Demographic analysis of the urban water supply and water supply and sanitation in Contemporary Brazil (1972 – 2002)[1]

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1. Introduction

The main goal of this paper is to use demographic tools to analyze the evolution of the urban and industrial Brazilian water and sewer networks according to demand and supply of services. Age, Period, Cohort (APC) models were used to show these perspectives, periods capturing the supply side and cohorts of the household heads capturing the demand side.

The investigation focus is on the last three decades of the twentieth century. A special emphasis is given to the 70's, since during this time the National Water Supply and Sanitation Plan (PLANASA - Plano Nacional de Saneamento) was introduced. The reduction of the water supply and sanitation deficit in a short period of time was PLANASA's main purpose. The analysis includes the most prosperous economic era of the country, as well as the times when the growth of the water supply and sanitation services was bearable. It investigates the demand and supply to the services considering two important demographic variables: age groups and cohorts of household heads. The study comprehends the periods between 1972 and 2002. We expect to observe improvements in these services during the first decade of PLANASA, as well as during the times of economic growth.

The information available in the Demographic Brazilian Census and in the National Household Sample Survey (PNAD) is extremely rich and is the great stimulus to this study. It is important to include demographic variables in the water supply sanitation analysis because of three main reasons. First, the effects of the water supply and sanitation variables on the household conditions are permanent and follow the cohorts; even so the younger cohorts are more related to the sanitary retrocession. Second, the household water supply networks and sewerage systems is closely linked to the household location, indicating the supply and sort of services available. Third, the sort of service available may be a good indication of the household head socioeconomic status. Studies of this nature are important for understanding the Brazilian water supply and sanitation services weakness and strengths, and for subsidizing politics to reach the universe of the coverage.

2. The Brazilian urban water supply and sanitation in demand and supply perspectives

The Brazilian industrialization and urbanization process was a preponderant element in the implementation of the national plan of water supply and sanitation. From the middle of the Twenty Century, an agrarian country, subordinated to the old international labor division was being industrialized and integrated for the new urban popular classes. The economy grew rapidly,

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culminating in the "economic miracle", from the end of 1960 decade to the first half of the 1970s. At that time, public policies like raising coverage of water supply and sanitation services were adopted as vehicle of the fast economic growth. This was determinant for the increase in the number of the cities and in the size of them (REZENDE & HELLER, 2002).

The increase of internal mobility designed the new demographic pattern, being responsible to speed up the growth of the bigger cities. The migratory chains from the Northeast toward the Southeast and from the countryside toward the urban areas were remarkable. The urbanization process raised the demand for essential services and pressured the social and physical environment. The demands related to the new urban problems disclosed a real dimension of water supply and sanitation lack in Brazil. Thus, a National Habitation Bank (BNH) was created, in 1965, to manage and to fund habitation and environment sanitation projects. The BNH Bank provided high resources for the PLANASA which raised coverage for water supply networks, from less than 50% to more than 70% of the total household number. Sewerage service coverage went from 20 to 40% (ALMEIDA, 1977; COSTA, 1994).

The 80’s marked the economic contraction, and brought stagnation and uncertainty for environment sanitation in the country, having reduced the rhythm of the coverage increase. The economic production fell, the unemployment raised, the real wages had lowered and the consumption was reduced. Regarding the environment sanitation, the 80´s began with concrete evidences of the positive results of the PLANASA, but the financial health of the Plan was threatened by stopping investments.

In 90´s, the problems associated to the absence of environment sanitation services acquired greater relevance in a social perspective, because of the habitation deficit and the related growth of slum quarters and the urban poor peripheries. In this scenario, the low-income population attendance was prioritized, mainly in great urban centers, where the problems were multiplied. The use of the appropriate technologies aiming to reduce costs and to improve efficiency had been distinguished. During the 90´s, the coverage for water supply networks services continued to grow in the same pace as in the 80´s. In 2002 it reached 90% of the Brazilian urban population. The greatest sewerage coverage rise was observed between 1992 and 1997. It increased from 47 to 60%. Although, some environment sanitation investments were retaken in 90´s, a strong and efficient policy, as the PLANASA, did not occurred again in Brazil (TUROLLA, 2002). It’s important to point out that, after the first decade of PLANASA, the national actions regarding urban water supply and sanitation were characterizing by advances and retrocession and fragmented policies (MPO/SEPURB/IPEA, 1995).

4. Age, period and cohort: conceptual aspects

The classical demographic events are associates to the transitions most important related to the life cycle. Such events are influenced by factors that are related to the age, period and cohort dimensions. Many social studies consider “age” an indispensable variable. Even though “age”, by itself, is not capable to explain the demographic processes, it is considered an important variable. It shows the event variation probability along the time; it indicates the aging process and has a longitudinal characteristic.

The age variable captures the life cycle effects related to biological, psychological, social and cultural process. The life cycle effects, associates to biological, psychological, social and cultural individual processes are associates to the age. Its analysis is based on the differences between the age groups, on a point of the time or throughout a cohort. Classical demographic events, such as death and migration are closely related to the age variable. The period effect captures the influence of contemporaries variables related to the ambient, social and economic conditions along the time, affecting all people. Its analysis involves diverse age groups or cohorts in a determined point of the time. The government forms, the economic fluctuations and the citizenship level of the society are elements that have great influence on the demographic variable in the period perspective. The period are associates the wars, scientific epidemics, behavior, legislative and politics changes and discoveries. These moments are responsible for the variation in demographic rates, not necessarily when they occur, but to long of the period dimension.

The cohort effects are conditioned by genetic changes, size, education, etc, in a historical perspective. Different cohorts are affected differently by socioeconomic and political-cultural conditions of the environment they incorporate a specific version of subsequent the social inheritance and relaying it new cohorts. The cohort analysis intents to quantify and to describe, to the long of the time, specific group behavior, inferring that the social transformations cause different impacts in people of different ages, being persistent the effect of these transformations (RYDER, 1965).

New youngest cohorts are more active in changing and introducing new behaviors. Since they are less influenced by historical aspects and more capable to adapt to new situations or life stile. Besides that individual histories, embebed in important cohort life experiences are continuous and their effects are unending when changes occurs, a comparison of the transformations experienced by both the cohorts, which are involved in the process, and those which are not, can be very useful for the analysis of the new social behaviors (RYDER, 1965).

The APC analysis seems simple and relatively direct. However, it has a basic problem involving the three dimensions: linear dependence relation between them because of that, it is only possible to identify two of the three effects. For overcoming this problem researchers have considered different solutions. Some of methodologies are used in studies about education, labor market, health and crime. They proved the validity and the utility of the APC analysis (WILMOTH, 1998, FIENBERG & MASON, 1985, HALLI & RAO, 1992).

