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Estimate of Life Expectancy Reduction in China Following the End of the Zero-COVID Policy

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Introduction

After three years of strict control to contain the spread of COVID-19, China relaxed the zero-COVID policy on November 11, 2022 and ultimately lifted it on December 7 2022. The abrupt policy shift is believed to have left both the public and healthcare facilities unprepared. As one example, vaccine completion among older adults remained relatively low before the policy shift. By July/August 2022, among those aged 80 and over, only 71.9% completed the primary series and 46.7% completed booster shots and the vaccination rates remained stagnant (Wang et al. 2023). While anecdotal reports and indirect estimates indicate increased mortality, no direct, nationally representative estimates data have been available (Yao, Hu, and Liu 2023).

A few studies have attempted to estimate excess mortality in China immediately following the policy change. One approach combines age-specific infection fatality rates, drawn either from China prior to the policy change or from regions outside mainland China that experienced comparable Omicron outbreaks[1], with vaccination data and population structure to build simulation models (Du et al., 2023; Ioannidis et al., 2023). Two other studies estimated all-cause mortality rates using published obituaries from high-profile educational and professional institutions (Raphson and Lipsitch 2024; Xiao et al. 2023). For example, Raphson and Lipsitch (2024) used obituaries of members of the Chinese Academy of Engineering (CAE) to calculate mortality rates among senior CAE members and extrapolated the number of excess deaths among urban residents in China. Similarly, Xiao et al. (2023) calculated regional mortality rates by dividing the number of published obituaries of deceased official employees from three top

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[1] According to a report from China's CDC, between December 1, 2022, and January 23, 2023, a total of 10,165 valid SARS-CoV-2 genome sequences from domestic cases were reported nationwide, all of which were identified as Omicron variants.

universities by the total number of employees. To extrapolate these local mortality rates to a national estimate of excess mortality, they incorporated data on changes in online search behavior. Specifically, they used the relative increase in the volume of internet searches for mortality-related keywords, such as “crematorium”, on a major Chinese search engine as a proxy for the geographic and temporal intensity of mortality events. By scaling the observed regional mortality rates according to the pattern of these search trends across provinces, they inferred the likely excess deaths nationwide. Huang et al. (2023) employed a comparable method by analyzing changes in online search volume for terms related to mourning and funerals before and after the policy shift, but used mortality levels from two years prior to the pandemic as the benchmark, rather than institutional obituary-based estimates.

Although innovative in providing timely mortality estimates following the policy change, these estimates are indirect and, as noted in the original studies, may be subject to bias in either direction. Drawing on reports of recent household deaths from the Annual Sample Survey on Population Changes (APC), this study applies traditional demographic methods to examine changes in all-cause mortality following the relaxation and eventual end of the zero-COVID policy. Questions on recent household deaths have been incorporated into censuses and large household surveys in many countries, and have proven useful for accessing mortality levels and trends especially in places lacking comprehensive civil registration and vital statistics (CRVS) systems or during health crises (da Silva and Castanheira 2024; Lankoandé et al. 2022). Compared to other data sources that provide only summary mortality indices for specific age groups, reports on recent household deaths enable the construction of complete life tables at both national and subnational levels (Lankoandé et al. 2022; Adjiwanou et al 2020).

An additional strength of the APC is its coverage of the years immediately before and after the policy change. Conducted in every non-census year on November 1, the APC asks respondents to report any household deaths that occurred over the preceding year. The 2022 wave was administered just before the relaxation of the zero-COVID policy, while the 2023 wave captured mortality from November 1, 2022, to October 31, 2023, providing data for the first full year following the policy shift. As such, it captures not only the mortality surge in December 2022 but also its aftermath, including deaths linked to strained health system capacity and delayed reporting.

Data and Method

The APC, which samples one-thousandth of the national population (around 1.4 million individuals), employs a multi-stage, systematic cluster sampling design with probability proportional to estimated size. The National Bureau of Statistics aggregates population and death counts at the national level and publishes them in the annual China Population and Employment Statistical Yearbook. Age-specific mortality rates are calculated by dividing the reported death counts by the average population in the survey year provided in the yearbook's tabulation. To address this limitation, I first compare the age structure of the APC samples with the national census to assess representativeness and then construct uncertainty intervals when estimating mortality rates.

