

Migration and the population structure of the Metropolitan Region of Belo Horizonte in 1991-2010

Migração e estrutura populacional da Região Metropolitana de Belo Horizonte em 1991-2010

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Abstract

This article analyzes the effects of migration on population structure (by sex and age) in the Metropolitan Region of Belo Horizonte between 1991 and 2010. Migrations in the region's municipalities were estimated using information from the 2000 and 2010 Population Censuses. The population structures in 1991, 2000, 2010, and 2022 were represented and analyzed in light of the migrations that occurred in the period, and a brief explanation was given concerning what the data currently available from the 2022 Population Census suggest. The results obtained indicate a reduction in migration intensity in the region between the 1990s and 2000s and direct relationships between net migrations and the age structure and rate of aging of the metropolitan population.

Keywords: Metropolitan Region of Belo Horizonte; migration; population structure; population aging.

Resumo

Este artigo analisa as implicações das migrações sobre a estrutura populacional – de sexos e etária – na Região Metropolitana de Belo Horizonte entre 1991 e 2010. Mediante a utilização de informações dos Censos Demográficos de 2000 e de 2010, estimaram-se as migrações dos municípios da região. Foram representadas e analisadas as estruturas populacionais em 1991, 2000, 2010 e 2022, ante as migrações ocorridas no período, e feita uma breve explanação sobre o que sugerem os dados ora disponíveis do Censo Demográfico de 2022. Os resultados obtidos indicam a redução da intensidade migratória na região entre as décadas de 1990 e 2000 e relações diretas entre as migrações líquidas e a estrutura etária e o ritmo de envelhecimento da população metropolitana.

Palavras-chave: Região Metropolitana de Belo Horizonte; migração; estrutura populacional; envelhecimento populacional.



This study investigated the role of migration in the population structures by sex and age – and their changes amid the advance of DT and changes in spatial mobility – of the MRBH in the 1990s and 2000s. Furthermore, it also assessed possible trends that the results of the 2022 Demographic Census suggest for the population composition of the region.

This article was guided by two hypotheses, supported by the research¹ from which this study is derived. The first is that migration has the power to alter and impact populations, both at the origin and destination, which is fundamental to the dynamics of other demographic components (Vignoli, 2004; Vignoli, 2013). After all, by impacting the sex and age composition of populations, migration influences a variety of factors such as birth rates through female age groups in the reproductive years; the size of young, working-age, and, to a lesser extent, elderly populations; population rejuvenation or ageing, etc. (Wong and Carvalho, 2006; Skeldon, 2021). The other hypothesis is that spatial mobility plays an increasingly greater role in population dynamics – even as a protagonist –, considering the context of the final phase of the DT, in which Natural Increase (NI) is increasingly lower due to the continuous decline in fertility.

Following this introduction, there is a brief explanation of migratory selectivity and its implications. Next, concepts, data used and processing methods, and key indicators are discussed. Subsequently, we discuss results concerning migration and population structures of the Metropolitan Region of Belo Horizonte (MRBH) and groups formed by its municipalities, based on the net migration rates estimated from the 2010 Demographic Census. We then provide evidence based on the available results from the 2022 Demographic Census. Lastly, we conclude this article with our final considerations.

Migration: selectivity and implications

Along with fertility and mortality, migration is an essential component of any population's dynamics. After all, migration affects population growth, population structure – mainly by sex and age – and population characteristics, influencing the dynamics of other demographic components (Vignoli, 2013). Therefore, the occurrence of numerous demographic events reveals the mutual nature of the three components, as well as some common features and differences between them. In this sense, migration is perhaps the component that most distinguishes itself in relation to others. While, for an individual, birth and death are unique events, migration may occur multiple times or might not even happen at all. Furthermore, it is the only demographic component that necessarily involves two locations in a given period (Skeldon, 2021).

One of the most obvious characteristics of migration is its selectivity, significantly associated with “factors in the act of migration” (Lee, 1980). This means that attributes of individuals and groups – sex, age, race or ethnicity, income, education, marital status, occupation, etc. – can influence the propensity to migrate. Among these attributes, sex and age are the most important in determining the decision to migrate (Vignoli, 2004).

Regarding sex, Ravenstein (1980), at the end of the 19th century, stated that women were more likely to migrate; however, almost a century later, Rogers and Castro (1981) observed a reversal: men began to show greater mobility than women. Therefore, what Almeida (2021) states in relation to this attribute is pertinent: approaches to sex as a variable for

migration must consider gender relations, which are constructed from social norms and contexts, and historical, political, economic, and urban processes.

For Rogers and Castro (1981), age is the most determining factor for migration – even more so than sex – and follows a regular pattern observed across age groups in various populations, like a curve with some curvatures. The volume of migrants in the early years of life is significant, as children accompany their mothers and fathers, also migrants. Subsequently, migration rates decline steadily through adolescence, until they rise again, peaking between the ages of 20 and 25 years old, which corresponds to the beginning of economically active life. Thereafter, there is a further, gentler but continuous decline – apparently corresponding to the phase of professional consolidation and family formation – until age 50 years old, when, again, there is a modest increase in migration, likely return migration and favored by retirement (Santos and Barbieri, 2019).

According to Skeldon (2021, p. 29), one of the few universal generalizations that can be made about migration is that “[...] the majority of those who move are young adults, destination populations tend to be youthful, with higher proportions in the labour force, while origin areas may experience the loss of the more dynamic elements of their populations”. Furthermore, the place of origin suffers losses in productive and reproductive capacities, and the opposite occurs in the destination (Skeldon, 2021).

Therefore, migration can alter the age and sex structures of origin and destination locations, directly and indirectly, especially in places with smaller populations, such as municipalities in the MRBH. But how does it happen?

The direct effects are more immediately perceived, as they affect the place of origin upon departure and the destination upon arrival.

Evidently, individuals who migrate are of a specific sex and age at the time of displacement, thus forming groups that alter the sex and age composition of the population from which they depart and the population where they arrive to establish their residence.

Considering the pattern supported by Rogers and Castro (1981), the losses suffered by the place of origin will tend to cause a decline in the birth rate – which may affect fertility – and, with the increasing ageing of the population, mortality will also rise, so that this may also be observed in the long term. On the other hand, the destination place will have a larger contingent of children and adolescents and may experience an increase in fertility, which will allow the population to rejuvenate and, in the long term, reduce mortality. Thus, the structures by sex and age groups are altered in the populations of origin and destination, and it will continue as long as such migrants survive and remain there. Therefore, the place of origin will tend to experience a decline in its population due to its increasingly lower Natural Increase (*NI*) and its negative Net Migration (*NM*); conversely, the destination place may experience positive population growth due to its gradually higher *NI* and positive *NM*.