Usually, attempts to identify the problem are based in additional hypotheses, which make possible to breakout each effect. Three main strategies have been proposed as a solution for this problem: direct measures, interaction and translation terms and arbitrary assumptions.

A first approach consists of recognizing that cohort, period and age "are measured of our ignorance" and can be substituted by direct measures as proxies of these dimensions. The macroeconomic variables are direct measured of period; the cohort size and attainment educational are proxies for cohort and incomes, as proxies for age (FIENBERG & MASON, 1985). The age as an aging indicator is a variable difficult to substitute. The aging tends is the most difficult substitution variable.

A second approach to the identification problem focuses the regression in two phases. A first regression is carried through with only two of the three parameters, and one-second regression involves the residues of the first one with the third parameter. HALLI & RAO (1992) suggest a model linear of squared minimums, where the dependent variable is a logit transformation. The main effect models are gotten with the adjustment of the dummy variables of each one of the effect - A, P, C - followed by the models of first-class interaction - AP, AC e PC. The age and period coefficients in the AP model and the cohort coefficients are gotten from a regression having involved the residues of the AP model. From the complete model age-period-cohort is esteem the determination coefficient R2 of the interaction between effects.

A third alternative is based on the development of arbitrary assumptions about the linear trend of one of the three dimensions. The arbitrary assumptions are made from qualitative analyses about the three dimensions with respect to any dependent variable. FIENBERG & MASON (1985), WILMOTH (1990), HALLI & RAO (1992) AND RIOS-NETO & OLIVEIRA (1999) use this strategy to skirt the identification problem. A particular solution of this nature is the omission of one of the dimensions, admitting the existence of only two dimensions. It is evident that such assumption must be justified with arguments that do not represent only a convenient strategy to interpret a statistical model.

In the United States, MASON & FIENBERG (1979) use the APC models in educational analysis. In their application, the dependent variable is constituted by the proportions of individuals who are 20 years old and older, who earlier in life had moved to one educational level to another. The authors observed that the benefits from years of schooling, in general, increase slightly for a cohort of adult or were constant. The age effects showed a little importance in this model, so, they were kept fixed for some series of age.

5. Methodology

5.1 Material

The urban water supply and sanitation analysis is done by using the 1970 Brazilian Demographic Census and the 1977, 1982, 1987, 1992, 1997 and 2002 National Household Survey. The emphasis is given to the age, period and cohort dimensions. The water supply and sanitation variables analyzed are those that indicate the existence of typical services in the urban household. The purpose is to evaluate the urban water supply networks and sewerage stressing the role of the public supply of services.

Six age groups (30-34 through 55-59 years old), six period-calendars (1977, 1982, 1987, 1992, 1997 and 2002) and nine cohorts of household heads - C2 to C10 are examined. The period and age groups form these nine cohorts. Cohort 2 (C2) is the oldest one, as shown in the contingency table below.

Period / Age		1977 *P6*	1982 *P5*	1987 *P4*	1992 *P3*	1997 *P2*	2002 *P1*
30-34	*A6*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*
35-39	*A5*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*
40-44	*A4*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*
45-49	*A3*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*
50-54	*A2*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*
55-59	*A1*	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*

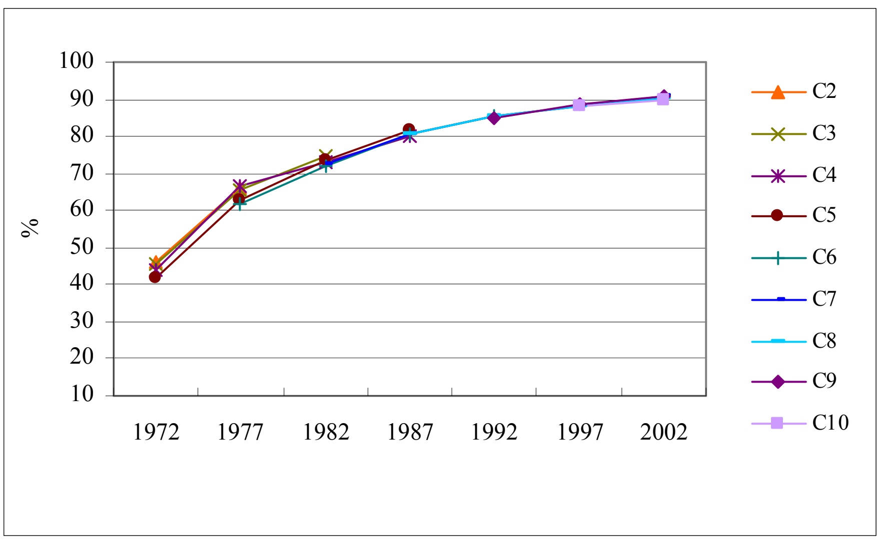
5.2 Age, period and cohort effects in the urban water supply and sanitation

PALMORE (1978) indicates the existence of three levels of analysis: the longitudinal, the transversal or "cross-section", and the secular or "time-lag". The longitudinal differences involve one cohort along the time. In this analysis, the cohort effect is fixed and the age and the period effects are variable. In the transversal analysis different ages are investigated in a fixed point in the time. The period is fixed, while the age and cohort varies. The "time-lag" approach involves different cohorts in a moment when they had a same age. Age is fixed, but period and cohort vary.

The longitudinal and cross-section differences give the age effect. The cohort effect comes from the cross-section and of time-lag differences, and the period effect comes from the longitudinal and of time-lag differences. PALMORE (1978) believes that age, period and cohort are only abstractions and therefore they cannot be directly observed, but they allow the development of a more complex statistical study.

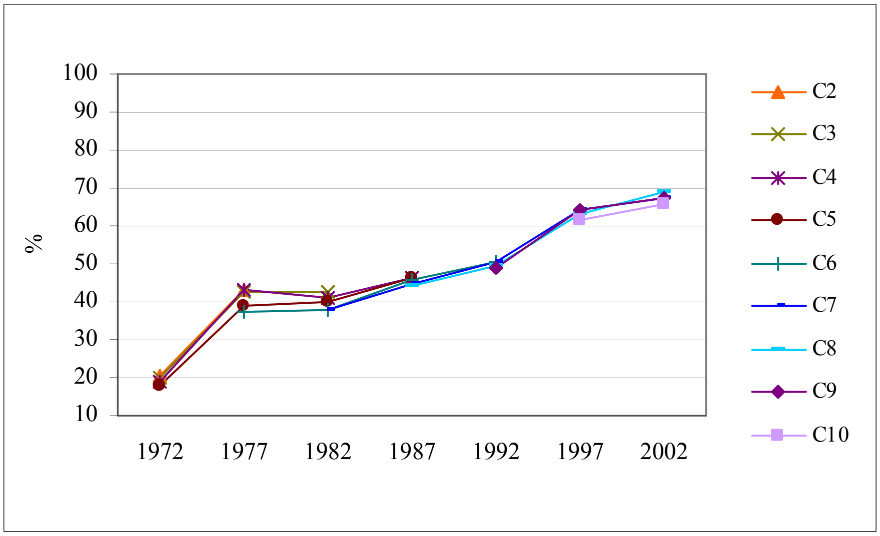
The Graphs 1 and 2 shows the evolution of the water supply networks and sewerage system coverage along of household head cohorts in Urban Brazil, between 1972 and 2002. The coverage for water supply networks increased from 50% to more than 70% during the PLANASA era. Besides that, the sewerage service enhanced its coverage from 20 to 40%. The 80’s were characterized by the economic constriction, reducing the rhythm of the coverage increase. During the 90´s, the coverage for water supply networks continued to grow at the same pace as it did during the 80´s. In 2002 it reached 90% of the Brazilian urban population. The greatest sewerage coverage rise was observed between 1992 and 1997. It increased from 47 to 60%.

