Mortality selection among adults in Brazil: the survival advantage of Air Force Officers.

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ABSTRACT

In this study we took a novel look at military data and its implications for demographic and health research in Brazil. Notwithstanding the relevance of other demographic and epidemiologic work that focused on military data as a means of analyzing the extremely negative effects of warfare related issues on health and mortality, such as starvation, stunting and Post Traumatic Stress Disorder, we argued that the military, and especially career officers in a conflict-free context, are also paramount to understanding extremely positive effects on health and mortality. Even more importantly, in a developing country scenario where high-quality data is lacking, focusing on those subgroups places us closer the “true” mortality function. We used longitudinal mortality data from 1947 to 1960 (n=706, 66 years follow-up), for a highly selected Brazilian group, the Air Force officers (BAF), in order to test two main hypotheses: (1) mortality levels for BAF officers are lower than for the average Brazilian; (2) mortality differentials due to distinct socioeconomic backgrounds are offset by their long-lasting exposure to a privileged health setting. Our results not only confirmed a survival advantage of BAF officers when compared to the average Brazilian male in 2000, but also that BAF life expectancy is comparable to those of low mortality countries, such as Sweden, France and Japan in 2000. Place of birth had no statistically significant association with BAF mortality. Officers who were born in the more developed regions of Brazil presented no survival advantage relative to those who were born in the less developed regions, indicating that despite coming from different socioeconomic settings during childhood, it did not affect their mortality differentials.

Key-words: Adult Mortality. Early-Life conditions. Mortality selection. Brazilian Air Force
INTRODUCTION

The mortality advantage of certain population subgroups has attracted increasing attention of demographers because of the spread of new high quality data and the interest on disentangling the pathways to increasing longevity. Earlier research has shown, for a large and heterogeneous list of countries, survival advantages associated with higher income, higher educational attainment, better occupational status (Cutler and Lleras-Muney 2008; Christensen and Johnson 1995), gender (Crimmins and Saito 2001; Case and Paxson 2005; Norris K. and Nissenson A., 2008), race (Elo and Preston 1994; David and Selina 2009) and marital status (Zick and Smith 1991; Goldman, 1993; Waite and Gallagher 2000; Rahman 1991), just to mention a few of the most well-know factors.

Some other studies have examined the survival advantages of population subgroups that represent significantly smaller but selected fractions of the populations, including certain learned societies (Andreev et al. 2011; Winkler-Dworak & Kaden 2013), religious groups (Breslow 2008; McCullough et al. 2000), and the military (Costa 2012; Costa and Kahn 2010; Costa 2010). Usually, data on military mortality are useful for those who want to learn more on survival under extreme conditions, such as war and famine, as well as on the mechanisms responsible for mortality differentials over the life cycle. However, in countries that have not been involved in internal conflicts or foreign wars, the military live in favorable conditions, with officers being positively selected with respect to health. In this type of context, military data may help reveal the upper limits of mortality gradients. In addition, the tradition of the military in collecting vital data can be valuable in developing countries where it remains unclear the magnitude and determinants of mortality differentials.

In this article, we benefit from reliable longitudinal mortality data available for Air Force officers from Brazil to look more closely at the survival of this selected group of Brazilian adults. For that purpose, we obtained information from 706 male officers who enrolled in the Brazilian Air Force (BAF) between the years 1947 and 1960. We followed these individuals until 30th June 2013 and recorded information on place of birth and career (pilot or administrative officer), in addition to mortality (total and by large groups of causes of death). Our primary objective is to examine the magnitude of the mortality advantage of the Air Force
Officers compared to the total Brazilian population and to other populations living in low mortality countries. Unfortunately, our database includes only male officers, since women engaged in military duties solely in 1991, as administrative officers. It was only after 2003 that they enrolled to become pilots in the Brazilian Air Force. Nevertheless, all male officers in our analysis had permanent contact with the Air Force throughout their lives, until their moment of death or the end of period study. Therefore, we provide one opportunity to improve the knowledge on male survival of a selected group living in a developing country, over a period of intensive socioeconomic, demographic and health transitions that characterized the second half of the last century in Brazil.

