obligation, but also a stimulus for governments, since it involves transfer of funds – particularly for municipal administrations, which are most responsible for primary and lower secondary education.

Brazil's largest conditional cash transfer program, "Bolsa Família," also depends on information gathered within the Educational Census. The "Bolsa Família" program targets families in extreme poverty throughout the country, seeking to ensure that these families receive basic access to food, education, and healthcare. More than 13.9 million households nationwide benefit from the Bolsa Família. Among its requirements, families must ensure that their children aged 6 to 15 attend school at least 85% of all school days and 75% for adolescents aged 16 to 17[20].

---

[19] http://mecsrv04.mec.gov.br/sef/fundef/pdf/Aval1998.pdf (accessed in July 2016).

[20] See: http://bolsafamilia.datasus.gov.br/w3c/bfa.asp (accessed on 7/25/2016).

The public policies implemented by FUNDEF, and later by FUNDEB and the Bolsa Família, improved the registers of school children significantly. From 2007 onwards, the Educational Census began registering individual school children, providing each student with a unique identification number. This innovation, along with better verification of administrative records, has furnished the increasing reliability of the Educational Census as a source of demographic data. Nevertheless, some shortcomings remain within the administrative registers, particularly in regards to the transitional follow-ups (promotion, repetition, and drop-out rates) of the students, year-to-year. Due to cases of lost identification numbers, yearly transition estimates merit caution. However, the Educational Census is successful in consistently registering enrolment, as discussed earlier in this section.

The Educational Census figures are comparable with PNAD data. From the Continuous PNAD microdata sample, for each of the 12 grades of the Brazilian basic education system, it is possible to select the individuals of a given age enrolled in each of the grades, as well as people of the same age having left school after concluding at least one grade. Individuals who have left school and those who have never entered school are the out-of-school population. Hence, the enrolled populations aged 6-10 and 11-14 on the survey date - which is the second trimester to be closest to Educational Census - are available after applying the weights.

4. Comparison of enrolment and out-of-school rate based on the different data sources

The size and regional representativeness of Continuous PNADs ensure that they are a reliable source for estimating the school-age population of Brazil. Table 5 shows the target populations of primary- and lower-secondary-age children, the number of students attending school at the corresponding level of education[21], and the number out-of-school children, from 2012 to 2015.

The data in **Table 7** support a well-known pattern of Brazilian demographic dynamics, common in societies with noted population aging, in which the size of younger cohorts is decreasing while the size of older cohorts increases. This trend of decrease is echoed within the population of young people actively attending school as well.

[21] The 6-10 age group correlates roughly with the Primary Education cohort, and the 11-14 age group corresponds to the Lower Secondary cohort. A child enrolled at a more advanced level than his or her recommended year is also counted. Children of lower secondary age attending primary education are also counted as in school.

Table 7. Brazil: Population, population enrolled in school, out-of-school population, continuous PNAD, 2012 to 2015

Age	Population				Population enrolled at school				Out-of-school Population			
	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
6	2 924 926	2 788 355	2 793 166	2 756 303	2 300 910	2 233 175	2 276 888	2 262 855	624 016	555 180	516 278	493 448
7	2 927 547	2 918 884	2 916 246	2 815 179	2 799 044	2 791 695	2 820 908	2 724 337	128 504	127 189	95 339	90 842
8	2 913 721	2 941 723	2 879 299	2 888 714	2 858 619	2 887 953	2 827 604	2 843 684	55 102	53 771	51 695	45 030
9	3 100 983	2 951 189	2 929 136	2 966 537	3 059 918	2 914 407	2 898 713	2 938 868	41 066	36 782	30 423	27 669
10	3 019 062	3 130 228	3 039 072	3 049 954	2 985 755	3 093 759	3 009 341	3 021 734	33 308	36 469	29 731	28 220
6-10	14 886 240	14 730 380	14 556 919	14 476 688	14 004 244	13 920 990	13 833 454	13 791 477	881 995	809 390	723 465	685 210
11	3 333 859	3 144 094	3 134 222	3 026 622	3 299 852	3 110 780	3 097 091	2 994 709	34 008	33 314	37 130	31 913
12	3 699 884	3 497 278	3 240 906	3 217 068	3 656 269	3 459 638	3 206 382	3 189 603	43 614	37 640	34 524	27 464
13	3 464 375	3 684 267	3 491 232	3 237 077	3 408 141	3 620 399	3 429 646	3 190 752	56 235	63 868	61 586	46 324
14	3 605 717	3 447 867	3 671 620	3 433 659	3 493 019	3 334 973	3 563 141	3 336 875	112 698	112 894	108 479	96 784
11-14	14 103 835	13 773 507	13 537 980	12 914 425	13 857 281	13 525 790	13 296 260	12 711 940	246 555	247 717	241 719	202 485
Total	**28 990 075**	**28 503 886**	**28 094 899**	**27 391 113**	**27 861 525**	**27 446 780**	**27 129 714**	**26 503 418**	1 128 550	1 057 107	965 184	887 695

Source: IBGE, PNAD (2012 to 2015, 2nd trimester)

Table 8 depicts the relatively high degree of school attendance in contemporary Brazil, with enrolment rates among children at the official age for primary and lower secondary education – which are mandatory in Brazil – approaching maximum coverage. However, a closer analysis indicates that to reach full attendance, the school entrance rate at age six, and to a lesser extent at age 7, must increase at a faster pace. This explains the lower rates of coverage at the primary education age in comparison to the lower secondary cohort.