Graph 1 - Urban Brazil, 1972 through 2002 – water supply networks coverage according to household cohorts (%)



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002.

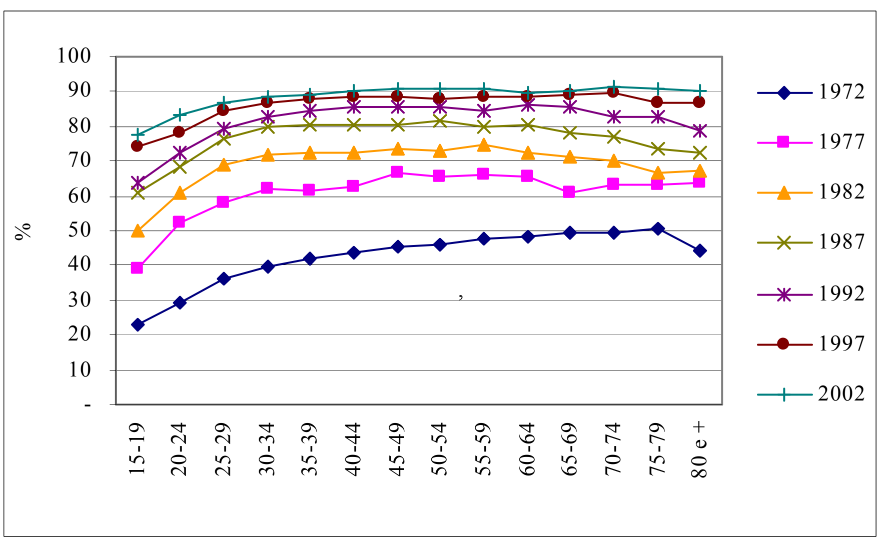
Graph 2: Urban Brazil, 1972 through 2002 – sewerage system coverage according to household cohorts (%)



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002.

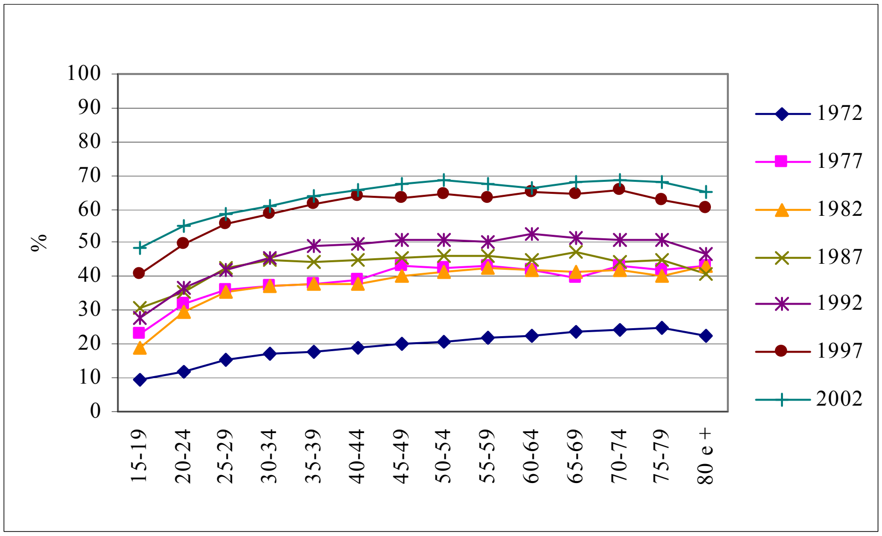
The age variable, or the effect of life cycle, captures the biological, psychological, social and cultural individual processes. The household heads characteristics, according to their age groups, consist in the study of the differences among the age groups, in one point of the time or throughout one cohort. The household head economic and social upward mobility is linked to the age, as it is show in Graphs 3 and 4. In these Graphs it is possible to observe that there is a positive association between the household head age group and the water supply networks and sewage services. This scenario can be observed until the 30-34 age group. After that, the coverage water supply networks and sewerage proportions become approximately constant, phenomenon clearly noticed in the recent years.

Graph 3 - Urban Brazil, 1972 through 2002 – water supply networks coverage according to household head age groups (%)



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

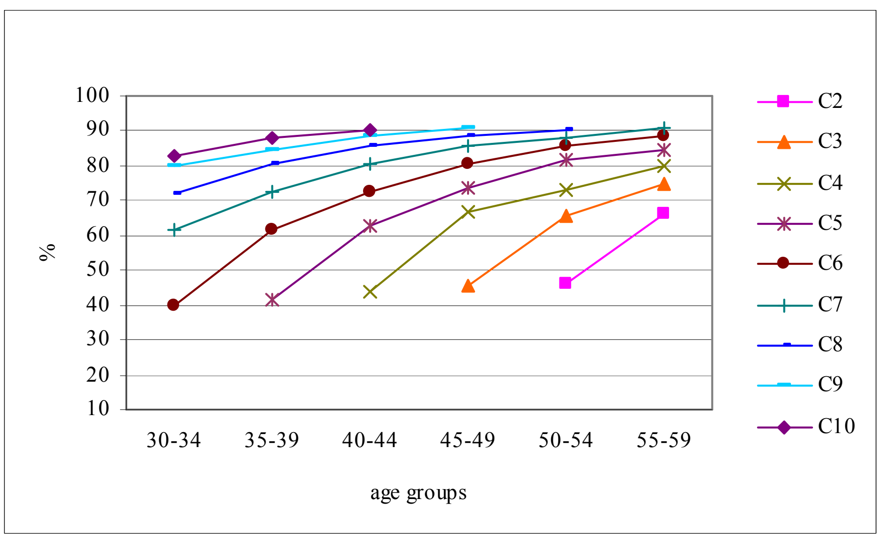
Graph 4: Urban Brazil, 1972 through 2002 – sewerage system coverage according to household head age groups (%)



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

The cohort effects are also important in the water supply networks and sewerage variables distribution analysis in the urban Brazil because different cohorts experienced distinct socioeconomic, political and cultural scenarios during the country's urbanization process. The Graphs 5 and 6 shows the water supply networks and sewerage coverage according to age central groups of household heads of the cohorts C1 to C11.