Our second objective is to examine the possible influence of early-life conditions on the survival of Air Force officers latter in life. According to Preston, Hill and Drevenstedt (1998), childhood conditions may influence adult mortality through a physiological, direct mechanism or through a non-physiological, indirect mechanism. Both mechanisms may affect adult mortality positively or negatively. Other authors have shown how different exogenous influences on childhood can affect adult mortality, including economic recessions, climate change and starvation periods (Bengtsson 2000; Van den Berg 2007; Van den Berg 2009; Doblhammer 2003). Since the group of military officers studied here enrolled in the Air Force at relatively young ages (15-24 years old), we use information on place of birth as a proxy for their very early life conditions, considering the unequal regional development in Brazil.

One might expect that officers born in the northern areas of Brazil, where life conditions are worse than the national average may experience higher mortality latter in life. However, there is evidence in the literature that mid-life factors, such as behavior related to tobacco and alcohol abuse and sedentary life styles, may mitigate or intensify the influence of earlier life events on old age mortality (Hayward and Gorman 2004; Kannisto 1994; Kannisto et al. 1997). Indeed, over their careers and later in life, Brazilian officers receive excellent health care services, and are eligible to nutritional and physical intervention programs. In addition, the Brazilian Air Force follows the practices of other military forces in the world by employing a very restrictive selection process to choose officers. Therefore, we hypothesize, that in the case of Brazilian military, despite the implications of regional inequality, the combination of health selection with improved health conditions over the life course may offset the effect of differences in early life conditions on adult survival.
BACKGROUND

Although it is reasonable to assume that members of the military are healthier than the average citizen it is still somewhat surprising that they experience lower mortality than most groups in society, even in the context of extreme settings such as famine (Costa 2012; Horiuchi 1983) and war (Buzzell and Preston 2007). Buzzell and Preston (2007) estimated the death rates of United States troops in Iraq since the beginning of the U.S invasion. According to the authors, death rates for black males aged 20-34 in 2002 living in Philadelphia were 9% higher than for troops in combat in Iraq. A much earlier work from MacIntyre (1978), which followed the U.S Navy’s cohort of 800 survivors from World War II and the Korean conflict, showed that pilots experienced not only lower all-cause mortality, but also lower mortality from cardiovascular, cancer, and accidental causes when compared to the U.S civilian population. The main explanation, according to the author, was the generally good socioeconomic background of members of the military. He also speculated about the positive genetic influence of long-lived parents, above average intelligence, and the health and fitness orientation of the military aviators (MacIntyre, 1978). Some scholars have argued that the survival advantage of the military accrues from a selection bias at enlistment or recruitment, sometimes called the “healthy soldier effect” (Mclaughlin 2008; Shah 2009), in which the selection of the healthier and fitter results in lower mortality rates.

Variations in risk of death among the military officers, particularly during times of war, reflect several underlying factors including military branch and service component, as well as rank in service. Buzzell and Preston (2007) showed that these characteristics affect exposure to combat and therefore, the variability of mortality risk across subgroups. Therefore, it is not surprising that being older, female and occupying lower ranks (such as the case of African Americans) are often associated with reduced mortality rates within the military (NIOSH 1996; Buzzell and Preston 2007; Ozcan 2012).

Other research have used military data to approach epidemiologically the pathways through which more risky and stressful situations affect survival and causes of death within a life cycle perspective (Costa 2012; Costa and Kahn 2010; Costa 2010; Kang et al 2006; Dirkzwager et al 2001; Elder et al. 2009). Models of mortality selection posit that insults at younger ages can yield more robust individuals at older ages (Horiuchi and Wilmoth 1998; Manton and Stallard
1981, Preston et al. 1996), but there is also evidence of positive associations between hazardous life events and morbidity and mortality later in life (Finch and Crimmins 2004; Horiuchi 1983; Kannisto et al. 1997). Recent research evidenced that veterans from the American Civil War who experienced greater stress in battle had higher mortality rates at older ages and were at greater risk of developing Post-Traumatic Stress Disorder (PTSD) (Costa and Kahn 2010). Other work on PTSD show that exposure to military trauma can impact physical health in later years. In a longitudinal study of male American Veterans of WWII, exposure to combat significantly increased mortality risk, whereas individual differences in education, mental health, and age at entry into the military did not (Elder et al. 2009). Veterans from other countries also experienced PTSD. Among the Dutch aging military Veterans who fought WWII and Korea, 27% were diagnosed with PTSD in 1992 (Dirkzwager et al 2001). Also, former American World War II prisoners of war (POWs) had statistically significant increased risk of PTSD, and those POWs with PTSD also had statistically significant increased risks of cardiovascular diseases, including hypertension and chronic ischemic heart disease when compared to both non-POWs and POWs without PTSD (Kang et al. 2006).