The PNAD results show that approximately 5% of primary-age children did *not* attend primary school in the first five years of the 2010s, corresponding to an average of roughly 775,000 individuals aged 6-10 for the period of 2012 to 2015. Table 5 also reveals a trend of continuous decline in the number of out-of-school primary-age children, from 882,000 in 2012 to 685,000 in 2015.

Table 8. Brazil: Net enrolment and out-of-school rates for the population aged 6-14, continuous PNAD, 2012 to 2015

Age	Net Enrolment Rate				Out-of-school Rate			
	2012	2013	2014	2015	2012	2013	2014	2015
6	78,67	80,09	81,52	82,10	21,33	19,91	18,48	17,90
7	95,61	95,64	96,73	96,77	4,39	4,36	3,27	3,23
8	98,11	98,17	98,20	98,44	1,89	1,83	1,80	1,56
9	98,68	98,75	98,96	99,07	1,32	1,25	1,04	0,93
10	98,90	98,83	99,02	99,07	1,10	1,17	0,98	0,93
6-10	94,08	94,51	95,03	95,27	5,92	5,49	4,97	4,73
11	98,98	98,94	98,82	98,95	1,02	1,06	1,18	1,05
12	98,82	98,92	98,93	99,15	1,18	1,08	1,07	0,85
13	98,38	98,27	98,24	98,57	1,62	1,73	1,76	1,43
14	96,87	96,73	97,05	97,18	3,13	3,27	2,95	2,82
11-14	98,25	98,20	98,21	98,43	1,75	1,80	1,79	1,57
Total	**96,11**	**96,29**	**96,56**	**96,76**	**3,89**	**3,71**	**3,44**	**3,24**

Source: PNAD (2012 to 2015, 2nd trimester)

The lower secondary cohort, on the other hand, presents the lowest out-of-school figures, approximately 235,000 individuals on average for the same period. The same cohort has witnessed a decrease in its number of out-of-school children. Data from the Continuous PNAD suggests that while the total number of out-of-school children across both levels of schooling was approximately 1,000,000 in the mid-2010s, net enrolment rates are steadily increasing, and thus will ultimately lead to a decline in out-of-school rates.

The enrolment data from the Educational Census and their comparison to the PNAD figures from Table 5 are depicted in **Table 9**. The total number of enrolments from the Educational Census gradually decreases, falling from 27.7 million in 2012 to 26.1 million in 2015, in line with the trend in the size of the population aged 6-14 years. This trend of decline occurs both at primary (3%) and lower secondary (9%) age.

When compared to the PNAD data in **Table 10**, the number of total enrolments counted by the Educational Census was 0.4% lower in 2012 and 1.4% lower in 2015. However, while the Educational Census enumerates a greater number of primary school students and the difference between the two sources decreases from 3.5% to 1.9% during the 2012-2015 period, the same does not hold true for the lower secondary cohort.

Table 9. Brazil: Educational census enrolments, PNAD enrolments and differences between census and PNAD data, 2012 to 2015

Age	2012		2013		2014		2015		2012	2013	2014	2015
	Census	PNAD	Census	PNAD	Census	PNAD	Census	PNAD	Census - PNAD Enrolments			
6	2 643 850	2 300 910	2 616 166	2 233 175	2 671 010	2 276 888	2 620 199	2 262 855	342 940	382 991	394 122	357 344
7	2 909 242	2 799 044	2 848 058	2 791 695	2 784 038	2 820 908	2 798 146	2 724 337	110 198	56 363	56 363	73 809
8	2 936 361	2 858 619	2 951 836	2 887 953	2 879 198	2 827 604	2 794 884	2 843 684	77 742	63 883	63 883	- 48 800
9	2 973 657	3 059 918	2 959 364	2 914 407	2 967 061	2 898 713	2 877 005	2 938 868	- 86 261	44 957	44 957	- 61 863
10	3 034 196	2 985 755	2 990 060	3 093 759	2 971 124	3 009 341	2 959 936	3 021 734	48 441	- 103 699	- 103 699	- 61 798
6-10	14 497 306	14 004 244	14 365 484	13 920 990	14 272 431	13 833 454	14 050 170	13 791 477	493 062	444 494	455 625	258 693
11	3 138 348	3 299 852	3 048 783	3 110 780	3 001 613	3 097 091	2 965 366	2 994 709	- 161 504	- 61 997	- 61 997	- 29 343
12	3 339 934	3 656 269	3 146 389	3 459 638	3 055 578	3 206 382	2 990 087	3 189 603	- 316 335	- 313 249	- 313 249	- 199 516
13	3 445 541	3 408 141	3 337 937	3 620 399	3 142 770	3 429 646	3 031 508	3 190 752	37 400	- 282 462	- 282 462	- 159 244
14	3 325 270	3 493 019	3 418 047	3 334 973	3 305 837	3 563 141	3 095 777	3 336 875	- 167 749	83 074	83 074	- 241 098
11-14	13 249 093	13 857 281	12 951 156	13 525 790	12 505 798	13 296 260	12 082 738	12 711 940	- 608 188	- 574 634	- 574 634	- 629 202
Total	27 746 399	27 861 525	27 316 640	27 446 780	26 778 229	27 129 714	26 132 908	26 503 418	- 115 126	- 130 140	- 119 009	- 370 510