This is where the indirect effects of migration arise, especially when the population of interest is in the final phase of the DT, with low fertility and mortality rates that result in a small *NI*. According to Rigotti (1999), the indirect effects of migration consist of both migrants who were born in their parents' destination region and had children, survived, and did not out-migrate (indirect effect of in-migration), and the children of migrants who did not return to their parents' region of origin (indirect effect of out-migration). Therefore, migration plays a central and determining role in demographic dynamics, impacting the other components.

Population growth follows the same direction as the *NM*. This is because women, on average, have postponed motherhood (Castanheira and Kohler, 2017), which also applies to migrants. In this regard, Santos (2019) argues that the timing of the birth of the first child follows reproductive behavior influenced by the Fertility Transition (FT), also reflected by the higher average age at motherhood, and the decreasing Total Fertility Rate (*TFR*). This reflects the fact that migration affects the reproductive capacity of the destination, also driven by its increased productive capacity. Depending on other factors, such as cultural ones, migrants may have a different fertility level than women previously resident in the destination, and these differences will determine the magnitude of migrants' contribution to the destination population's *NI*. Conversely, the place of origin is also influenced in these aspects, as it has lost population in active and reproductive ages, which contributes to economic issues and population ageing resulting from the reduction in the number of young contingent, especially, of women.

Migration and migrant

According to the UN (1970), migration is a movement that originates in one area, destined to another, carried out over a period of time. It consists of a change in place of habitual residence, the displacement of which crosses the limits of a geographic-administrative unit (Morrison, Bryan and Swanson, 2004; Moultrie et al., 2013; Grupo de Foz, 2021).

Based on the definition of migration, a migrant is an individual who leaves the area of origin to establish habitual residence in another destination location for a minimum period of time (UN, 1970; Moultrie et al., 2013; Grupo de Foz, 2021), as discussed previously.

For this study, the formal boundaries of the MRBH and its municipalities were adopted. Migrants are defined as individuals whose usual place of residence is in one of the municipalities of the MRBH on the reference dates of the demographic censuses, but who lived in another Brazilian municipality five years prior. Therefore, we considered internal migrations within the MRBH – between municipalities in the region of interest – and those involving the region with other municipalities in Minas Gerais and other Brazilian states; international migrations were not included.

Data

To estimate migration, two questions from the 2000 and 2010 Population Censuses were used.

The first is the “Municipality of Residence on a Previous Fixed Date” (MRFD), which asks respondents their place of residence five years before the reference date of the census respective. This question is more helpful compared to other information available in the demographic censuses consulted.² It should be noted that this question only includes those who are 5 years old or older, since individuals under this age were not alive at the time of the date to which this question refers. The other question is “Municipality of Residence on the Census Reference Date” (MRCD). Migrants were identified and included when the responses to both questions were different.

All information regarding the questions discussed above was obtained from microdata from the 2000 and 2010 Demographic Censuses, formatted to be processed using Redatam7.³

Furthermore, we used census data from 1991 and 2022, relating to the composition by sex and five-year age groups to understand profiles of the municipal and metropolitan

populations during this period. The 2022 Demographic Census data, in particular, allowed us to verify the dynamics of the population structure from the early 1990s to the present day, in addition to identifying and indicating demographic trends – fertility, population ageing, spatial distribution of dependent groups and the working-age population.

Indicators

The Net Migration Rate ($NMR_{0,t}$) is the result of a quotient whose denominator can vary depending on the population of interest – the origin or destination of the migrations. In this work, we analyzed migrations for their contributions to population growth at the end of the intercensal period (UN, 1970; Rigotti, 1999). Therefore, the $NMR_{0,t}$, estimated for each intercensal period and measured as a percentage, will be the division between the differences between in-migrants ($I_{0,t}$) and out-migrants ($O_{0,t}$), which are the Net Migration ($NM_{0,t}$), and the observed population at t – that is, P_t :

$$TLM_{0,t} = \frac{I_{0,t} - E_{0,t}}{P_t} \times k, k = 100 \quad (1)$$

To measure the variation in population sizes, the contribution of Natural Increase ($NI_{0,t}$) was estimated by residual, based on the Balancing Equation of Population Change (Preston, Heuveline and Guillot, 2001):

$$CN_{0,t} = P_t - P_0 - SM_{0,t} \quad (2)$$

The $NI_{0,t}$ does not necessarily mean understanding fertility and mortality rates. However, it allows us to compare it with the $NM_{0,t}$ and determine the relative weights of

each for population sizes. This allows us to observe the relative share of migration in the variations in the population contingents residing in the MRBH.

The 34 municipalities of MRBH were grouped according to their $NMR_{2005,2010}$. However, there are two exceptions: Belo Horizonte was treated individually, as its $NMR_{2005,2010}$ is very different from that of the other municipalities, and Betim and Contagem form one of the groups, because they are municipalities with significant migratory intensity, as they are conurbations and, within the region, more populous.

The MRBH and each group of municipalities had their population compositions demonstrated by sex and five-year age groups, with the exception of the age groups aged 80 years old and older, which will be represented by open interval, using population pyramids. Similarly, the population structures by sex and five-year age groups specific to in-migrants and out-migrants from the periods between the fixed dates and the census reference dates were also addressed.

Population structures were also evaluated using three indicators: Sex Ratio, Dependency Ratio and Ageing Index.

The Sex Ratio (SR_t) is the main indicator referring to the composition by sexes (Hobbs, 2004), and corresponds to the quotient between the male contingent P_m and the number of women P_f multiplied by one hundred:

$$RS_t = \frac{P_m}{P_f} \times 100 \quad (3)$$

Although it is a simple indicator, in addition to the potentials mentioned above, it is also useful for reflecting mortality differentials between men and women (Moultrie et al., 2013). Furthermore, the trend of continuous reduction in SR_t as age advances can be modified by significant net migration (ibid.).