Earlier literature has also taken advantage of military data to explore the relationship between nutritional status, exposure to infections and anthropometric measures, such as height and weight, and their impact on subsequent mortality levels (Costa and Fogel 2004; Fogel, 1997; Costa 2004). Costa (2003) examined the effect of early-life infections on later mortality in the Union Army population. The author found that stomach ailments while in the army significantly predicted mortality from all causes, chronic diseases, heart diseases other than cerebrovascular, and ischemic heart disease. In addition, respiratory infection significantly predicted mortality from respiratory illnesses and death from acute illnesses when other wartime disease covariates were excluded (Costa 2003). In another study, Costa (2004), using data on Civil War soldiers (mid- nineteenth century America), showed that differences and changes over time in body frame size between white, Indian and black American males explained three-fifths of the mortality decline among white men between 1915 and 1988, and help to predict even sharper declines in older age mortality between 1988 and 2022.

In addition, the relationship between height and body mass among Union Army veterans has been evidenced to be powerfully predictive with respect to morbidity and mortality at later ages, when considering their height at enlistment (ages 23-49) and the period of risk from ages
55 to 75 (Fogel 1997). Short men (under 168cm or 66 in.) are at greater risk of death, even when body weight is at standard acceptable level (ideal BMI depending on height). Poor body builds increase vulnerability to both contagious and chronic diseases, and stunting during developmental ages had a long reach age (Fogel 1997; Fogel et al. 1996; Costa and Fogel 2004).

**The historic and demographic context of the military institution in Brazil**

Some features of the Brazilian military institution and the time period here considered are important to account for when analyzing this group, since they are fundamental in understanding the characteristics of our cohort study. First, an important cultural aspect of the military institution and one that particularly makes it different from other social settings is that it is a “totalizing” social environment (Simmel 1972). Which means, as Castro (1990; 2000) shows, that individuality in the military is not encouraged, their social circles are more restricted and their social ties are more homogenous. In addition, more traditional familistic values are stressed, with officers marrying at relatively young ages, preferably with members of other known military families. The professional pathways are standardized and they go through similar experiences of socialization, as well as “the same institutional rites and career turning point” (Castro 2000). This standardized setting is a crucial element in efficiently coping with military training and duty, which often involves risky and stressful situations, since it is considered to provide a more predictable guide to behavior.

Second, the period considered in this study witnessed important historical changes, which had an impact on the military institution. Castro’s research shows how the social origins of the military and the society’s perception of the institution changed over time in Brazil. Throughout the 1940’s, 78.8% of the enrolled military were from the bourgeoisie, with some especial participation of the elite (19.8% were from the traditional higher classes). In the 60’s, however, the participation of the higher classes decreased to 6%, while the participation of the working class raised from 4% to 9%. Between 1940 and 1960, the military were accepted and respected in the highest social segments. However, after the 1964 military coup in Brazil, the prestige of the military declined before the civil society. Parallel to that, other ongoing movements starting in the end of the 60’s, such as the feminist revolution, exposed social structures that conflicted with some of the traditional aspects of society, as well with those of the military profession. The increase in women empowerment, with higher female labor force participation rates and
education levels, progressively affected the marriage market for military officers, who often marry early and rely more on traditional relationship structures (Castro 1990).