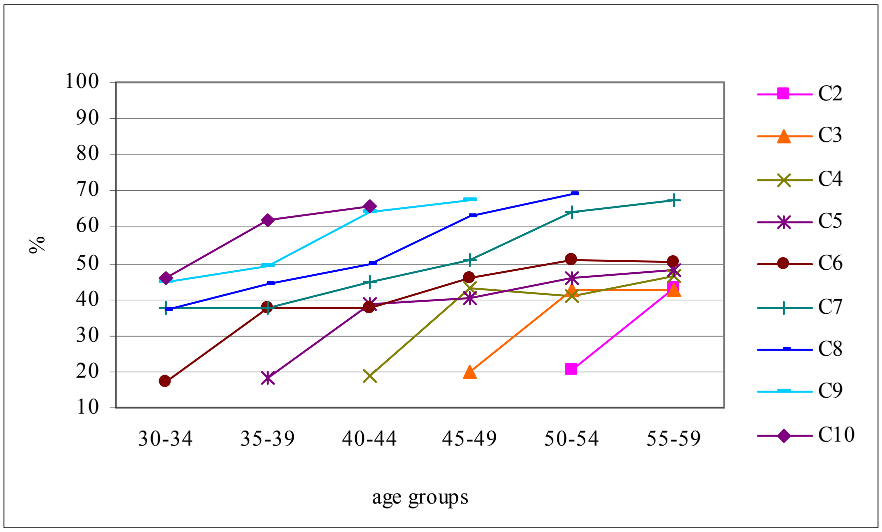
Graph 5: Urban Brazil, 1972 through 2002 – water supply system coverage according to age groups of the household heads cohorts (%)



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

During the first decade of PLANASA the existents cohorts experienced a great increase in the access to the water supply and sanitation services. The post-70's cohorts had been also benefited from the program; since the increase in the water supply networks and sewerage coverage was significant. In the 80´s, the improvement verified in water supply networks and sewerage coverage observed earlier decreased. In the 90's it increased again, specially the sewage collection. The notable growth in the water supply networks coverage, and in a lesser extension, in the sewerage systems during the 70's was considered the great responsible for the scenario presented in the next decade.

Graph 6: Urban Brazil, 1972 through 2002 – sewerage system coverage according to age groups of the household heads cohorts (%)



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

The greatest increase in the water supply networks and sewerage are observed in the cohorts that already existed in the 70´s (C2 the C6). But, the youngest cohorts (C7 to C11) presented the greatest growth. The sewage collection coverage presents two moments of incomparable growth: for those cohorts formed in the 70´s (C2 to C6) and those formed during 80´s, since between 1992 and 1997 a significant growth in the coverage was verified.

6. The model's choice

The descriptive analysis in section 5.2, showing the distribution of the water supply networks and sewerage variables by period, by the age groups and cohorts, reveals that age and cohort effects are apparently less important than the period effect. The Graphs 3 and 4 display the smaller age effect in the evolution of the water supply networks and sewerage actions. It is observed for the 35-39 through 55-59 years old age groups. Because of that binomial logistic regression analysis is done, considering only the cohort and period effects. The presence or absence of the urban water supply networks and sewerage characterizes the analysis. In these variables discrete distribution of probability models is recommendable, and the dependent variable (water and sewer) is associated to the household's characteristics and to their respective heads (HOSMER & LEMESHOW, 1989). In this case, the identification problem had a direct solution, because where the coverage variation for water supply networks and sewerage were reduced, only the central age groups were observed (30-34 the 55-59 years). This procedure also avoids one to consider those ages where there is a greater propensity of transitions and new entrances of household heads.

The age-period-cohort model is represented as follow:

$F(r_{ijk}) = \mu + \alpha_i + \beta_j + \theta_k + \varepsilon_{ijk}$.

In this formula, r_{ijk} represents a demographic rate observed for occurred events in a given age i, in year j, to the cohort k (k=i-j); The function F(.) is some transformation applied to observed rates; μ establishes the global level to the $F(r_{ijk})$; the parameters α_i, β_j and θ_k describe changes in $f(r_{ijk})$ by age, period e cohort. The final term, ε_{ijk} represents the error that can be associated to model specifications.

The logistic regression models aim to determine the pure effects from period and cohort the in water supply networks and sewerage situations, and can be described as: $ln\ P / (1-P) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$;

Ln P/(1-P) – presence or absence of water supply networks and sewerage systems;

X_1 – Period: 1- 1977 2- 1982 3- 1987 4- 1992 5- 1997 6-2002

X_2 – Cohort: C2 a C10, as contingency table in Section 5.1 shows.

X_3 – Schooling

Ten regression models had been analyzed. Five of them considered the water supply networks presence and five to the sewerage presence. The independent variables for water and sewage models are (1) age, (2) period, (3) cohort, (4) age, period, cohort (5) period, cohort, schooling and cohort x schooling. All the models had presented significant coefficients, with sufficiently easy and direct interpretations.

Table 1 shows the coefficients resulting from these models. They represent the water supply networks and sewerage odds ratio during the years included in the analysis and for those cohorts of interest considering both a year and a cohort of reference.

7. Discussion

The categories water supply networks and sewerage services are jointly analyzed, although to have been analyzed in separate regressions (see Table 1).

1a and 1b models - age: in this model a small variation is noticed in the coverage odds ratio, along of the age groups. However, the household head chance to have water supply networks and sewerage increases lightly with your age. The estimate coefficients for age effect are very next to the reference value, represented by younger age group (30-34), and its interpretation is a little meaningless (see Table 1).

2a and 2b models - period: the changeable period has a strong positive correlation with the coverage increase for water supply networks and sewerage services. Table 1 shows that the household heads chance to have water supply networks is ten times bigger, in 2002, relatively the 1977. To presence of sewerage service, the chance is four times bigger in 2002, comparatively the 1977. It’s evident that the chance of water supply networks access was superior to the sewerage access.

3a and 3b models - cohort: this analysis shows a more favorable sanitary situation for younger cohorts (see Table 1). However, it has certainly a strong influence of the period dimension on cohort and the two models present similarities.

4a and 4b models - age, period and cohort: This analysis aims at to catch the pure effect of the three dimensions. To eliminate the linear dependence problem between the three variables, it was consider the two older cohorts (C2 and C3) are the same, or in other words, cohort C2 disappears and it is assimilated by cohort C3. As a consequence the variable cohort is formed by 8 cohorts of household heads: C3 the C10.