The Dependency Ratio addresses the relationship between age groups based on economic productivity: the youth (4a) and elderly (4b) groups are considered economically inactive and therefore depend on the working-age portion of the population. Thus, this indicator, which results from dividing an inactive group by the working-age group, can be estimated disaggregated, using the youth or elderly groups as the numerator, or by adding these (4c) to form the Total Dependency Ratio (DR_t), always with the working-age group in the denominator.

$$RD_j = \frac{P_{0-14}}{P_{15-64}} \times 100 \quad (4a)$$

$$RD_i = \frac{P_{65+}}{P_{15-64}} \times 100 \quad (4b)$$

$$RD_t = \frac{P_{0-14} + P_{65+}}{P_{15-64}} \times 100 \quad (4c)$$

Although this indicator is essentially economic in nature, it is a measurement of population structure (Hobbs, 2004) and, therefore, is valuable for observing the proportion between the three major age groups.

Finally, the Ageing Index (A) relates, through division, the population aged 60 years old and over with the young age groups (Hobbs, 2004; Grupo de Foz, 2021):

$$E = \frac{P_{60+}}{P_{0-14}} \times 100 \quad (5)$$

In this way, this indicator measures how much a population has aged, or even rejuvenated, in a given period, which depends, indeed, on the dynamics of the contingents of these age groups over time.

Migrations

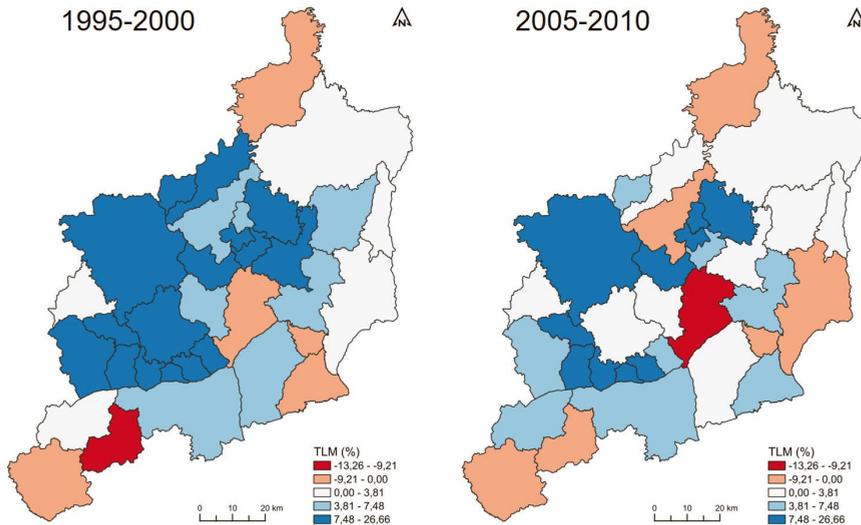
Before addressing population structures by sex and age groups, it is worth to mention a few more aspects in relation to migrations that involved the MRBH during the period under study.⁴

Between 1995 and 2000 and 2005 and 2010, the MRBH exhibited contrasting migration patterns. In the late 1990s, the MRBH experienced positive net migration, with the largest contribution coming from migration originating from other regions of Minas Gerais. Conversely, net migration from the MRBH, as ascertained in the 2010 Demographic Census, was negative.

The estimated migration flows revealed that, as observed in previous decades (Rigotti, 1994), between 1991 and 2010, population movements from outside the MRBH were predominantly directed to Belo Horizonte and its more populous neighbors. However, these municipalities experienced the largest numbers of out-migrants. Furthermore, it is worth noting that, throughout the study period, there was a significant reduction in net migration from the municipalities, as shown in Figure 2.

The migratory intensity of the MRBH is concentrated in internal migration, which largely followed a pattern: while Belo Horizonte was the largest source of migrants, the municipalities of Betim, Contagem, and Ribeirão das Neves were the main destinations. In this sense, the Capital served as a stage for many migrants, who subsequently headed to other municipalities in the region, especially neighboring ones,

Figure 2 – *NMR*, by municipality, between 1995-2000 and 2005-2010



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses.

given the possibility of commuting to carry out daily activities in Belo Horizonte. Evidently, there were also some changes in the individual participation of municipalities during the period of interest, notably Nova Lima and Lagoa Santa, which attracted significant interest from the real estate market through luxury condominium developments.

Population structures by sex and age

Chart 1 contains the composition of each group of municipalities. First, the sex and age structures of the MRBH population were analyzed, followed by those of the groups of municipalities.

Chart 1 – Groups of municipalities in the MRBH, according to their $NMR_{2005,2010}$

Groups of municipalities	Municipalities
Belo Horizonte (-9,21%)	Belo Horizonte
Betim (3,81%) and Contagem (1,57%)	Betim and Contagem
< 0,00% (except Belo Horizonte)	Baldirim, Caeté, Itaguara, Pedro Leopoldo, Raposos and Rio Manso
≥ 0,00% and ≤ 3,81% (except Betim and Contagem)	Florestal, Jaboticatubas, Matozinhos, Nova Lima, Nova União, Santa Luzia and Taquaraçu de Minas
> 3,81% and ≤ 7,48%	Brumadinho, Capim Branco, Ibirité, Itatiaiuçu, Mateus Leme, Rio Acima, Sabará and Vespasiano
> 7,48%	Confins, Esmeraldas, Igarapé, Juatuba, Lagoa Santa, Mário Campos, Ribeirão das Neves, São Joaquim de Bicas, São José da Lapa and Sarzedo

Source: prepared by the author.

Table 1 – Dependency Ratios of the MRBH and its groups of municipalities

Groups	1991				2000				2010				2022			
	RD _j	RD _i	RD _t	RD _j	RD _i	RD _t	RD _j	RD _i	RD _t	RD _j	RD _i	RD _t	RD _j	RD _i	RD _t	
RMBH	50,91	6,42	57,33	39,78	7,58	47,36	30,08	10,04	40,11	24,82	16,52	41,35				
Belo Horizonte	45,75	7,18	52,93	34,93	8,94	43,87	26,18	12,02	38,20	22,81	20,22	43,03				
Betim and Contagem	56,13	4,42	60,55	42,89	5,49	48,38	31,78	7,54	39,31	26,26	13,51	39,77				
<0,00%	53,38	8,42	61,80	41,48	9,64	51,12	31,30	11,67	42,97	25,74	19,26	45,00				
≥ 0,00% and ≤ 3,81% (except Betim and Contagem)	58,59	6,03	64,62	44,30	6,75	51,05	33,41	9,08	42,49	26,91	15,14	42,04				
> 3,81% and ≤ 7,48%	60,26	5,74	66,00	47,41	6,17	53,58	35,84	8,10	43,94	28,22	13,17	41,39				
> 7,48%	64,39	5,09	69,48	49,36	5,61	54,97	36,93	7,65	44,58	28,65	12,52	41,17				