Third, during the life course of the cohorts being investigated here, the demographic transition was operating at its full force in Brazil and certainly has affected the chances of surviving of our sample. The total fertility rate dropped from 6.2 in 1940 to 2.4 in 2000, although it only started to decline in the mid-1960s. Life expectancy at birth rose from 45.5 years in 1950 to 70.4 in year 2000, mainly because of a dramatic decline in infant mortality rates (IBGE 2000; Vasconcelos and Gomes 2012). Therefore, the total population soared up from about 40 MM to 170MM, during the 60 year period, and changes in the age structure were also rapid. The aging index (the proportion of persons with more than 60 years old relative to 15 years younger) increased from 9.5% in 1940 to 28.9% in 2000. Due to its vast territory and different regional development, Brazil’s epidemiological and demographic transitions were not only fast-paced, but happened at different levels and timings throughout the country, revealing its regional disparities. For example, while the infant mortality rate in southern area of Brazil declined from 81.9 in 1970 to 16.9 per thousand live births in 2000, in the northeast, the rate was about 146.40 per thousand in 1970, and despite its substantial decline, it remained at significantly higher level than the south in 2000 (38.4 per thousand) (IBGE 2000; Vasconcelos and Gomes 2012).

Unfortunately, there are no accurate socioeconomic indicators for the military population over the period of our analysis. However, we know that in 2012 the average wage of the occupied population in Brazil was 2,136 reais (IBGE 2015), while an Air Force career military officer earned twice as much, an average of 4,901 reais (Ministry of Defense 2012). Not surprising, in the U.S, the differences were relatively lower than in Brazil, suggesting a lower degree of socioeconomic selection: military personnel are from families with an average annual wage of $43,122 (in 1999), whereas a typical American family earned $41,994. Therefore, in this article, we follow a cohort which was exposed to a period of important social, political, epidemiological and demographic changes, composed of individuals who entered the Air Force between 1940 and 1960, most typically from above average income families, but also from different regional backgrounds. Considering that their median age at enrolment in the institution was around 19 years old, they were also individuals who were born in a period before the demographic and epidemiological transitions took place, in a context of yet low, but increasing
life expectancy at birth, and high birth rates. In addition, these individuals probably shared fundamental elements, such as similar social experiences and standardized pathways in their careers, which enabled them to fulfill military duties and cope with the demanding expectation of the military service.

**DATA AND METHODS**

The data for this study come from an electronic database of the Air Force pension fund system (Brazilian Air Force Health Center/DIRSA). The database contains information on officers who (1) are still alive and retired; (2) officers who are already deceased but whose families receive survival benefits; and (3) officers who died on duty (casualties) and did not support any designated beneficiary in the BAF pension plan. We were not able to retrieve information for a minority group of officers composed of deceased individuals who did not die on duty and had no wives and children or whose beneficiaries are also dead. All individuals receive a service identification number in the system, which helps the data managers keep track of them. Since the BAF pension system demands utmost control due to government legal accountability issues, the data are continuously updated and checked, making them particularly reliable when compared to other cohort data in Brazil.

Because our objective is to examine mortality during most of officers’ lifetime, we looked for the oldest cohorts for whom mortality and demographic information were reliable and readily available. We are also interested in selection mechanisms within a developing country context. Thus, we only gathered data on career officers, excluding enlisted personnel and recruits. Admission to the academies is competitive, requiring high academic, physical, and social accomplishments. Academy cadets receive free tuition, other expenses, and a stipend, living a complete immersion into military life. Following these criteria, we collected data for officers who joined the BAF from 1947 through 1960. Of the 808 eligible individuals from those cohorts, we excluded officers for whom there was no information on place of birth (n=90), and cases with missing birthdates (n=12). Thus, our analysis is based on a sample of 706 individuals: 395 survivors and 311 deceased. We compared the proportion of total deaths, the proportion of deaths during military service, and the career profile of the 102 individuals excluded from the

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1 The Director of the Center, Brig. Gen. Jorge Marones de Gusmão, granted and formally approved access to the military records.
analysis with the remaining 706 officers in our sample, and found no statistically significant differences between the two groups (results available upon request).

Variables

In order to measure the mortality patterns among BAF officers, we recorded complete dates of enrollment, birth and death (or end of follow-up, which was set at 30\textsuperscript{th} of June 2013, date of the last system update). Information on deaths was available for two groups of causes of deaths: deaths during military service (casualties) and other remaining causes of death. For analyzing the possible effect of childhood conditions we obtained information on place of birth as of the enrollment date in the BAF, which was categorized according to two main geographic regions: the Northern states located in the northeast, north and center-west parts of Brazil and the Southern states located in the south and southeast parts of the country. Whereas the northern area comprise the least socially and economically developed states of Brazil, the southern area include the wealthiest states. In addition, candidates at that time chose upon their application if they wanted to follow a career on aviation or on administrative affairs, so we were able to collect information on these two types of career. Once enrolled, officers could be dismissed or opt to leave, but their choice of career was fixed and could not change throughout their training or thereafter.