It is observed that the possibility of the household to have water supply networks diminishes slightly with the age of the household head. For the sewerage this chance is practically the same in all age groups (Graph 7). The period effect is increasing along the time: the chance of a household to have water supply network, in 2002, is 15 times greater than in 1977; the chance of a household to have sewerage, in 2002, is 6 times greater than in 1977 (Graph 8). Again the difference is evident between water supply networks and sewerage services coverage.

The cohort effect shows an opposite trend to those presented by models 3a and 3b. The coverage chances decrease to younger cohorts (Graph 9). Thus, household cohorts formed, or in formation, during the70's, represented by C2 through C7, have the largest chances of accessing to the water supply networks and sewerage systems. The reduction of water supply networks coverage declines from 75% to 50% for Cohorts C2 through C5 and it is observed a decline of 65% to 40% in the sewerage coverage for these same cohorts. From cohort C5 until cohort C7 this coverage is stabilized. A new reduction in the coverage odds is observed from cohort C7 through C10, strengthening the hypothesis that 70's cohorts, benefited for the ample investments made in the scope of PLANASA.

Adjustment Statisticians

Comparing the log-likelihood had shown that the coefficients of the explicative variables not vanish, or either, all variables presents in the model are representatives. The association between the predicted probabilities and the observed answers varies of 0,159 (Tau-a statistics) until 0,706 (c statistics), for the presence of water supply networks and of 0,138 (Tau-a statistics) until 0,640 (statistics c), for the sewerage presence in household. The measures vary between 0 and 1, with large values corresponding to stronger association between the predicted and observed values. These results show that the APC models prediction for the water supply and sanitation is more changeable. This fact is due to not incorporation of the space dimension in the models.

Following analysis of the variance in APC models are observed low tolerance and high inflation of variance. This fact reveals the multicolinearity presence between the three variables, what it intervenes with the stability of the esteem coefficients in the models.

Considering that the age effects are responsible only for a small variation in the water supply networks and sewerage coverage in central age groups (30-34 until 60-64 years), it is assumed that the period and cohort dimensions are the most predictive of the demand and supply for water networks and sewerage in urban Brazil. In this in case, the solution for the identification problem was direct, assuming it existence of only two identifiable dimensions.

Table 1 – Urban Brazil, 1977 trough 2002: odds ratio of the water supply networks and sewerage presence

Models	Water supply			Sewerage		
1 - Age	**B**	**Sig.**	**Exp(B)**	**B**	**Sig.**	**Exp(B)**
30-34	0,000		1,000	0,000		1,000
35-39	0,085	0,000	1,089	0,099	0,000	1,105
40-44	0,134	0,000	1,143	0,163	0,000	1,178
45-49	0,148	0,000	1,160	0,203	0,000	1,225
50-54	0,139	0,000	1,149	0,227	0,000	1,255
55-59	0,133	0,000	1,142	0,207	0,000	1,230
60-64	0,144	0,000	1,155	0,233	0,000	1,263
Constant	1,257	0,000	3,516	-0,091	0,000	0,913
2 - Period	**B**	**Sig.**	**Exp(B)**	**B**	**Sig.**	**Exp(B)**
1977	0,000		1,000	0,000		1,000
1982	1,156	0,000	3,178	0,484	0,000	1,622
1987	1,587	0,000	4,889	0,729	0,000	2,072
1992	1,899	0,000	6,676	0,895	0,000	2,447
1997	2,199	0,000	9,013	1,442	0,000	4,230
2002	2,353	0,000	10,514	1,564	0,000	4,777
Constant	-0,172	0,000	0,842	-0,920	0,000	0,398
3- Cohort	**B**	**Sig.**	**Exp(B)**	**B**	**Sig.**	**Exp(B)**
C2 (older)	0,000		1,000	0,000		1,000
C3	0,779	0,000	2,180	0,370	0,000	1,448
C4	0,991	0,000	2,695	0,461	0,000	1,586
C5	1,178	0,000	3,247	0,633	0,000	1,884
C6	1,386	0,000	3,997	0,817	0,000	2,263
C7	1,832	0,000	6,246	1,009	0,000	2,743
C8	2,022	0,000	7,552	1,148	0,000	3,151
C9	2,103	0,000	8,188	1,210	0,000	3,352
C10 (younger)	2,172	0,000	8,779	1,319	0,000	3,741
Constant	-0,160	0,000	0,852	-0,853	0,000	0,426
4 - APC	**B**	**Sig.**	**Exp(B)**	**B**	**Sig.**	**Exp(B)**
30-34	0,000		1,000	0,000		1,000
35-39	0,187	0,000	1,205	0,014	0,000	1,014
40-44	0,173	0,000	1,189	0,015	0,000	1,015
45-49	0,151	0,000	1,163	0,024	0,000	1,024
50-54	0,129	0,000	1,137	0,033	0,000	1,033
55-59	0,073	0,000	1,076	-0,021	0,052	0,980
1977	0,000		1,000	0,000		1,000
1982	1,212	0,000	3,361	0,519	0,000	1,680
1987	1,697	0,000	5,457	0,805	0,000	2,236
1992	2,061	0,000	7,851	0,996	0,000	2,707
1997	2,434	0,000	11,409	1,592	0,000	4,912
2002	2,674	0,000	14,491	1,774	0,000	5,896
C2 (older)	0,556	0,000	1,743	0,409	0,000	1,506
C3	0,506	0,000	1,659	0,357	0,000	1,429
C4	0,435	0,000	1,545	0,312	0,000	1,366
C5	0,420	0,000	1,522	0,302	0,000	1,353
C6	0,371	0,000	1,449	0,285	0,000	1,329
C7	0,322	0,000	1,380	0,279	0,000	1,322
C8	0,208	0,000	1,231	0,185	0,000	1,203
C9 (younger)	0,000		1,000	0,000		1,000

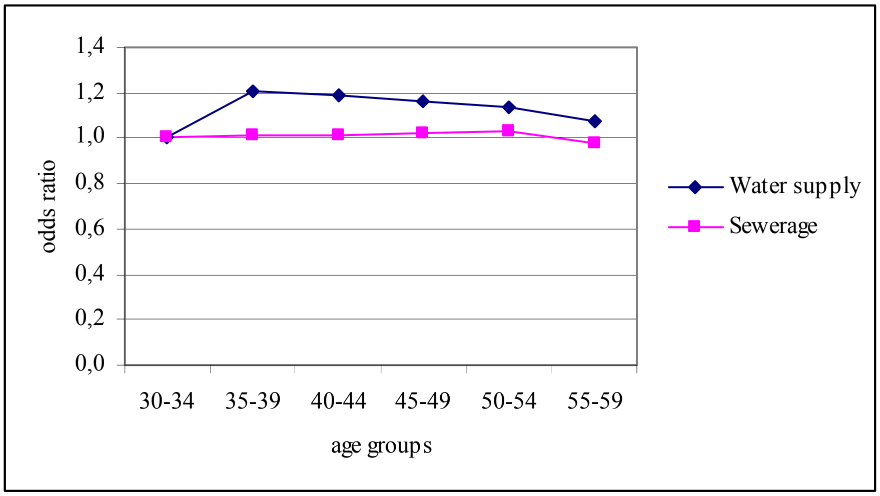
Basic data source: IBGE - PNAD 1972, 1977, 1982, 1987, 1992, 1997, 2002.