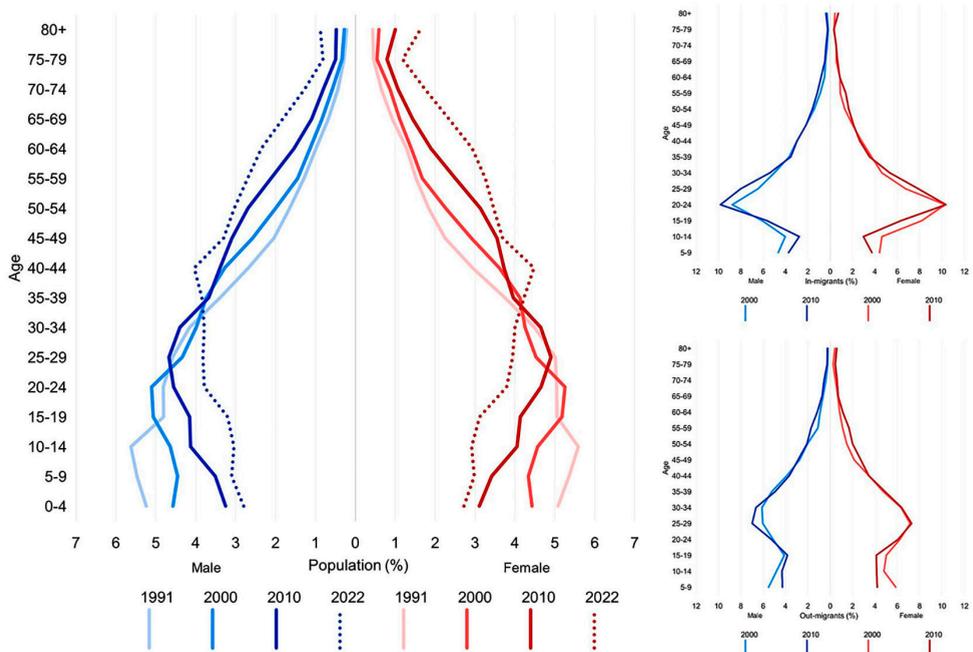
Source: prepared by the author.

Table 2 – Sex Ratios and Ageing Index of the MRBH and its groups of municipalities

Groups	1991		2000		2010		2022	
	RS_t	E	RS_t	E	RS_t	E	RS_t	E
RMBH	93,47	19,65	93,55	28,48	92,35	49,37	90,70	96,64
Belo Horizonte	89,87	24,25	89,50	37,64	88,26	66,49	86,77	125,14
Betim and Contagem	97,91	12,78	97,12	19,98	95,38	36,74	92,73	77,60
<0,00%	97,05	23,64	97,27	33,70	96,48	54,60	94,07	109,03
≥ 0,00% and ≤ 3,81% (except Betim and Contagem)	98,33	15,82	97,29	23,12	95,19	40,95	93,31	83,20
> 3,81% and ≤ 7,48%	98,84	15,03	97,86	19,80	95,67	34,21	94,15	70,67
> 7,48%	100,75	12,68	100,65	17,49	99,65	31,58	98,36	65,83

Source: prepared by the author.

Graph 1 – Population pyramids of the MRBH in 1991, 2000, 2010 and 2022



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses, and data from the 1991 and 2022 Population Censuses.

The population of MRBH in 1991 was young, with the age groups from 0 to 14 years old being the largest – a consequence of the high fertility in the past. Subsequent age groups gradually decreased, with the elderly representing just over 4% of the total population. However, important and ongoing changes occurred in the 21st century. With the advance into the final phase of the DT and the reversal of migration flows, the young population declined due to falling fertility and negative net migration, which resulted in a reduction in the young and working-age populations aged 25 years old and older.

In 2000, all age groups were, in absolute terms, more numerous than in 1991, with a contribution from migration, which was positive for all age groups and both sexes. The high birth rate – favored by positive $NMR_{2005,2010}$ in the 15 to 29 years old age groups – culminated in positive increase, but, concomitantly, there was population ageing.

In 2010, lower fertility and a significant increase in age groups aged 65 years old and older were significant factors in population

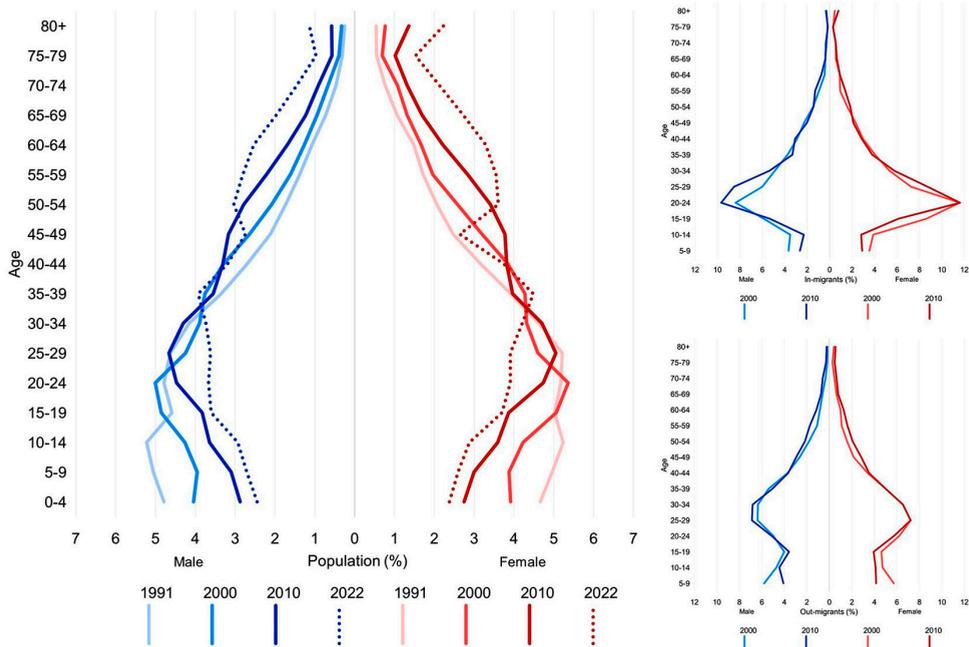
ageing. Not all age groups increased in number like the previous period – those aged 0 to 24 years old declined. This, however, should not be attributed to migration, given the increase of these cohorts since 2000.