Source: INEP (Educational Census, 2012 to 2015), and PNAD (2012 to 2015, 2nd trimester)

Table 10. Brazil: Differences between educational census and PNAD enrolments (% of PNAD data) and net enrolment rate (enrolment data from educational census divided by population estimate from PNAD), 2012 to 2015

Age	Differences Census - PNAD Enrolments (%)				Net Enrolment Rate (%)			
	2012	2013	2014	2015	2012	2013	2014	2015
6	14,90	17,15	17,31	15,79	90,39	93,82	95,63	95,06
7	3,94	2,02	-1,31	2,71	99,37	97,57	95,47	99,39
8	2,72	2,21	1,82	-1,72	100,78	100,34	100,00	96,75
9	-2,82	1,54	2,36	-2,11	95,89	100,28	101,29	96,98
10	1,62	-3,35	-1,27	-2,05	100,50	95,52	97,76	97,05
6-10	3,52	3,19	3,17	1,88	97,39	97,52	98,05	97,05
11	-4,89	-1,99	-3,08	-0,98	94,14	96,97	95,77	97,98
12	-8,65	-9,05	-4,70	-6,26	90,27	89,97	94,28	92,94
13	1,10	-7,80	-8,36	-4,99	99,46	90,60	90,02	93,65
14	-4,80	2,49	-7,22	-7,23	92,22	99,14	90,04	90,16
11-14	-4,39	-4,25	-5,94	-4,95	93,94	94,03	92,38	93,56
Total	-0,41	-0,47	-1,30	-1,40	95,71	95,83	95,31	95,41

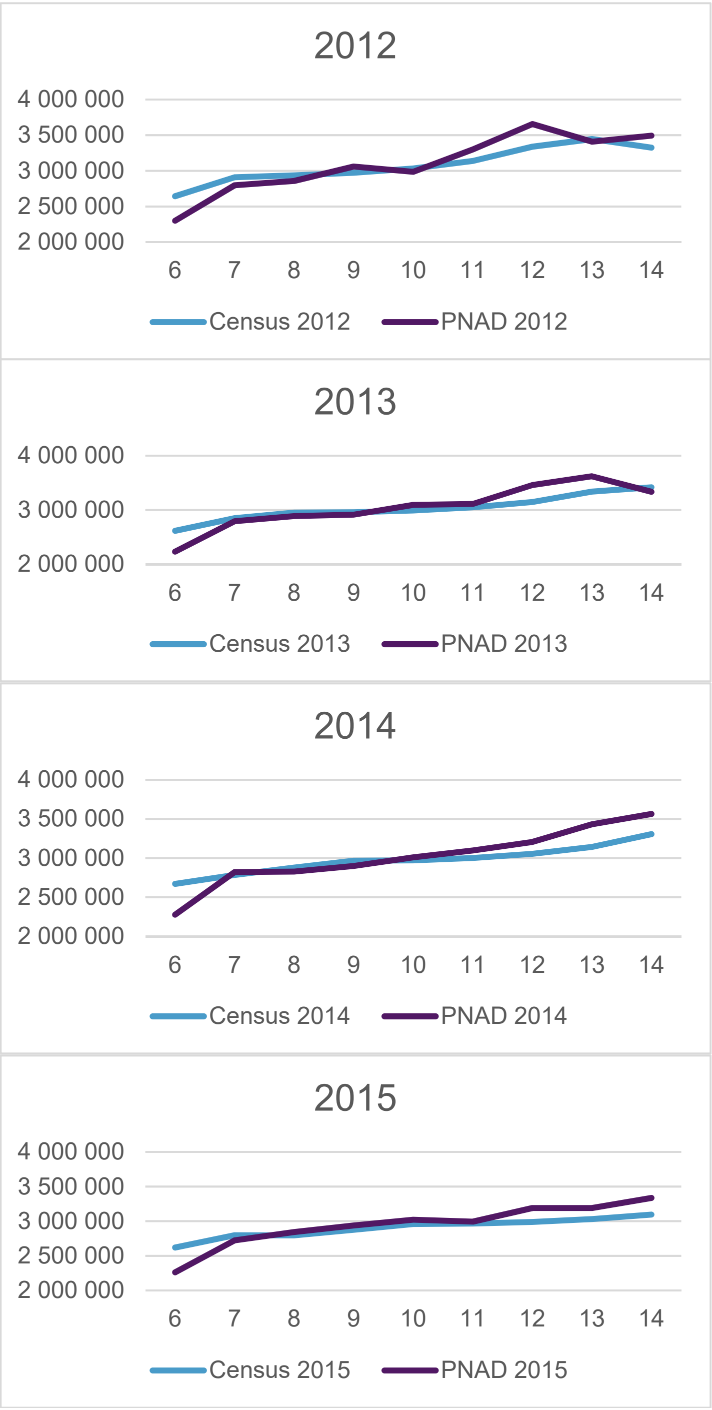
Source: INEP (Educational Census, 2012 to 2015), and PNAD (2012 to 2015, 2nd trimester)