Table 1 - Urban Brazil, 1977 trough 2002: odds ratio of the water supply networks and sewerage presence (continuation)

Models (continuation)	Water supply			Sewerage		
5 - Period, cohort, schooling, (cohort*shcooling)	**B**	**Sig.**	**Exp(B)**	**B**	**Sig.**	**Exp(B)**
1977	0,000		1,000	0,000		1,000
1982	0,180	< ,0001	1,197	0,014	< ,0001	1,014
1987	0,262	< ,0001	1,300	0,061	< ,0001	1,063
1992	0,336	< ,0001	1,400	0,131	< ,0001	1,140
1997	0,377	< ,0001	1,458	0,293	< ,0001	1,340
2002	0,386	< ,0001	1,472	0,321	< ,0001	1,378
C2 (older)	0,422	< ,0001	1,525	0,448	< ,0001	1,565
C3	0,354	< ,0001	1,424	0,410	< ,0001	1,506
C4	0,321	< ,0001	1,379	0,354	< ,0001	1,424
C5	0,288	< ,0001	1,334	0,324	< ,0001	1,383
C6	0,249	< ,0001	1,283	0,280	< ,0001	1,324
C7	0,206	< ,0001	1,229	0,229	< ,0001	1,258
C8	0,188	< ,0001	1,207	0,189	< ,0001	1,209
C9	0,113	< ,0001	1,120	0,136	< ,0001	1,146
C10 (younger)	0,000		1,000	0,000		1,000
<= 1 year	0,000		1,000	0,000		1,000
2-3	0,087	< ,0001	1,091	0,096	< ,0001	1,101
4-7	0,165	< ,0001	1,179	0,200	< ,0001	1,222
>= 8 years	0,234	< ,0001	1,263	0,370	< ,0001	1,448
School(1) x C(2)	0,158	< ,0001	1,171	0,068	< ,0001	1,070
School(1) x C(3)	0,144	< ,0001	1,155	0,051	< ,0001	1,052
School(1) x C(4)	0,133	< ,0001	1,142	0,032	< ,0001	1,033
School(1) x C(5)	0,119	< ,0001	1,127	0,022	< ,0001	1,022
School(1) x C(6)	0,101	< ,0001	1,106	0,016	< ,0001	1,016
School(1) x C(7)	0,073	< ,0001	1,076	0,021	< ,0001	1,021
School(1) x C(8)	0,058	< ,0001	1,060	0,003	0,0320	1,003
School(1) x C(9)	0,036	< ,0001	1,037	0,019	0,2700	1,019
School(1) x C(10)	0,000		1,000	0,000		1,000
School(2) x C(2)	0,363	< ,0001	1,437	0,186	< ,0001	1,205
School(2) x C(3)	0,315	< ,0001	1,371	0,137	< ,0001	1,147
School(2) x C(4)	0,262	< ,0001	1,299	0,101	< ,0001	1,106
School(2) x C(5)	0,239	< ,0001	1,270	0,088	< ,0001	1,092
School(2) x C(6)	0,210	< ,0001	1,233	0,082	< ,0001	1,085
School(2) x C(7)	0,178	< ,0001	1,194	0,059	< ,0001	1,060
School(2) x C(8)	0,155	< ,0001	1,168	0,045	0,044	1,046
School(2) x C(9)	0,088	< ,0001	1,093	0,031	0,310	1,031
School(2) x C(10)	0,000		1,000	0,000		1,000
School(3) x C(2)	0,462	< ,0001	1,588	0,298	< ,0001	1,347
School(3) x C(3)	0,392	< ,0001	1,480	0,252	< ,0001	1,286
School(3) x C(4)	0,347	< ,0001	1,415	0,192	< ,0001	1,211
School(3) x C(5)	0,329	< ,0001	1,389	0,172	< ,0001	1,188
School(3) x C(6)	0,291	< ,0001	1,338	0,145	< ,0001	1,156
School(3) x C(7)	0,253	< ,0001	1,288	0,113	0,0005	1,120
School(3) x C(8)	0,247	< ,0001	1,280	0,084	0,142	1,087
School(3) x C(9)	0,135	0,017	1,144	0,043	0,250	1,044
School(3) x C(10)	0,000		1,000	0,000		1,000

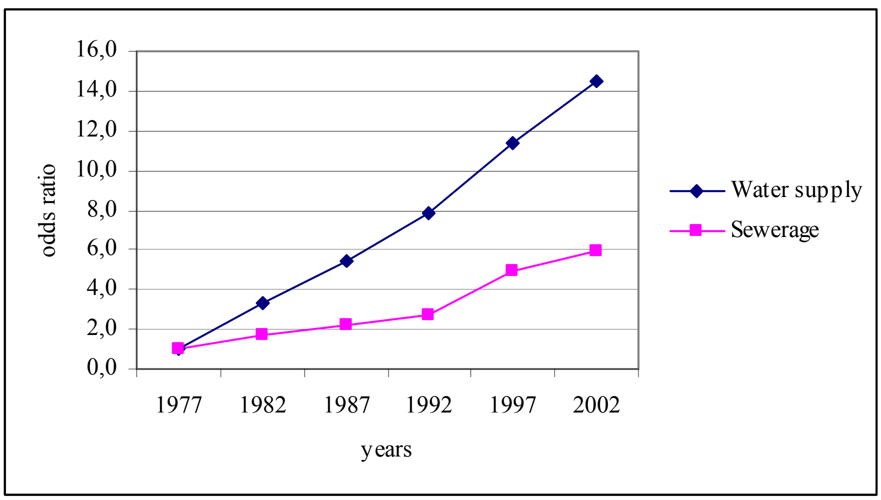
Basic data source: IBGE - PNAD 1972, 1977, 1982, 1987, 1992, 1997, 2002.