[Figure 1 here]

Figure 1 compares the unweighted age distribution from the APC surveys with the population age structure from the 2020 census. The age distribution of the sample aligns closely with that of the census, suggesting that the survey samples provide a reasonable approximation of the general population structure. Still, the resulting age-specific mortality rates are likely to underestimate the true mortality level in the absence of appropriate weighting. Even with information on sample weight, survey question asking recent death from household are known to underestimate mortality levels for several reasons (Lankoandé et al. 2022; Timæus 1991).

Death events are relatively rare and often clustered. The death of a household member, especially in single-person households, can result in household dissolution before the survey is conducted. Additionally, deaths may be forgotten or deliberately omitted, and longer recall periods increase the likelihood of underreporting, particularly for deaths that occurred early in the reference period. For example, Lankoandé et al. (2022) found that deaths among those over age 60 were underreported in the Burkina Faso census, leading to life expectancy at birth being underestimated by 4 years for men and 8 years for women compared to national surveillance data. On the other hand, mortality estimates based on household deaths offer a reliable measure of adult mortality. Using survey data from Peru, da Silva and Castanheira (2024) demonstrate that adult mortality estimates based on household deaths successfully capture the effects of the pandemic and closely align with the estimates from the World Population Prospects (WPP). For these reasons, I estimate life expectancy at birth using three approaches: (1) constructing a complete life table using raw age-specific mortality rates from the APCs, (2) applying a model life table to adult mortality rates from the APCs, and (3) applying a model life table to adult mortality rates from the APCs combined with infant and under-five mortality rates from surveillance-based annual reports from the National Health and Family Planning Commission (NHFPC)[2].For the model life table, I use the United Nations Far Eastern pattern. Arriaga's decomposition was applied to assess the contribution of each age group to changes in life

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[2] Because the infant and under-five mortality rates from the NHFPC are reported without gender disaggregation, I applied the total rates to both male and female estimates.

expectancy at birth between the year before and after the policy change, based on complete life tables constructed using method (1).

I also compare the estimated adult mortality rate and life expectancy at birth from APC with those estimates from the WPP 2024. The age-sex pattern of mortality in the WPP were estimated using a combination of methods for child, adult, and old age mortality with a Bayesian hierarchical model. The neonatal, infant, and under-five mortality rates up to 2023 were directly obtained from death registration data from the NHFPC. The adult and old-age mortality rates for the years 2021 to 2023, however, are based on model estimations. More importantly, the WPP 2024 incorporates additional empirical information on “China 2022–2023 COVID-19 excess deaths based on vital registration statistics from Hong Kong SAR” to inform age-sex mortality patterns for China in 2022 and 2023 (United Nations 2024). However, it should be noted that the reference time periods underlying the mortality estimates from WPP and APC are not identical. While the WPP estimate is based on the calendar year, the APC estimate covers the period from November 1st to October 31st.

I construct 95% uncertainty intervals using a three-step simulation approach following the method of da Silva and Castanheira (2024). I first assumed that the reports of household deaths were drawn via simple random sampling, as the survey’s sampling weights are not publicly available. Under this assumption, and treating deaths as Poisson-distributed events, I approximated the standard error of the log mortality rate for each age group using the delta method. This standard error serves as a proxy for sampling uncertainty in the absence of actual survey weights. Next, I simulated 10,000 values of log-transformed age-specific mortality rates from a normal distribution, with means equal to the log of the point estimates derived from the APC and standard deviations equal to the proxy standard errors. In the third step, I simulated

10,000 age-specific death counts from a Poisson distribution using the mortality rates from step 2. This step captures stochastic uncertainty arising from random variation in death occurrences, even when the underlying mortality rate is fixed (Hendi 2023). I then divided the simulated death counts by the observed population exposures to obtain simulated age-specific mortality rates. Finally, 95% uncertainty intervals were constructed using the 2.5th and 97.5th percentiles of the simulated distributions.