Alterations in the age structure have caused dependency ratios to vary, with an uninterrupted decline in DR_y and an increase in DR_e , and contributed to the rise in A – from 19.65 in 1991 to 96.64 in 2010. Therefore, the metropolitan population, since 1991, has been ageing, and increasingly rapidly.

As observed in the past (Rigotti, 1994), between 1991 and 2010, women continued to constitute the majority of the metropolitan population and had a slight increase during the period. In addition to lower female mortality, net female migration was higher, although it was negative between 2005 and 2010.

Belo Horizonte plays a decisive role in the composition of the MRBH population, which is evident in the similarities between its population pyramids.

Graph 2 – Population pyramids of Belo Horizonte in 1991, 2000, 2010 e 2022



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses, and data from the 1991 and 2022 Population Censuses.

In 1991, the population of Belo Horizonte was predominantly young, due to the high birth rate of previous decades – as indicated by the age groups up to 14 years old, at the time the most numerous –, favored by the large female contingent in reproductive age.

In 2000, the age structure remained young, with the birth rate still high, in view of the nearly 15% increase in the number of women in their reproductive years. However, it was lower than in 1991, given the decline in fertility throughout the decade. In that year, only the female age group 15 to 24 years old experienced positive net migration, which, although low, contributed to a slight increase in the number of women in their reproductive

years and, by extension, contributed to the birth rate, even with fertility declining and close to replacement-level.

Nevertheless, significant changes in the age structure were verified in 2010. In the Capital, the population continued to age in both sexes. This can be attributed to fertility rates during the period, which were still lower than ten years earlier. Furthermore, despite negative net migration for both sexes across all age groups and the inevitable incidence of mortality, the 15 to 29 year old cohorts increased compared to their 2000 cohorts.

Evidently, changes in age structure also affected the working-age and elderly populations, which experienced relative

increases between 1991 and 2010, and caused the proportional size of young people to shrink, to the point where A was greater than 100 – that is, the elderly population surpassed the youth contingent. This was contributed to by declines in mortality and fertility, in addition to negative specific net migration to the modal ages for greater mobility, between 25 and 39 years old.

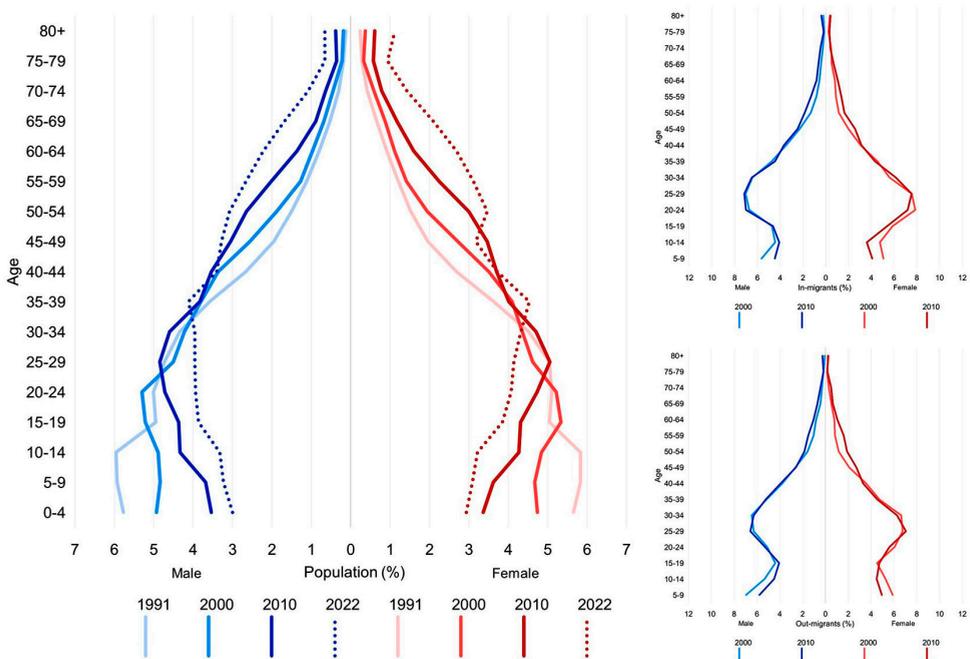
Regarding the composition by sex, the SR_t suffered a slight decline between 1991 and 2010. This can be attributed to two reasons: the

higher male mortality specific rate; and the less negative female net migration, further favored by the higher male net emigration.

Finally, it is worth noting that the negative NMR observed during the study period was offset by the NI , which caused the Capital's population to increase until 2010.

The combined populations of Betim and Contagem had a young structure in 1991, which can be attributed to the high fertility levels of the then recent past and the large number of women in reproductive age.

Graph 3 – Population pyramids of the group formed by Betim and Contagem in 1991, 2000, 2010 and 2022



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses, and data from the 1991 and 2022 Population Censuses.

Although it remained young, the age structure in 2000 underwent some modifications. The first is that the most populous age groups were those between 10 and 44 years old, especially those aged 20 to 34 years old, with a $NMR_{2005,2010}$ above 10%. The groups aged 45 to 64 years old experienced little variation in size, suggesting that net migration was close to replacing the losses caused by mortality. Cohorts aged 55 years old and older, on the other hand, declined, possibly because their net migrations did not compensate for the mortality.

According to the 2010 census data, the trend of all age groups increasing in number continues – except those born during this intercensal period –, despite the increase in female groups aged 15 to 49 years old and positive net migration in groups up to 9 years old. This is a sign of the sharp decline in fertility in these municipalities. The age groups between 15 and 34 years old recorded the highest $NMR_{2005,2010}$, which contributed to the growth of these groups and made them the most numerous.