Analytical approach

To estimate mortality levels among BAF officers, we first predicted age-specific death rates based on the coefficients of Poisson modeling that controls only for age. We then compared the age specific death rates for the BAF officers with male death rates for Brazil and a selected number of countries, which are known for their low levels of mortality and high quality mortality data. We not only compared mortality rates, but also the estimated truncated life expectancy at age 80 for all populations being considered in the analysis. The truncation is necessary to make the comparisons consistent with the average age of BAF officers at the end of the following-up period.

The list of countries in our analysis includes Chile, Sweden, France and Japan. The mortality data for these countries were obtained in HMD (The Human Mortality Database). We also compared our estimates with mortality data for Brazil obtained from IBGE (Instituto Brasileiro
The mortality estimates for the selected countries are for the year 2000, because this is the earliest year we were able to get official mortality data for Brazil. About 60% of deaths of the 1947-1960 BAF cohorts occurred between the years 1995 and 2013 and therefore, the choice of year 2000 does not imply in any important bias in our comparisons. However, to improve our analysis, we also estimated age-specific mortality rates for the Brazilian males born in 1935 (the mean year of birth of the BAF cohorts) using data from the United Nations complete life tables for the years 1950 to 2015, and compared to the military mortality estimates.

In the second part of our analysis, we examined the association of place of birth with survival among the individuals of the BAF cohort, controlling for career. We looked at two groups of causes of death, casualties and other causes, through a competing risks framework. The standard approach for survival analysis is the non-parametric Kaplan-Meier estimator survival curve, usually followed by Cox proportional-hazards regression models. However, it has been discussed that depending on the research question, due to its assumption of independence between causes, the Kaplan-Meier is a biased estimator, overestimating the incidence rates of a particular cause when in presence of other causes (for details, see Klein et al 2001). Hence, we used the cumulative incidence function (CIF), a non-parametric summary curve for analyzing competing risks data, which provides the cause-specific hazards in presence of other causes. CIF is defined as: $F_k(t) = \int_0^t \bar{F}(s-)\lambda^*_k(s)ds$, with $\bar{F} = \exp\{-\sum_{k=1}^K \int_0^t \lambda_k(s)ds\}$, and represents the probability that an event of type $k$ has occurred by time $t$. In a competing risks setting, there is an underlying hazard $\lambda^*_k$ that corresponds to the cause-specific cumulative incidence function, also denominated the subdistribution hazard. This underlying hazard, called sub-hazard ($\lambda^*_k$), corresponds to the cause-specific cumulative incidence function via $\bar{F} = \exp\{-\sum_{k=1}^K \int_0^t \lambda^*_k(s)ds\}$.

After describing the survival curves for cohort of BAF officers, we modeled the underlying hazard through the proportional hazards model for the subdistribution (FG), proposed by Fine and Grey (1999). The FG model is very similar to the Cox regression model, with the difference that the former applies to the sub-hazard underlying the cumulative incidence function (CIF). The model is estimated using the partial likelihood principal and weighted principles. Since our
concern is not specifically with modeling the cause-specific hazards, but understanding if place of birth is associated to cumulative cause-specific hazards, the FG approach is more appropriate than the Cox regression, which gives the effect on the instantaneous risk of death. One disadvantage of using the FG approach is the difficulty in interpreting its results in terms of the magnitude of the effects. On the other hand, because the transformation is monotonic, positive coefficients indicate increases in the CIF and negative ones indicate decreases. Since for the purposes of this study it suffices to know the direction of the effect, we did not have problems interpreting the results.