Graph 7 - Urban Brazil, 1977 the 2002
Age, Period and Cohort models: odds ratio of water supply networks and sewerage coverage according to groups of age



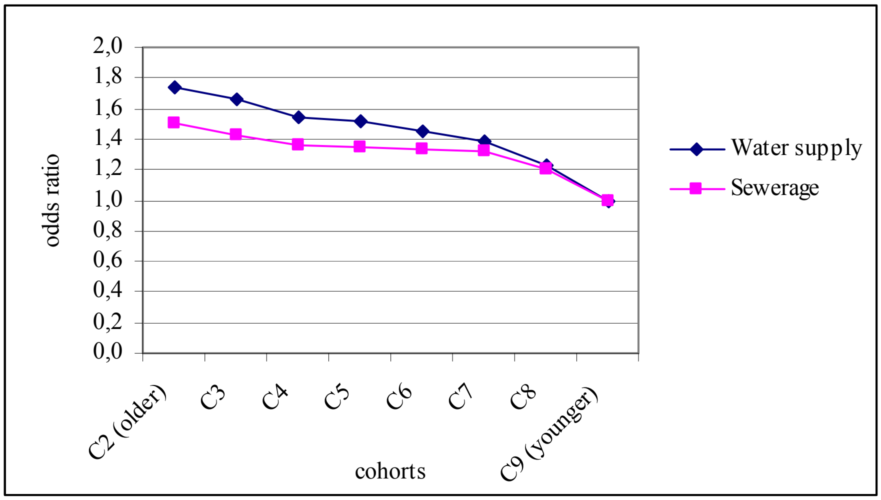
Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

Graph 8 - Urban Brazil, 1977 the 2002
Age, period and cohort models: odds ratio of water supply networks and sewerage coverage according to period



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

Graph 9 - Urban Brazil, 1977 the 2002
Age, period and cohort models: odds ratio of water supply networks and sewerage coverage according to cohorts



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

5a and 5b model: period, cohort, schooling and interaction between cohort and schooling:

In present model, the odds ratio curve by water networks coverage has derived first positive and derived second negative, release that despite the growth in the coverage during all the period, the growth rates comes falling with the time. The largest growth in the coverage odds of the water supply network presence is verified between 1977 and 1982, around 20%. After this period, the rhythm of the growth is reduced, reaching an increase around 2% in the last interval of time (1997-2002).

The chance of a household have water supply network, in 2002, is 50% greater than in1977. This view represents the water supply networks evolution in the Brazilian urban household and show that the first decade of the PLANASA was the period of the most concentration in efforts to extend these systems. After the 70's, the water supply systems had been capable to assimilate the magnifying of the networks. Moreover, some new water supply networks were implanted, but in lesser number relatively to the 70's.

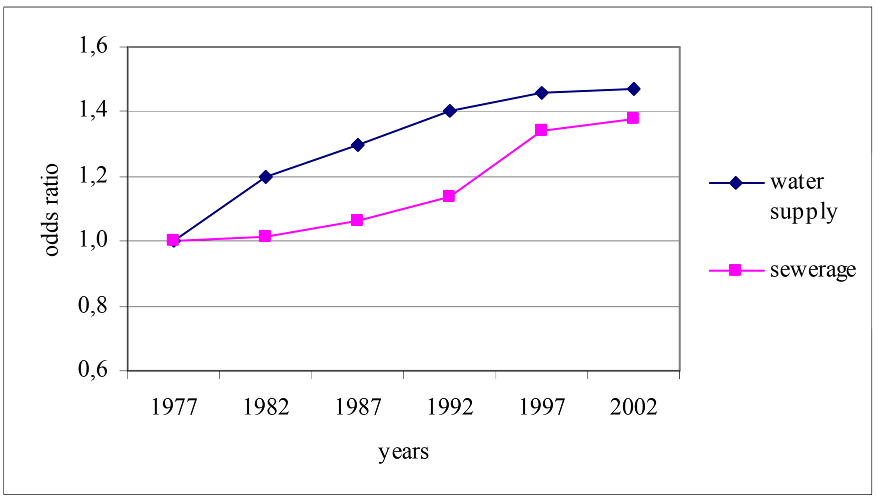
The chance of the water supply networks presence of sanitary exhaustion in the households increases until the year of 1997, as well as its growth rates. In other words, the derived first and second of the function are positive. Thus, the growth rhythm is bigger in the last considered interval (1992-1997), period and that a growth of 30% in the odds is observed to have sewerage. This chance is 40% greater in 2002 relatively the1977.

The older cohort (C2) has odds 50% greater relatively to the reference category (younger), for the water supply network, and 40% greater for the sewerage presence. The differentials between the odds ratios curves of water and sewer networks presence are reduced and practically inexistent from cohort C7.

According to educational level, it is possible to observe that those with highest educational level present a chance 45% greater to have access to the sewerage than those with lower educational level, and a chance 27% greater to have access to the water supply network. When the sewerage supply exists in the household it is possible to observe a positive growth in the odds to have a service as well as a positive growth in the rates. For the water supply network , the coverage odds increases linearly along to the schooling categories.

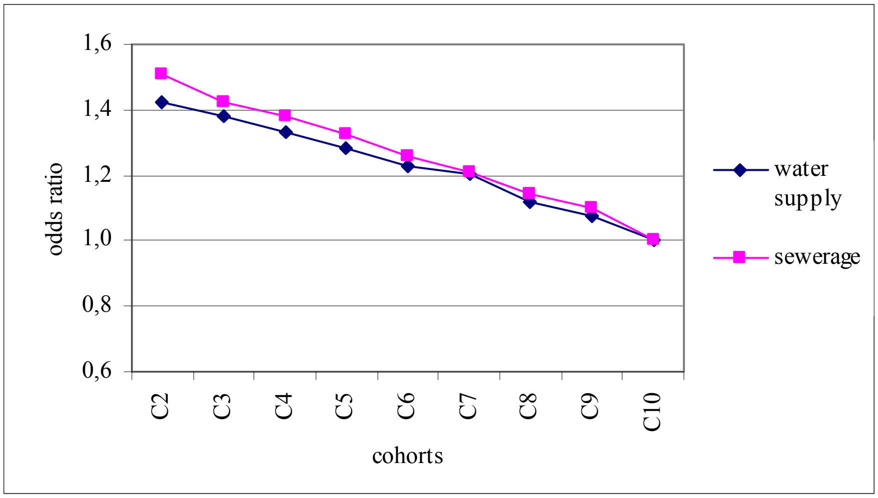
The interaction between cohorts and schooling shows that the coverage odds for water and sewer networks are greater for older cohorts, whose household heads have more than 8 years of schooling. However, the differentials between the schooling categories are similar. A reduction in the odds differentials of water supply network and sewerage in household is observed from cohort C7 through C10. The C2 household head that has more than 8 years of schooling has a 50% more chances to have water supply network, in comparison to a C10 household head that has until one year of study. A household head who belongs to C2 and has high educational level presents 30% more chance to have sewerage in comparison to a household commanded for a younger cohort member (C10), with low schooling.