The variations in DR_y and DR_e , and in A demonstrate the ageing of these municipalities, albeit at a slower rate than that of Belo Horizonte. This can be attributed

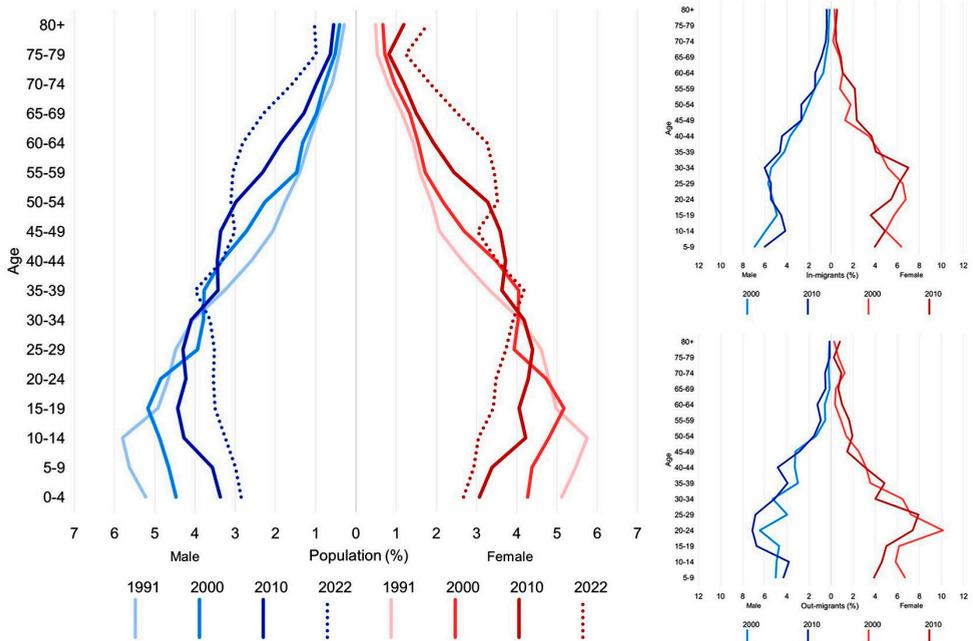
to the progressive declines in fertility and net migration, especially among the age groups up to 34 years old.

Throughout the 1990s and 2000s, women not only remained most of the population in the group Betim-Contagem, but their relative share increased. Considering the small differences between male and female net migration during this period, it is clear that mortality was a decisive factor in men becoming a minority of the population.

In 1991, the population of the group of municipalities with negative $NMR_{2005,2010}$ had young people as the largest contingent, with the 10 to 14 years old age group being the most numerous. The higher fertility in the past meant that young people constituted the majority of the population of this group of municipalities.

Between 1995 and 2000, municipalities in this group had positive NMR , although some age groups had negative net migration. As a result, in 2000, all age groups were larger than those enumerated in the previous census – except those aged 0 to 14 years old. Thus, the 2000 population pyramid has a slightly narrower base compared to that of 1991. Even so, these municipalities experienced population growth, likely due to relatively high fertility, albeit lower than in the previous period, and positive net migration for most age groups.

Graph 4 – Population pyramids of the group formed by municipalities with negative $NMR_{2005,2010}$ in 1991, 2000, 2010 and 2022



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses, and data from the 1991 and 2022 Population Censuses.

In 2010, most age groups had negative $NMR_{2005,2010}$. The population pyramid that year is even narrower at the youngest ages and wider from 45 years old onwards, for both sexes. As a consequence of the continually lower fertility, the age groups up to 9 years old are fewer than in the previous period, as are those aged 15 to 24 years old. Furthermore, all age groups from 25 years old onwards are more populous. It is worth highlighting the large increase in the age group aged 80 or over, which was just over 43%.

While the 0 to 9 years old and 40 to 44 years old cohorts in 2000 increased larger in 2010, this was not observed in any of the other

cohorts. Therefore, the negative net migration of these municipalities was reflected in the age structure, through the loss of population aged 20 years old and older. Thus, it is understood that population growth was mainly driven by the positive $NI_{2005,2010}$ and greater longevity.

This group also experienced, between 1991 and 2010, a gradual ageing process: during this period, A varied from 23.64 to 109.03, meaning that the population aged 60 years old and over became more numerous than the population aged up to 14 years old. A decisive factor for this was the negative $NMR_{2005,2010}$ of the groups aged 15 to 29 years old – especially females –, who are more prone to reproduction.

The differences between the numbers of men and women are not large. However, between 2000 and 2010, the female share had a slight proportional increase, despite the female net migration being lower than that male.

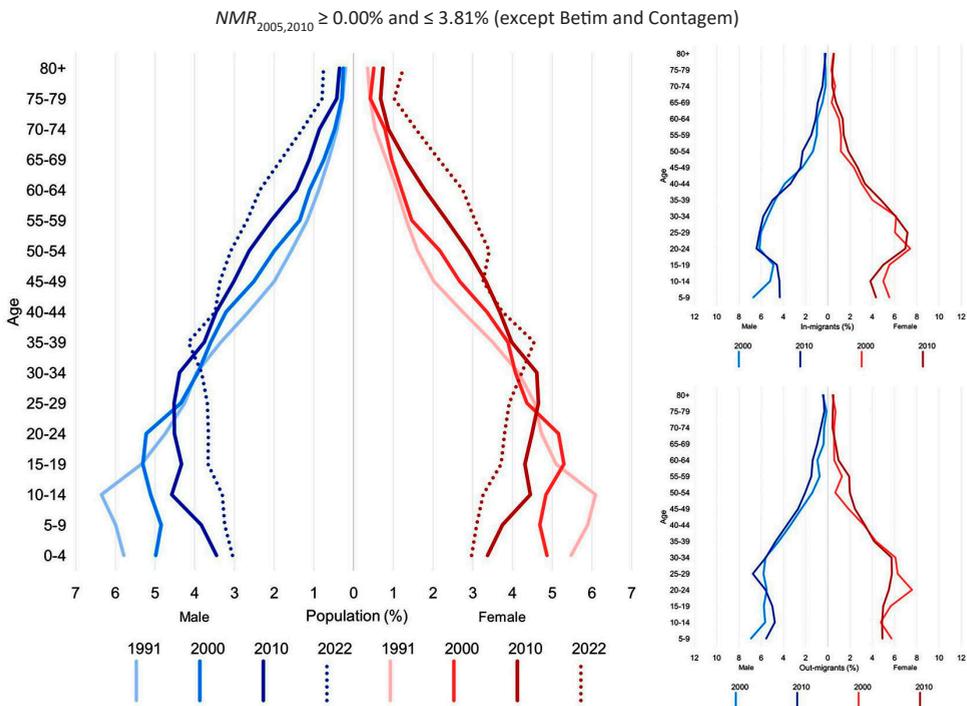
The groups of municipalities that registered null or positive $NMR_{2005,2010}$ had different dynamics from the groups discussed previously, except for the group formed by Betim and Contagem.