Figure 6 illustrates a smoother curve for the Educational Census data, depicting a greater number of enrolments than the PNAD data for age 6, and fewer enrolments for ages over 10. If the population figure determined by the PNAD data *(see Table 7)* is used as the denominator for the enrolment figures from the Educational Census, the results encompass a more diverse pattern, evident in the final columns of Table 9. For some ages, the net enrolment rate exceeds the theoretical maximum value of 100%, which indicates inconsistencies between enrolment figures from Educational Censuses and population estimates from Continuous PNAD.

Overall, the net enrolment rates for students aged 6-14 do not stray far from those described in Table 6. Primary-age students do, however, present a higher enrolment rate than those of lower secondary age, the apparent inverse of the results of the PNAD data *(see Table 6)*.

While it is not easy to discern which of the estimates is the most accurate, some hypotheses may be formulated from the data in relation to trends within the Brazilian education system of the late 1990s. The Continuous PNAD is undoubtedly one of the more reliable datasets for estimating enrolment rates and out-of-school rates in Brazil, but as with any household survey, it contains a certain level of error. Although the Continuous PNAD gathers data on more than 560,000 individuals per trimester (including approximately 45,000 individuals of the 6-10 age group and 40,000 individuals of ages 11-14), its estimates of school populations by single year of age and the erratic shape of the curves portrayed in Figure 5 reveal the probable presence of random fluctuation, age heaping, or sampling error within its data. Overall, the greater the scope of data collection, the more consistent an estimate will be. Censuses are subject to smaller sources of error than the PNAD, simply because they survey the entire population.

Figure 6. Brazil: Enrolment figures for the educational census and the PNAD, 2012 to 2015



Source: INEP (Educational Census, 2012 to 2015) and PNAD (2012 to 2015, 2nd trimester)

Brazil faces serious setbacks in recording grade transitions among primary and lower secondary students because of lost or changed identification numbers and some of the highest repetition and drop-out rates in Latin America. Both indicators vary greatly depending on grade and age. Klein (2006), who has analyzed transition rates in Brazil for many years, concluded:

> "There was great improvement in the late 1990s, with repetition and dropout rates falling steadily up until 1998. However, the rates are still high. ... Only repetition rates between 1st and 4th grade show a downward trend" (Klein, 2006: 146).

To make matters worse, the number of drop-outs increases as repetition rates grow. Students make little upwards progress before being and eventually drop out from school. In a recent study, Klein (2016) updated his estimates of these rates. In 2013,

> "the promotion rate was 95% for the 1st grade, falling to 86.5% after three years, and plummeting to 79.5% by the sixth year. The promotion rate by 9th grade – the transitional year from middle school to high school – is a mere 81%, and by the first year of high school the promotion rate falls further, to 68%. Dropout rates are around 1% for the first three grades of primary school, and then begin to rise. They are approximately 7% from 6th to 8th grade, increasing to 10% by 9th grade and continuing to grow over the first two years of high school" (Klein, 2016: 307).

While the Brazilian educational system was able to significantly reduce repetition and dropout rates for primary school students, it has not achieved the same success for secondary school students. As such, it should be uncommon to find low enrolment rates within the first years of mandatory schooling, seeing as dropouts tend to occur in the later years of lower secondary school. Furthermore, it is highly implausible that the cohort of six-year-old students be the smallest registered in the Educational Census. For years, INEP has worked tirelessly to correct double-counting, successfully diminishing its salience today[22]. It is more probable, therefore, that data from the PNAD underestimates the number of six- and seven-year-old children. In this case, the primary school enrolment rate would be nearly equivalent to that of lower secondary students, resulting in a number of out-of-school children smaller than that previously estimated by the PNAD and shown in Table 6.

[22] Due to a Cooperation Agreement with INEP, CEDEPLAR has access to a database from 2008 to 2014, excluding double-counting. The difference in the number of enrolments between this database and the public microdata is less than 0.2%.

Comparing both datasets, the number of lower secondary enrolments registered in the Educational Census is significantly smaller, despite the fact that the PNAD data had estimated a particularly high enrolment rate *(see Table 6).* As affirmed by IBGE[23] , the main indicators of interest from the Continuous PNAD are the totals or ratios of two characteristics. However, the irregularity of the population figures used as the denominators for calculations in Table 5 and Figure 5 casts doubt on the consistency of cohort size for each single age. While it may be acceptable to observe a higher enrolment rate for primary school students as opposed to their lower secondary counterparts, it is far more problematic to assess the size of the population aged 11-14 – and hence its enrolment rate – by using Educational Census as the numerator.