RESULTS

Table 1 shows the distribution of cohort members according to survival status and the variables used in our analysis. The results show that 44% of the cohort is alive by June 30th, year 2013. Among all deaths, one fourth occurred on duty. When we analyze the differences by place of birth, we found that 56% of officers who were born on the Northern region of Brazil were deceased by the end of the follow-up period, compared to only 36% among those who were born on the Southern region. Also, among the deceased, 13% died from casualties in the Southern region, compared to 34% in the Northern region. As for career, 43% of pilots died by the end of the study period, compared to 50% of the administrative officers. Not surprisingly, most of deaths from casualties were concentrated among pilots (97%).

<table>
<thead>
<tr>
<th>Table 1: Descriptive Characteristics, by Region of Birth, Career and Causes of Death</th>
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<tbody>
<tr>
<td>Variables</td>
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<tr>
<td></td>
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<tr>
<td>Total</td>
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<tr>
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<td>Northern</td>
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<tr>
<td>Southern</td>
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<tr>
<td>Career</td>
</tr>
<tr>
<td>Pilot</td>
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<tr>
<td>Adm. Officer</td>
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</table>
Mortality differentials by age

With the purpose of analyzing mortality differentials by age, we first estimated age-specific mortality rates by fitting Poisson regression models accounting only for age. Afterwards, we compared the predicted age-specific mortality rates for the BAF cohort and compared them with the mortality rates for other populations: Sweden, Chile, France, Japan and Brazil (Figure 1). The concentration of on duty deaths at younger ages makes the death rates higher at age groups 15-24 and 25-34 among BAF officers than in any other population. This is true even when we compare the BAF age-specific mortality rates with those for the 1935 Brazilian cohort, suggesting that the risk of dying on duty was not trivial, despite the fact that Brazil was not on war during this time. After the age of 55, the mortality rates for BAF officers become comparable and even lower than those for the populations that are known for experiencing the lowest mortality levels in the world. These results suggest a high degree of health selection among BAF officers in Brazil.

In order to get a better understanding of the differences in mortality patterns across the populations compared in our analysis, we also estimated mortality ratios for ages 45 and above assuming the age specific mortality rates for Sweden as the standard. The closer the ratio is to the value of one, the closer the mortality of that given population in a certain age group is to Sweden’s mortality rate. As shown in Figure 2, the mortality rates for BAF officers, regardless if deaths from casualties are included in the analysis or not, present a very similar mortality pattern to that of Sweden.. The same is true for Japan (2000). For France (2000) and Chile (2000), mortality levels are somewhat larger at ages 45 to 64, but become more similar at the older age groups. More striking are the results for Brazil (2000) and for the Brazilian cohort born in 1935. There is a clearly downward mortality pattern for these two sets of estimates, characterized by much higher mortality levels at younger adult ages gradually reducing towards Swedish levels at older ages. These findings confirm earlier analyses that have shown a distinct pattern of mortality among adults in Brazil (Turra 2009; Paes 2005), which is probably caused by age misreporting at older ages. These results could also be indicating compositional effects from risk heterogeneity by age in the total population. However, the simple fact that the much flatter mortality pattern for the BAF officers is based on high quality information, offers another piece of evidence for the presence of data artifact at older ages in the national population (Preston, Elo and Stewart 1999).
Figure 1. Age-specific adult male mortality rates, Sweden (2000), Chile (2000), France (2000), Japan (2000), Brazil (2000), Brazilian cohort (1935) and BAF officers.

Figure 2. Mortality ratios Chile (2000), France (2000), Japan (2000), Brazil (2000), Brazil cohort and BAF (cohort), with Sweden (2000) as pattern.

The mortality differences translate into variations of the truncated life expectancy at age 80 across the populations. Not surprisingly, given the results discussed before, life expectancy by age for the BAF officers is very similar to life expectancy by age for the Swedish males in 2000 (Table 2). Consistently, Brazilians (both in the year 2000 and from the 1935 cohort) have much lower life expectancy at age 45 (respectively, 25.68 and 25.91 years of life) than BAF officers (30.25). At age 75, the difference between BAF cohorts and the 1935 Brazilian cohort is
inverted, reflecting the distinct (and probably biased) pattern of mortality in the Brazilian total population.
Table 2. Male life expectancies for BAF, Sweden, Brazil 2000 and 1935 Brazilian cohort