In 1991, all of these groups had a young age structure, with the up to 14 years old age groups being the most numerous. The adult

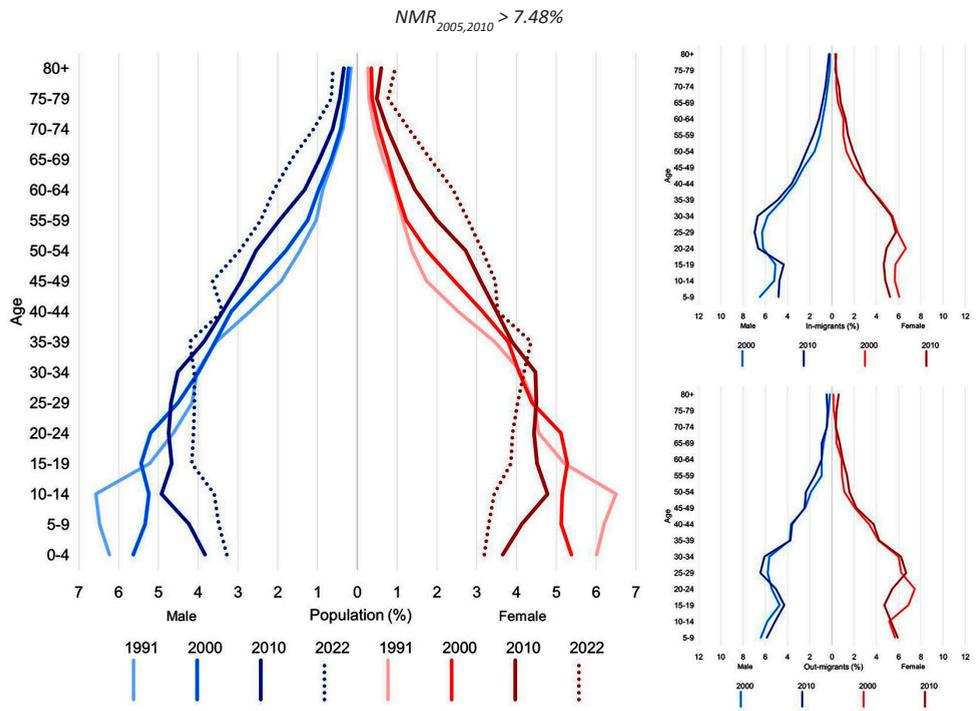
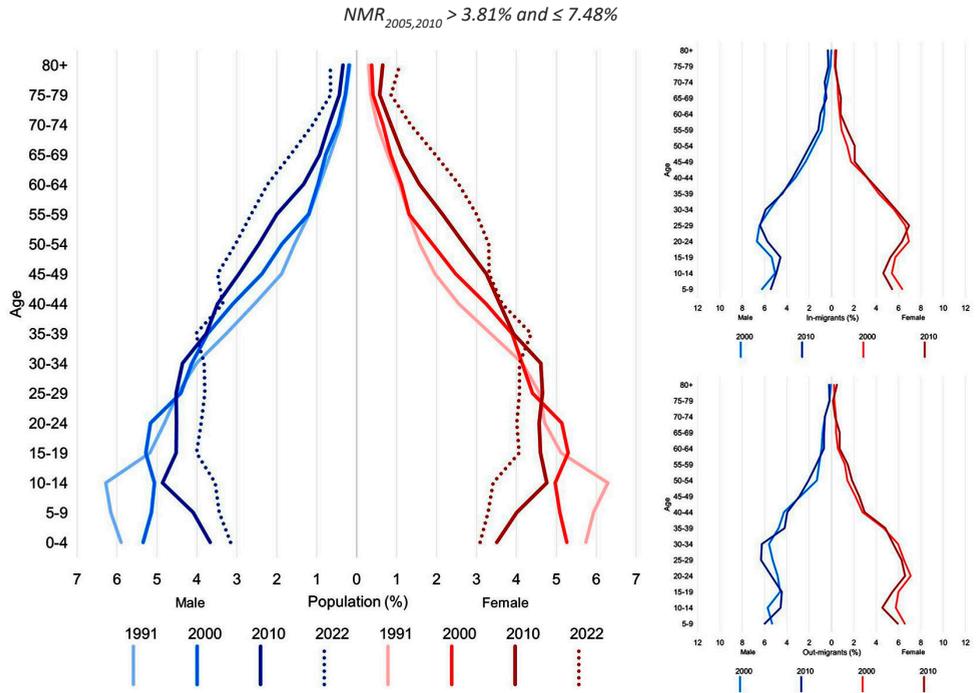
population was also large, concentrated between the ages of 15 and 29 years old. This can be attributed to the large number of women in reproductive age and the higher fertility in these municipalities at the time.

In 2000, the populations of these municipalities remained young, with the age groups up to 9 years old being the largest. The positive $NMR_{2005,2010}$ of the groups up to 14 years old and of women in reproductive age, which contributed to significant birth rates, are likely reasons for the young age structures.

Graph 5 – Population pyramids of the group formed by municipalities with null or positive $NMR_{2005,2010}$ in 1991, 2000, 2010 and 2022



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses, and data from the 1991 and 2022 Population Censuses.



Source: prepared by the author, based on microdata from the 2000 and 2010 Population Censuses, and data from the 1991 and 2022 Population Censuses.

Ten years later, these municipalities experienced changes in their age structures. One possible reason was the widespread decline in net migration, now lower than in the previous decade. This, however, did not prevent the young and adult age groups from growing due to migration. Another factor is the reduction in fertility, expected with the advancement of DT. The elderly age groups experienced significant increase, resulting from the improved survival probability at these ages, when migration is less likely.

In these groups of municipalities, the rejuvenating effect of migration is notable, as demonstrated by DR_t – due to the larger proportions of working-age populations – and by A due to the larger youth contingents. However, ageing, albeit at a slower pace, has been inevitable.

Regarding the composition by sex, all these municipalities had a decrease in DR_t , which can be attributed to the greater female net migration and the lower underlying mortality among women.

What we have, therefore, is that the population pyramids of the MRBH behaved very similarly to those of the groups of municipalities, evidently varying in the proportions of each age group in each year. It is important to note that the 1991 pyramidal geometry underwent modifications over time, and 31 years later has a geometric shape increasingly resembling that of a bell. If what is expected from the DT conclusion is confirmed – very low, almost null, or even negative NI at some point – the trend is for the region's age pyramids to become increasingly slender, with narrower bases and progressively wider tops.