Despite the overall accuracy of enrolment rate estimations for the 6-14 age group as a whole, estimates of enrolment rates from data gathered by the Educational Census and population data collected by the PNAD become more uncertain when using increasingly smaller age subdivisions. Population estimates from projections are problematic as well, as elaborated earlier. Both the IBGE and the UN WPP projections likely overestimate the size of the population in Brazil aged 6-14. The net enrolment results of the two projections are presented in **Table 11**.

Table 11. Brazil: Net enrolment rate calculated from enrolment from educational census and population aged 6-14 from IBGE and UN WPP projection, 2012 to 2015

Age	IBGE Net Enrolment Rate				UN WPP Net Enrolment Rate			
	2012	2013	2014	2015	2012	2013	2014	2015
6	81,36	83,40	84,63	84,25	80,13	82,11	86,78	87,39
7	88,30	87,67	86,95	88,68	85,95	86,85	87,87	91,19
8	87,93	89,61	88,65	87,31	84,78	87,60	88,32	88,68
9	87,91	88,65	90,10	88,61	84,51	85,56	88,43	88,73
10	88,61	88,42	89,02	89,91	85,64	84,90	85,99	88,57
6-10	86,86	87,25	87,90	87,78	84,24	85,43	87,47	88,91
11	90,55	89,06	88,79	88,88	88,54	85,98	85,14	85,88
12	97,24	90,81	89,28	88,47	94,29	88,81	86,08	84,69
13	100,10	97,21	90,74	88,61	97,42	94,32	88,73	85,28
14	96,67	99,34	96,31	89,40	94,55	96,75	93,49	87,40
11-14	96,13	94,10	91,29	88,84	93,69	91,46	88,36	85,81
Total	91,05	90,37	89,45	88,27	88,50	88,18	87,89	87,45

Source: IBGE (2013), UN WPP (2015), and INEP (Educational Census, 2012 to 2015)

23 See: ftp://ftp.ibge.gov.br/Trabalho_e_Rendimento/Pesquisa_Nacional_por_Amostra_de_Domicilios_continua/Notas_metodologicas/notas_metodologicas.pdf

The primary school cohort once again has the lowest enrolment rates for both estimates shown in Table 10. This result is unlikely, considering historical transition rates in Brazil (Klein, 2006, 2016), in which the intake rate at the beginning of the school life is high, besides the fact that the repetition and dropout rates between the 1st and 4th grades are much lower than in subsequent grades, and the high coverage of the Brazilian educational system. A possible explanation for such pattern is the overestimation of the population aged 6-10, given that there is little evidence for low Educational Census coverage among this cohort. Only the 2012 enrolment rate acts as a reliable estimate for the 11-14 age group, given that the decrease in enrolment rates displayed in subsequent years has little tangible support and is likely caused by erroneous data. Therefore, overall, Educational Census enrolments appear to decrease at a faster pace than the population. Seeing as infant mortality rates have witnessed no recent surge in Brazil, overestimated fertility is the more likely cause of the overestimation in the population aged 11-14.

The reliability of enrolment rates and out-of-school rates

For decades, the PNAD has been the most widely used database for estimating the size of Brazil's school-age population during non-census years. Recent changes to the PNAD, carried out by IBGE, have improved the scope and regional representativeness of the surveys, affording greater reliability to the current Continuous PNAD as a source for estimating the number of out-of-school children. Table 6 illustrates the high rates of enrolment that have characterized Brazil since the 1990s.

While a net enrolment rate of approximately 96.8% for all student-age children in 2015 *(see Table 6)* is notably high, it masks the enormous divergences that occur at ages 6 and 7 *(see Figure 6).* A slightly lower enrolment rate for six-year-olds in the first quinquennial of the 2010s is expected due to delayed entry, but a 20% out-of-school rate – as calculated by PNAD data – seems farfetched. The six-year-old cohort as enumerated by the Educational Census contains, on average, 15% more enrolments between 2012 and 2015 than the PNAD estimates *(see Table 9).* Given the credible absence of double-counting in the Educational Census, the PNAD data appears to have overestimated the number of out-of-school children by an average of 370,000 individuals during this period. As such, the number of out-of-school primary-age children is more likely to average 406,000 individuals annually between 2012-2015, instead of the 775,000 previously estimated.

Primary school enrolment data from both the PNAD and the Educational Census are fairly consistent, with the notable exceptions at ages 6 and, to a lesser extent, 7. The difference between the Educational Census and the PNAD data for all enrolment figures for children aged 6-10 results in an average of 367,000 out-of-school children between 2012 and 2015. Given the distinct methodologies behind the enumeration of enrolments, both out-of-school children figures are acceptable estimates for primary school children, working as a range of reliable estimates.

The same does not hold true for the IBGE and UN WPP projections. While the former estimates more than 2,000,000 out-of-school children between 2012 and 2015, on average, from ages 6-10, the latter estimates an average of 2,200,000 for the same period and demographic *(see **Table 12**).* There is no tangible evidence for such results in contemporary Brazil, and as such the use of these projections for estimating the number of primary-age out-of-school children is not recommended.