Results

Figure 2 compares age-specific mortality rates from the APC and WPP across two time periods. Among individuals aged over 20, the APC point estimates for the year following the lifting of the zero-COVID policy are generally higher than those from the preceding year, except for the 45–49 and 60–69 age groups. The uncertainty bounds are wider among younger age groups in the APC data, reflecting both smaller sample sizes and the inherent stochasticity of mortality. Although most APC point estimates from the two periods overlap within their uncertainty bounds, the mortality rate for the 80–84 age group is significantly higher after the policy change. Notably, the APC point estimates are consistently lower than those reported by the WPP, suggesting the reports of recent household death from APC may be underreported. However, it should be noted that the time periods underlying the mortality estimates from WPP and APC are not identical. While the WPP estimate is based on the calendar year, the APC estimate covers the period from November 1st to October 31st. The online appendix presents age-specific mortality rates by gender. Female curves are more irregular compared to male curves, especially for age groups below 45, suggesting the need for more cautious use of disaggregated mortality data from APC.

[Figure 2 here]

Figure 3 presents the estimated adult mortality probabilities (45q15) from APC by gender. The 45q15 is higher in the year after the lifting of zero-COVID policy than that of the year before the policy change. Again, the uncertainty intervals for the estimates from APC are large and do not capture the estimate the WPP estimate, suggesting an underreported of adult death.

[Figure 3 here]

Figure 4 uses Arriaga's method to decompose the contributions of each age group to the change in life expectancy at birth between the year before and after the policy change. Based on mortality estimates from the APC, the estimated life expectancy at birth declined by 1.26 years. The decomposition results indicate that this decline is primarily driven by increased mortality above age 75, which accounts for 83% of the total reduction. In addition, the contribution of age groups above 75 was statistically significant, as indicated by the simulated 95% uncertainty intervals being entirely below zero. The online appendix shows similar findings in the gender-specific analysis, indicating that increased old-age mortality is the primary contributor to the decline in life expectancy at birth for both men and women.

[Figure 4 here]

Table 1 compares life expectancy at birth across two periods using different estimation methods: raw age-specific mortality rates from the APC, adult mortality fitted with a modal life table, adult mortality combined with infant and under-five mortality and estimates from the WPP.

[Table 1 here]

Discussion

Using data from a national population survey, this study presents the first attempt to directly estimate of the change in life expectancy before and after the lifting of China's zero-

COVID policy. This study finds that life expectancy declined by 1.26 years from the year before to the year after the policy change, assuming that underestimation of deaths and sampling errors are systematic and consistent across years. In addition, results from Arriaga's decomposition indicate that 83% of this decline is attributable to increased mortality among individuals aged 75 and older. The estimated life expectancy reduction is lower than the 1.87-year decline in the US but higher than the 0.58-year average reduction across 21 other developed economies during the initial impact of COVID-19 from 2019 to 2020 (Woolf, Masters, and Aron 2022).

This study has several limitations. First, it relies on reports of household deaths from a one-thousandth sample survey to estimate age-specific mortality in the absence of sampling weights. Despite the effort to build uncertainty intervals, the estimates may still be biased if the sample is not representative or if reporting errors vary systematically across subpopulations and time. In addition, the estimates of life expectancy and its change are conservative, as previous studies suggest that household death reports from surveys consistently underestimate mortality levels (Lankoandé 2022; Timaeus 1991). Furthermore, COVID-19 disproportionately affected older populations, and life expectancy estimates based solely on adult mortality applied to a model life table may introduce bias. Individual-level surveys that collect information on parental survival status and date of death can serve as a valuable resource for future research on the impact of health crises on old-age mortality (Adjiwanou et al. 2020; Masquelier et al. 2024). This study focuses only on national-level estimates. However, as these surveys often include questions on socioeconomic status, future research could examine mortality differentials across socioeconomic groups.