Graph 10- Urban Brazil, 1977 through 2002
Period, cohort, schooling and cohort x schooling models – odds ratio of water supply network and sewerage systems coverage according to period



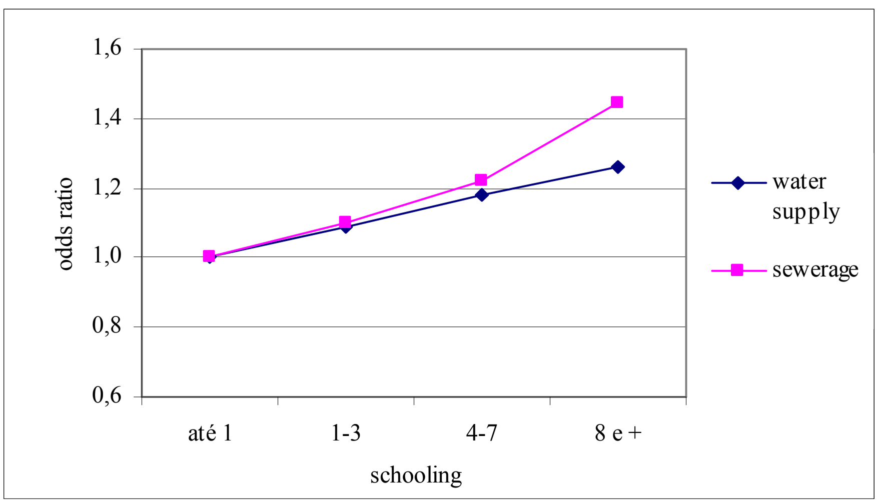
Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

Graph 11 - Urban Brazil, 1977 through 2002
Period, cohort, schooling and cohort x schooling models – odds ratio of water supply network and sewerage systems coverage according to cohort



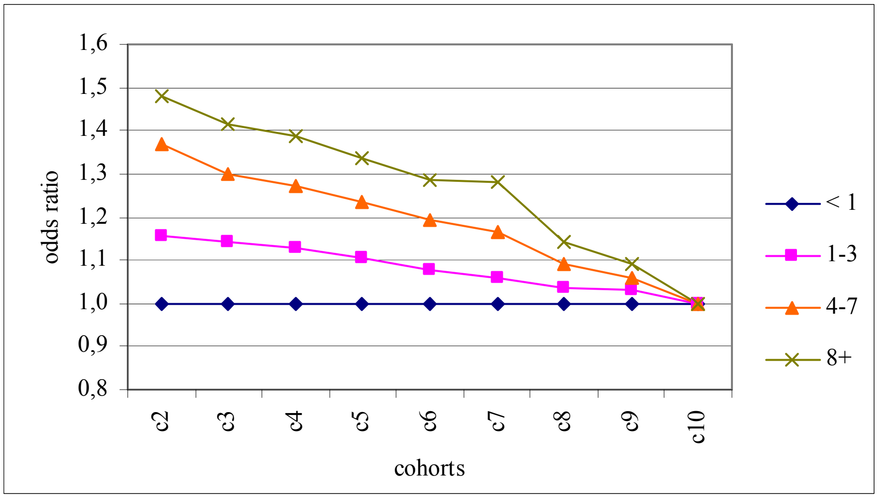
Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

Graph 12 - Urban Brazil, 1977 through 2002
Period, cohort, schooling and cohort x schooling models – odds ratio of water supply network and sewerage systems coverage according to schooling



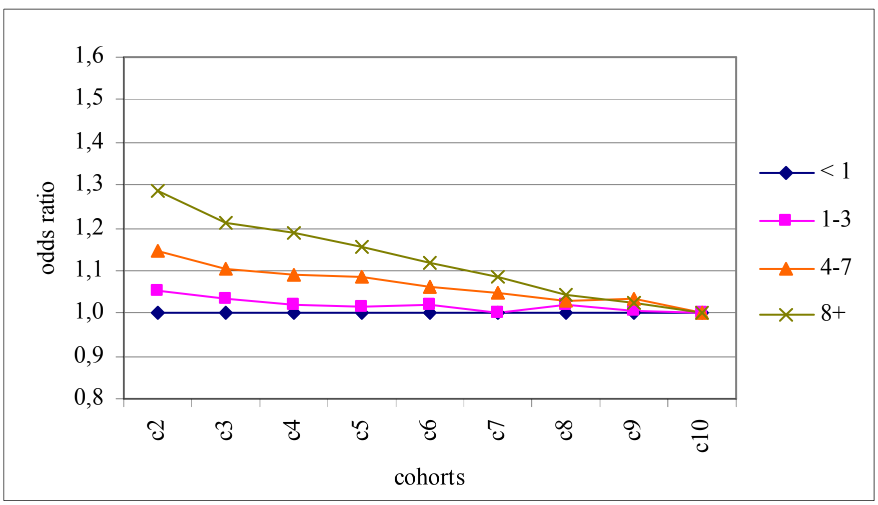
Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

Graph 13 - Urban Brazil, 1977 through 2002
Period, cohort, schooling and cohort x schooling models – odds ratio of water supply network coverage for cohorts according to schooling



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

Graph 14 - Urban Brazil, 1977 through 2002
Period, cohort, schooling and cohort x schooling models – odds ratio of sewerage system coverage for cohorts according to schooling



Basic data source: IBG-PNADs 1977, 1982, 1987, 1992, 1997 e 2002

8. Policy implications

This study brings a new approach to the water supply and sanitation analysis in Brazil. It gives emphasis to analysis of cohort household heads. The study reveals that older cohorts have greater chances for accessing water supply networks and sewerage services, and despite the notable growth in the sanitary coverage, younger cohorts are likely to face an exclusion from the services. These results show the importance of the attention of the new domiciles formed after the PLANASA. The dimension period, traditionally incorporated in the water supply and sanitation analysis, is important for understanding the development of these actions. However, this analysis can immediately be affected by the stock of households incorporated by original projects of water supply networks and sewerage, during the golden time of the PLANASA.

The period-cohort water supply networks and sewerage attendance analysis confirm the importance of the continuity in environmental sanitation policies, due to strong arguments. First, the coverage of water and sewer networks for older cohorts is greater, since they took more advantage from PLANASA. On the other side, younger cohorts have a more active role in the social change process and, therefore, they are most inclined to the sanitary retrocession. Moreover, the agricultural-urban migrations in the analyzed period have contributed for the growth of the cities in urban infrastructure absence, and the younger cohorts were the most likely group to face this risk. These arguments corroborate with the results: younger cohorts reflects the stagnation of the water supply networks and sewerage actions in the period that succeeds the PLANASA.

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