Table 12. Brazil: Numbers of out-of-school children: Educational census enrolment and IBGE and UN WPP projections, 2012 to 2015

Age	IBGE				UN WPP			
	2012	2013	2014	2015	2012	2013	2014	2015
6	605 578	586 511	484 978	489 817	655 457	570 194	406 856	378 029
7	385 546	400 530	417 832	357 070	475 624	431 339	384 243	270 240
8	402 946	342 099	368 572	406 197	527 120	417 836	380 887	356 776
9	408 934	379 080	326 046	369 969	545 021	499 618	388 025	365 267
10	390 204	391 562	366 388	332 284	508 925	531 686	483 969	382 105
6-10	2 193 208	2 099 782	1 963 816	1 955 337	2 712 147	2 450 673	2 043 980	1 752 417
11	327 456	374 546	378 978	371 155	406 334	497 303	523 816	487 419
12	94 735	318 333	366 705	389 499	202 391	396 527	494 090	540 634
13	- 3 572	95 660	320 900	389 763	91 213	200 872	399 005	523 364
14	114 665	22 849	126 719	366 868	191 658	114 912	230 081	446 475
11-14	533 284	811 388	1 193 302	1 517 285	891 596	1 209 614	1 646 992	1 997 892
Total	2 726 492	2 911 170	3 157 118	3 472 622	3 603 743	3 660 287	3 690 972	3 750 309

Source: IBGE (2013), UN WPP (2015) and INEP (Educational Census, 2012 to 2015)

The assessment of enrolment and out-of-school rates for lower secondary-age children is more complex. As discussed previously, the PNAD data for this cohort estimates a net enrolment rate higher than that of primary-age children. In reality, the exact opposite should be expected, given that drop-out rates are higher at older ages (Klein, 2006; 2016). However, if children aged six at the date of reference are excluded from PNAD data, enrolment rates for both levels of schooling draw nearer to one another.

Nonetheless, the number of enrolments of lower secondary students discerned by the Educational Census is considerably smaller than the PNAD figure – a total difference of 650,000 individuals. The adequacy of the representativeness of the PNAD sample may be a cause of this discrepancy, if the number of children attending school was overrepresented due to low survey coverage in remote areas with lower enroment rates. Although a plausible explanation, it loses weight in light of the improvements in the representativeness of the PNAD after redesigning its sample and becoming continuous in 2012.

Another explanation for this divergence may be the size of the population surveyed. While the number of primary school individuals surveyed by the PNAD is consistent with the corresponding number of enrolments from the Educational Census (with the notable exception of six-year-olds), the same does not hold true for the lower secondary cohort. **Figure 7** depicts the curves by single age for lower secondary-age children. The oscillation apparent in the PNAD data is not expected for cohorts of 3,000,000 individuals or more. The Educational Census data, on the other hand, depict an expected, smoother shape.

While the shape of the PNAD curves are unexpected results, assessing the size of the population aged 11-14 is far more challenging. While the Continuous PNAD is adjusted according to the IBGE Projection (Revision 2013), population sizes align only at the total population level, and may not correlate evenly within smaller subgroups. Given that the previous analysis within this study supports the assumption that the IBGE projection overestimates the population (see Table 11, depicting the apparent overestimation of out-of-school children), it is impossible to disprove the hypothesis that PNAD population counts for ages 11-14 are also overestimated, seeing as they are based on the IBGE projection as well.

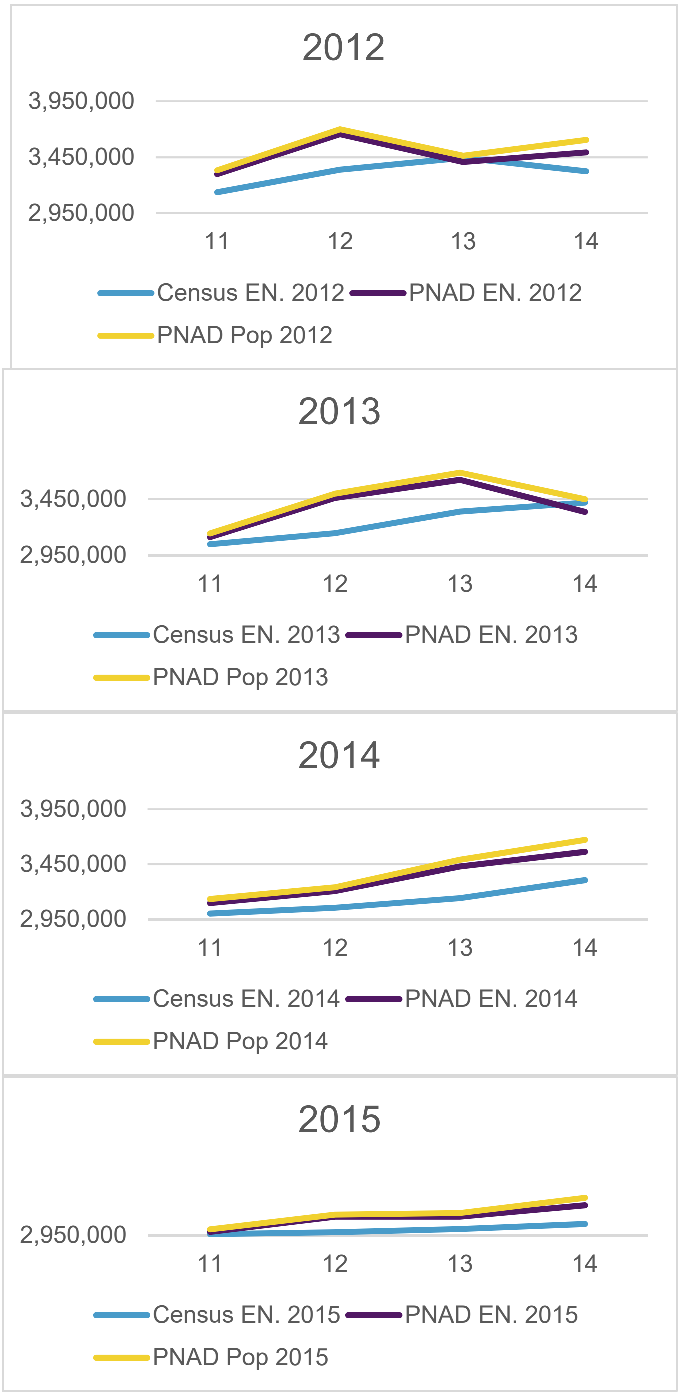
The enrolment figures by single age for lower secondary cohorts from the Educational Census denote more predictable demographic behavior, with cohort size decreasing gradually and few inflated peaks. These trends are compatible with primary school enrolment figures by single age from the Educational Census as well. Unfortunately, there exists no reliable projection for accurately assessing the size of lower secondary cohorts, as the UN WPP projection forecasts a result that conflicts with PNAD and Educational Census figures.