<table>
<thead>
<tr>
<th>Age</th>
<th>BAF</th>
<th>Sweden</th>
<th>Brazil</th>
<th>Brazil cohort</th>
</tr>
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<tbody>
<tr>
<td>45</td>
<td>30.25</td>
<td>30.43</td>
<td>25.68</td>
<td>25.91</td>
</tr>
<tr>
<td>55</td>
<td>21.16</td>
<td>21.22</td>
<td>17.85</td>
<td>18.58</td>
</tr>
<tr>
<td>65</td>
<td>12.67</td>
<td>12.57</td>
<td>10.73</td>
<td>11.60</td>
</tr>
<tr>
<td>75</td>
<td>4.33</td>
<td>4.46</td>
<td>4.04</td>
<td>4.38</td>
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</tbody>
</table>


However, one should be careful when comparing BAF estimates with those from other populations since the number of cases is small and there is large statistical uncertainty. The ratio of mortality rates in the upper bound to mortality rates in the lower bound can be as high as 8 for the age group 35-44 and as low as 2.29 for the age group 15-24.

Mortality and place of birth among BAF officers

In this section, we examine the association between place of birth and military mortality in Brazil. To do that, we first look at survival trajectories through cumulative incidence functions. Figure 4 shows the curves by other causes of death and casualties, respectively, with the corresponding 95% confidence intervals and p-values for difference between the curves. The CIF by other causes of death indicates that the pattern of mortality by region of birth is similar. The incidence curve looks lower in the southern region, especially in the first 30 years of follow-up, but the statistical test did not show any statistical difference. The median follow-up time is also similar in the two regions: 50.53 years for the northern region and 49.37 for the southern region.

When looking to casualties, however, the incidence of death is significantly higher for the northern region. The median time of follow-up was 10.78 years for officers born in the southern region compared to only 7.48 years for those form the northern states.

The results of the FG models confirm the CIF findings (Table 3). First, there is no significantly statistical difference by place of birth when we look at mortality by other causes. Interestingly, when we control for career type, the incidence of death from other causes is lower among pilots than for administrative officers (p<0.001), maybe suggesting they are positively selected for health. On the other hand, being born in the Northern region is positively associated with the
incidence of death from casualties, as shown by the CIF. Controlling for career type reveals that most of the excess mortality from casualties in the Northern region is due to the larger presence of pilots there, who of course are exposed to higher risks of dying on duty than administrative officers.
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Table 3. Fine and Grey Models for Regions of Birth and Career, by Causes of Death

<table>
<thead>
<tr>
<th>Region of birth</th>
<th>Deaths by Other Causes</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Deaths by Casualties</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
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<tbody>
<tr>
<td>Southern</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Northern</td>
<td>0.1272</td>
<td>0.1417</td>
<td>1.4596***</td>
<td>1.4596***</td>
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<tr>
<th>Career</th>
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<td>Administrative</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pilot</td>
<td>(-0.6390)***</td>
<td>2.1867**</td>
<td></td>
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*p<.05; **p<.01; ***p<.001

DISCUSSION

In this study we took a novel look at military data and its implications for demographic and health research in Brazil. Notwithstanding the relevance of other work that focused on military data as a means of analyzing the extremely negative effects of warfare related issues on health and mortality, such as starvation, stunting and Post Traumatic Stress Disorder, we argued that the military, and especially career officers in a conflict-free context, are also paramount to understanding positive effects on health and mortality. Even more importantly, in a developing country scenario where lack of reliable and longitudinal data leaves demographers and other researchers with great uncertainty regarding mortality schedules, focusing on subgroups that offer high-quality information places us closer to the whereabouts of the “true” mortality function. In addition, we argued that studying more closely highly selected subgroups of the population may contribute to a better understanding of the upper limits of life expectancy and the mechanisms underlying survival advantages.

With gained access to the pension fund system of the Brazilian Air Force and including only career officers, we were able to examine the mortality pattern, level and place of birth effect on adult mortality for this highly selected subgroup of individuals relative to their national
counterparts and other countries. These individuals are not only physically, psychologically and
cognitively selected to become officers, but they are also exposed to a healthy and controlled
environment since their admission in the institution. We thus tested two main hypotheses: (1)
BAF officers experience lower mortality levels than the average Brazilian male; (2) factors that
have been evidenced to affect adult mortality, such as different socioeconomic backgrounds, are
offset in the Air Force population subgroup by selection and their long-lasting exposure to a
privileged healthy environment. By testing those two hypotheses we aimed at providing further
insight on the factors that influence mortality in typically heterogeneous populations when we
have the opportunity of investigating more homogenous, select populations.