Evidence from the 2022 Population Census

At the time of this study, no results on migration and fertility were available from the 2022 Population Census (IBGE, 2023), and few on mortality. However, results on population sizes and population structure by sex and five-year age groups for Brazil, its States, and its municipalities were released.

According to the 2022 Population Census, the MRBH there were continued trends observed since 2000. The first is the decline in the birth rate – in line with the decline in fertility, as is typical of the DT – which resulted in the lowest number of people aged 0 to 9 years old recorded in the region. Along with this, the greater longevity of the population, evident in the uninterrupted increase in the age group 80 years old and older. Therefore, the metropolitan population continued to age. This also allowed the adult population, especially those aged 20 to 49 years old, to become proportionally larger.

As a result, the region's population pyramid is shaped almost like an ellipse, demonstrating the effects of DT: shrinking youth groups due to falling fertility; an increasingly large elderly population due to lower mortality; when compared with previous periods, proportionally smaller age groups from 15 to 39 years old; and a working-age population with a significant concentration between 40 and 64 years old.

Of the MRBH, only half of its municipalities had an average annual growth higher than that of Brazil, which was 0.52% (IBGE, 2023), and, with the exception of Baldim, all of its members

registered, between 2010 and 2022, average annualized growth rates (MAGR) lower than those registered in previous intercensal periods.

Belo Horizonte remained the only municipality in the MRBH with a population over 1 million, despite experiencing a population decline between 2010 and 2022, likely due to negative net migration and $NI_{2010,2022}$, as a result of even lower fertility rates below replacement-level and the mortality shock caused by the Covid-19 pandemic. Another fact is that the population aged 50 years old and over is larger, in absolute and relative terms, and with significant differences: the portion aged 65 years old and over corresponds to over 14% of the municipality's population.

Conversely, some municipalities stood out with the largest $MAGR_{2010,2022}$ in the region, for various reasons. Nova Lima grew by attracting residents through the real estate market, as did Lagoa Santa, which also benefited from large urban projects in the North Vector, such as Tancredo Neves International Airport in Confins and the Presidente Tancredo Neves Administrative City in Belo Horizonte. The population growth of Esmeraldas, Juatuba, Mateus Leme, and Sarzedo may be due to migrations driven by industrial activities in these municipalities and in other municipalities, including some outside the MRBH, such as Pará de Minas, Itaúna, and Divinópolis.

The significant declines in population growth in Betim, Contagem and Ribeirão das Neves, which are the most populous municipalities immediately after Belo Horizonte, are noteworthy, possibly due to issues associated with potentially higher costs of living, instability in the industrial sector and loss of economic dynamism.

The 2022 population pyramids for all groups of municipalities have the same geometric shape as that observed for the MRBH, evidently

with some variations in the proportional sizes of age groups. They suggest that, with due regard for proportions, the municipalities of the MRBH are undergoing processes such as a continuous decline in fertility, ageing, and a reversal of the dependency burdens of youth and elderly. Life expectancy at birth is also expected to recover and return to pre-Covid-19 pandemic levels and resume its gradual upward trend (Castro et al., 2021). Thus, the NI is expected to remain in decline and stabilize at low levels, and may even become negative, given the expected fertility trajectory.

Migration, in particular, is expected to be a major driver of population dynamics, given the greater stability of fertility and mortality. Migration is also expected to become progressively less intense in the MRBH and its municipalities, given the recent trend and significant shifts toward remote work and service delivery – teleworking, distance learning, telehealth etc. As seen previously, there are reasons to emigrate from the metropolis, or a lack of reasons to migrate to it: high housing and living costs; urban violence; unsatisfactory urban mobility; affordable lifestyles; precarious employment relationships; availability of resources for remote work, study, and other tasks; the ongoing ageing of the population, among other reasons. Thus, medium-sized municipalities, and even some smaller ones, are proving to be preferred destinations for those wishing to leave the metropolis and as locations with the greatest potential for population retention.

Considering the previous discussion and that the demographic dynamics of Belo Horizonte are decisive for that of the MRBH, we can assume that, in the future, this region will have a considerably elderly population, both due to low fertility and mortality, and the fading in migration, and due to the loss of population

of working-age and in the reproductive years through migration, since this age group is, by tendency, the most likely to move spatially.

Final considerations

Migration has been shown to alter and impact populations, both at origin and destination, and this is fundamental to the dynamics of other demographic components (Vignoli, 2004; Vignoli, 2013). By impacting sex and age structures, migration influences: birth rates among female reproductive age groups; the size of young, working-age, and, to a lesser extent, elderly populations; population rejuvenation or ageing etc. (Wong and Carvalho, 2006; Skeldon, 2021). Furthermore, in the context of the final phase of the DT, in which the *NI* is increasingly smaller due to the uninterrupted decline in fertility, spatial mobility, *lato sensu*, may play an increasingly greater role in population dynamics.

This article aimed to examine possible relationships between migrations involving the MRBH and the sex and age composition

of its population, as well as its municipalities. Migratory behavior within the MRBH was crucial, particularly given the region's current stage of the TD process, with low fertility and mortality rates.

Belo Horizonte, as the most populous municipality in the MRBH, had the greatest influence on the region's population dynamics throughout the study period, determining its population size and playing a polarizing role in mobility within the metropolitan area. Thus, the MRBH proved to be highly sensitive and susceptible to the demographic conjuncture of Belo Horizonte.

It is reasonable to consider the potential heterogeneity among municipalities in the MRBH regarding their phases of the DT, which is important for population growth by influencing fertility and mortality levels, especially for those with lower migration intensity. However, it is expected that, in the near future, all municipalities in the region will be in the final phase of the DT, with their population dynamics and compositions determined, mainly, by migration.

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Notes

(1) This article is based on the master's thesis by T. M. L. Moreira, entitled Population mobility in the Metropolitan Region of Belo Horizonte in the 1990s and 2000s, under the supervision by Professor José Irineu Rangel Rigotti at the Federal University of Minas Gerais (UFMG) in 2024. Available at: <http://hdl.handle.net/1843/79221>.

(2) On this, see Rigotti (1999).

(3) For more information, visit <https://www.redatam.org>.

(4) For more details, including full estimates, see <http://hdl.handle.net/1843/79221>.

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Authorship contribution

Thiago Machado Lage Moreira: conceptualization; data curation; investigation; methodology; writing—original draft; writing—review & editing.

Data Availability Statement

All the supporting data for the results of this study has been made available in the Institutional Repository of the Federal University of Minas Gerais and can be accessed at <https://hdl.handle.net/1843/79221>.

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