5. Recommendations

Brazil has historically faced some of the highest grade repetition and dropout rates in Latin America. For decades, policy makers incorrectly addressed the nation's problems with education, believing falsely that dropout rates were the greatest hindrance to improving Brazil's level of schooling.

However, since the 1990s, a key problem in the Brazilian education system was correctly diagnosed: the persistence of one of the highest rates of grade repetition in the world. The bloated and recurrent repetition rate within the first years of primary school not only diminished the average total years of schooling per student, but also incentivized greater dropout rates. Therefore, by the end of the 1990s, greater emphasis was placed on the incorporation of out-of-school children within the education system, as well as the targeted decrease of repetition – and subsequently dropout – rates.

Figure 7. Brazil: Population from PNAD (PNAD Pop.), enrolment from PNAD (PNAD EN.) and enrolment from educational census (census EN.), 2012 to 2015



Source: INEP (Educational Census, 2012 to 2015), and PNAD (2012 to 2015, 2nd trimester)

The 1990s and 2000s witnessed the consolidation of social programs under the guidance of FUNDEB and Bolsa Família, and the number of out-of-school children decreased noticeably as a result. At the present time, the improvement of school transition rates (promotion, repetition, and dropout) is a primary concern within Brazilian educational guidelines. Given that the effects of educational policy are not immediate, school attendance rates in Brazil are currently higher at the primary school level, decreasing gradually and culminating in elevated dropout rates by the end of high school. Subsequently, a higher enrolment rate for the lower secondary cohort is improbable.

In light of the issues discussed in the present study, the author recommends:

1) An analysis of the phases of demographic transition that Brazil is currently experiencing, including the identification of assumptions behind demographic projections and the comparison of estimates across different sources. In the case of Brazil, information from civil birth registries should be taken into account as a source for fertility estimates;

2) Avoiding the use of current IBGE and UN WPP projections to estimate enrolment rates and out-of-school rates. Evidence suggests that their adjustment for under-coverage and underlying fertility assumptions vastly overestimate the school age population;

3) The identification of the main features that characterize the Brazilian education system, particularly in regards to the evolution of school attendance rates and grade transition rates (promotion, repetition, and dropouts). The reliability of estimates must be evaluated by educational level (primary versus lower secondary);

4) The use of the Continuous PNAD for the estimation of aggregate enrolment and out-of-school rates, with minimal subdivision by age. Our findings suggest that estimating rates by single year of age is not recommended due to an insufficient sample size:

5) The analysis of preferably longitudinal Educational Census data and its trends so as to maximize consistency by number of students per year by single age. The Educational Census allows following the cohorts of students, by age, sex and area of residence, year-to-year. Given the high coverage of the Brazilian school system, the Educational Censuses are a powerful tool for estimating consistent transition rates, and for assessing the size and age structure of the population aged 6-14;

6) The discernment of an adequate denominator for enrolment rate calculations as estimated by an administrative source, such as Educational Census data. While the Continuous PNAD proved to be more consistent as a denominator for population counts than figures from the projections, its sample does not appropriately reflect subdivisions by educational level; and

7) The revision of the current population projections, given that they are fundamental to ascertaining population estimates in non-census years. Our study pointed out inconsistencies, mainly in the fertility assumptions, which seems to overestimate the number of births, and likely the launch-year population for the projections. In the current context of near-universal school attendance, the Educational Census and its accordingly high levels of coverage must be utilized as an authoritative data source alongside current projections. The use of the Educational Censuses themselves could be an invaluable source of assistance to estimate the school-age population.