Our results confirmed a significant survival advantage of BAF officers when compared to the
average Brazilian male in 2000 as well as men from the 1935 Brazilian birth cohort. We showed
that BAF life expectancy is comparable to those in low mortality countries, such as Sweden,
France and Japan in 2000. Since BAF estimates are based on follow-up data, collected since
1947, BAF mortality is probably even more selective compared to the low mortality populations
than the results showed in this article. This result has an important implication. It indicates that
there is no specific developing country threshold of mortality. In other words, one could expect
either that the mortality range had a specific limit, in a sense that even the most selected
population subgroup in a developing country could not outlive another in a low mortality
country, or that health and mortality inequalities can be so large that one might see “islands of
Sweden” within a country like Brazil. Our results confirm the last case.

Our results also confirmed findings from earlier studies that looked at the influence of mid-life
conditions over survival of a certain subgroup (Kaden 2013; Kannisto 1997). We found that
place of birth had no statistically significant association with BAF mortality throughout the
follow-up period when considering other causes of death. Officers who were born in the more
developed regions of Brazil presented no survival advantage relative to those who were born in
the less developed regions, indicating that despite coming from different socioeconomic settings
during childhood, there are no signs of scarring effects among individuals born in the northern
region. Both the selection of officers during enrolment and the impact of providing similar health
and socioeconomic conditions during enrolment may explain these results. It is well known that
the military institutions in Brazil make strong efforts to continuously provide nutrition,
healthcare, income and all other types of support since officers join the forces. Also, standardized experiences, as we have mentioned previously (Castro 2000), is a crucial element in efficiently coping with military training and duty, which often involves risky and stressful situations. In addition, other research has shown that strong social ties and cohesiveness may be an important predictor of mortality and health outcomes. For example, among the Union Army veterans of the American Civil War, those who faced greater wartime stress experienced higher mortality rates at older ages, but those who were from more cohesive companies were statistically significantly less likely to be affected by wartime stress (Costa and Kahn 2010). However, it is important to note that the direction of health effects in a cohort perspective depends on the relative contributions of selection, scarring and immunity (Myrskyla 2010; Costa 2012), and they tend to occur together. At the same time that early exposure to disease or socioeconomic deprivation may influence later mortality by disease latency (Elo and Preston 1992) and increased inflammation levels (Finch and Crimmins 2004), an amount of early exposure to disease may be beneficial to the immune system (Gurven et al. 2008). In addition, it is possible that at the cohort level early-life conditions are important to explain morbidity later in life, but not mortality differentials, not to mention the important debate on what matters most for later-life conditions on mortality: period or cohort effects (Finch and Crimmins 2004; Barbi and Vaupel 2005). In order to test for those debated effects, we need currently unavailable information on health and morbidity for those officers. So, despite the fact that there are no significant mortality differentials among them, further investigation is needed to know if the same applies to morbidity.

This work also points out the importance of studying more closely male mortality (Yates, 2008; Hayward, 1997; Rosero-Bixby, 2008). Despite being an important limitation of our work to not include women, studies that focus on women mortality and health are often more numerous because women live longer and mortality data for them are of better quality (Case and Paxson 2005; Case and Deaton 2003). In this sense, another contribution of our study is to acknowledge male adult mortality in Brazil.

Finally, our mortality estimates for BAF officers provide a more accurate indication of the current upper bounds for male survivorship in Brazil and also yield a more reliable mortality pattern, especially at older ages. Learning about mortality limits is important in a very unequal
country. In addition, mortality data, particularly at older ages, are defective. Although our sample is small and limited to a particular subgroup, our data is accurate, longitudinal and contains complete information on ages at birth and death in a substantially better way than in other traditional mortality datasets in Brazil. We argue that analyzing selected subgroups is key to better understanding mortality and health outcomes in such a context.
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