References

Andreev, Kirill, Vladimíra Kantorová and John Bongaarts (2013). "Demographic Components of Future Population Growth". Technical Paper No. 2013/3. New York: United Nations Department of Economic and Social Affairs, Population Division.

Carvalho, J.A. M. de (1985). "Aplicabilidade da Técnica de Brass a Fecundidade Declinante ou a uma População Abert"a. Belo Horizonte, Working paper, CEDEPLAR.

Castanheira, H. C., & H.-P. Kohler (2015). "It is Lower Than You Think It Is: Recent Total Fertility Rates in Brazil and Possibly Other Latin American Countries". Working Paper 15-5. Population Studies Center, University of Pennsylvania. Accessed at: http://repository.upenn.edu/psc_working_papers/63

George, M. V., Stanley K. Smith, David A. Swanson and Jeff Tayman (2004). "Population Projections". In: Jacob S. Siegel and David A. Swanson (eds.), *The Methods and Materials of Demography* (pp. 561-602). San Diego: Elsevier Academic Press.

Instituto Brasileiro de Geografia e Estatística (2008). "Metodologia das estimativas das populações residentes nos municípios brasileiros para 1º de julho de 2008: Uma abordagem demográfica para estimar o padrão histórico e os níveis de subenumeração de pessoas nos censos demográficos e contagens da população." Access at: http://www.ibge.gov.br/home/estatistica/populacao/estimativa2008/metodologia.pdfInstituto

Instituto Brasileiro de Geografia e Estatística (2013). "Projeções de População. Brasil e Unidades da Federação". Série Relatórios Metodológicos, v.40. Accessed at: ftp://ftp.ibge.gov.br/Projecao_da_Populacao/Projecao_da_Populacao_2013/srm40_projecao_da_populacao.pdf

Klein, R. (2016). "Como está a educação no Brasil? O que fazer?". Revista Ensaio: Avaliação e Políticas Públicas em Educação, [S.l.], v. 14, n. 51, p. 139-172, apr. 2006. ISSN 1809-4465. Access in July 2016 at: http://revistas.cesgranrio.org.br/index.php/ensaio/article/view/692

Klein, R. and L.M. Lins (2016). "Cálculo das Taxas de Transição entre Séries (Calculation of transition rates between Series)". ANAIS VIII Reunião da ABAVE. Avaliação de Larga Escala no Brasil: Ensinamentos, Aprendizagens e Tendências. Nº 2, p. 291-312. Accessed at: http://abave.com.br/ojs/index.php/Reunioes_da_Abave/article/viewFile/340/146

Miranda-Ribeiro, A., E.G. Rios-Neto and J.A.M. Carvalho (2013). "Efeitos tempo, parturição e quantum no Brasil: indicadores de período e evidências empíricas". R. bras. Est. Pop., Rio de Janeiro, v. 30, n. 1, p. 145-170. Accessed at: http://www.scielo.br/pdf/rbepop/v30n1/v30n1a08.pdf

Rigotti, José Irineu Rangel (2006). "Geography of population flow according to the Migrants' Educational level". *Estud. av.* [online].vol.20, n.57 [cited 2016-07-28], pp.237-254. Accessed at: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103401420060002000 18&lng=en&nrm=iso>

Rigotti, José Irineu Rangel, D. Fazito and J. Campos. "A distribuição espacial de mão de obra qualificada no Brasil é um entrave ao crescimento econômico de maior valor agregado no interior do país?" In: M. P. P. de Oliveira; P. A.M. Nascimento; A. N. Maciente; L. A. Caruso; E.M.Schneider (eds.), *Rede de pesquisa formação e mercado de trabalho: coletânea de artigos: Tendências e aspectos demográficos do mercado de trabalho,* p.75-116. Brasília: IPEA/ABDI. Accessed at: http://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=24229

Rios-Neto, Eduardo L. G. And A. Miranda-Ribeiro (2015). "Fertility Decline in Brazil: Tempo, Quantum and Parity Composition Effects". In: 2015 Population Association of America Annual Meeting, San Diego, Califórnia.

Rosero-Bixby, L., T. Castro-Martín and T. Martín-García (2009). "Is Latin America starting to retreat from early and universal childbearing?". *Demographic Research,* 20(9): 169-194.

Shryock, Henry S., Elizabeth A. Larmon and Jacob S. Siegel (2003). *The Methods and Materials of Demography*, Vol. 2. U.S. Dept. of Commerce, Social & Economic Statistics Administration, Bureau of the Census.

Siegel, Jacob S. and David A. Swanson (2004). *The Methods and Materials of Demography, Second Edition.* Elsevier Academic Press, 2004.

United Nations Department of International Economic and Social Affairs (UNDESA) (1983). "Indirect techniques for demographic estimation". *Population Studies*, No. 81. Accessed at: http://www.un.org/en/development/desa/population/publications/pdf/mortality/Manual_X.pdf

United Nations Department of Economic and Social Affairs, Population Division (2015). "World Population Prospects: The 2015 Revision, Methodology of the United Nations Population Estimates and Projections", Working Paper No. ESA/P/WP.242. Accessed at: https://esa.un.org/unpd/wpp/publications/Files/WPP2015_Methodology.pdf