Nevertheless, our estimates provide a valuable reference for the health emergency following the lifting of the zero-COVID policy. Future research should reassess these estimates when higher-quality data, such as those from the civil registration and vital statistics system or the national disease reporting system, become available.

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Figure 1. Age Distributions by Surveys/Census

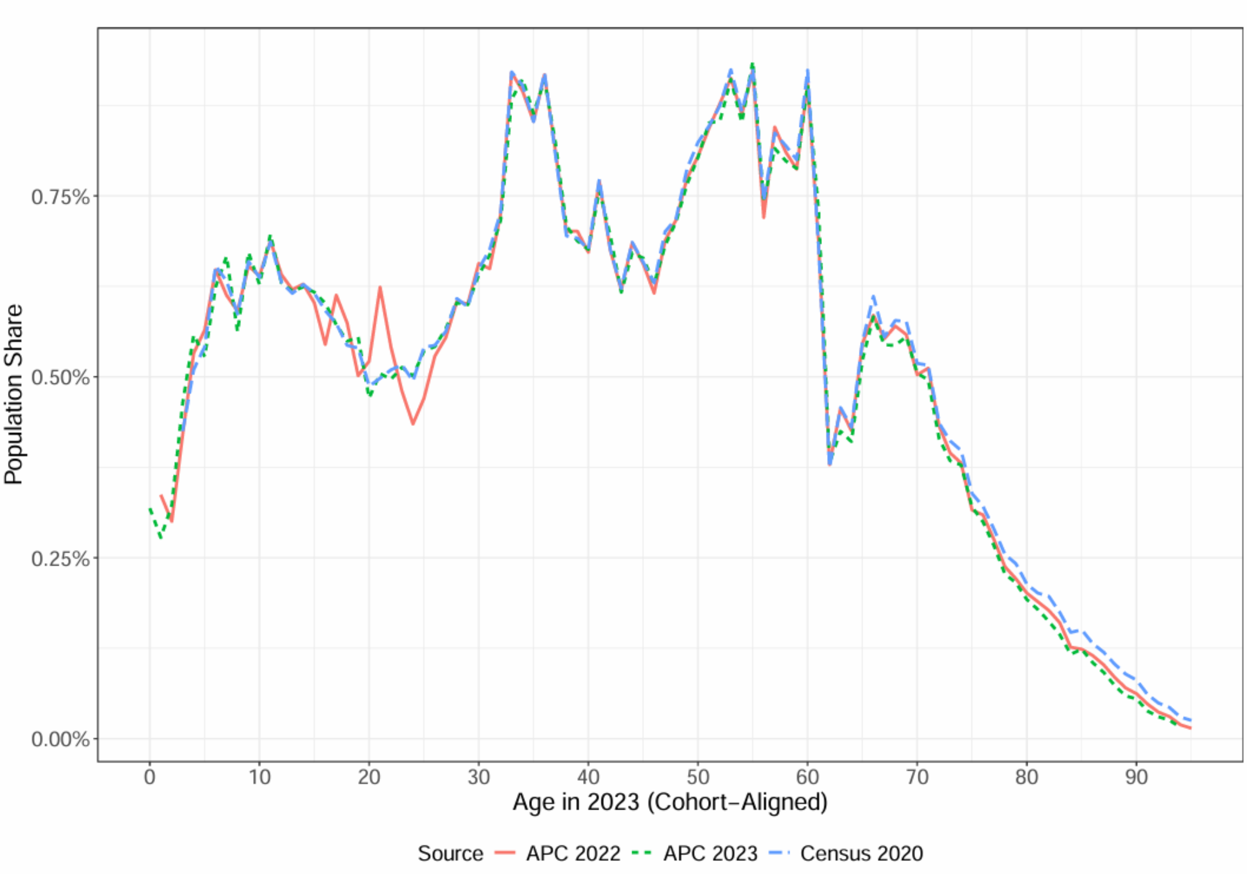

Figure 2. Age-Specific Mortality Rates by Surveys/Census

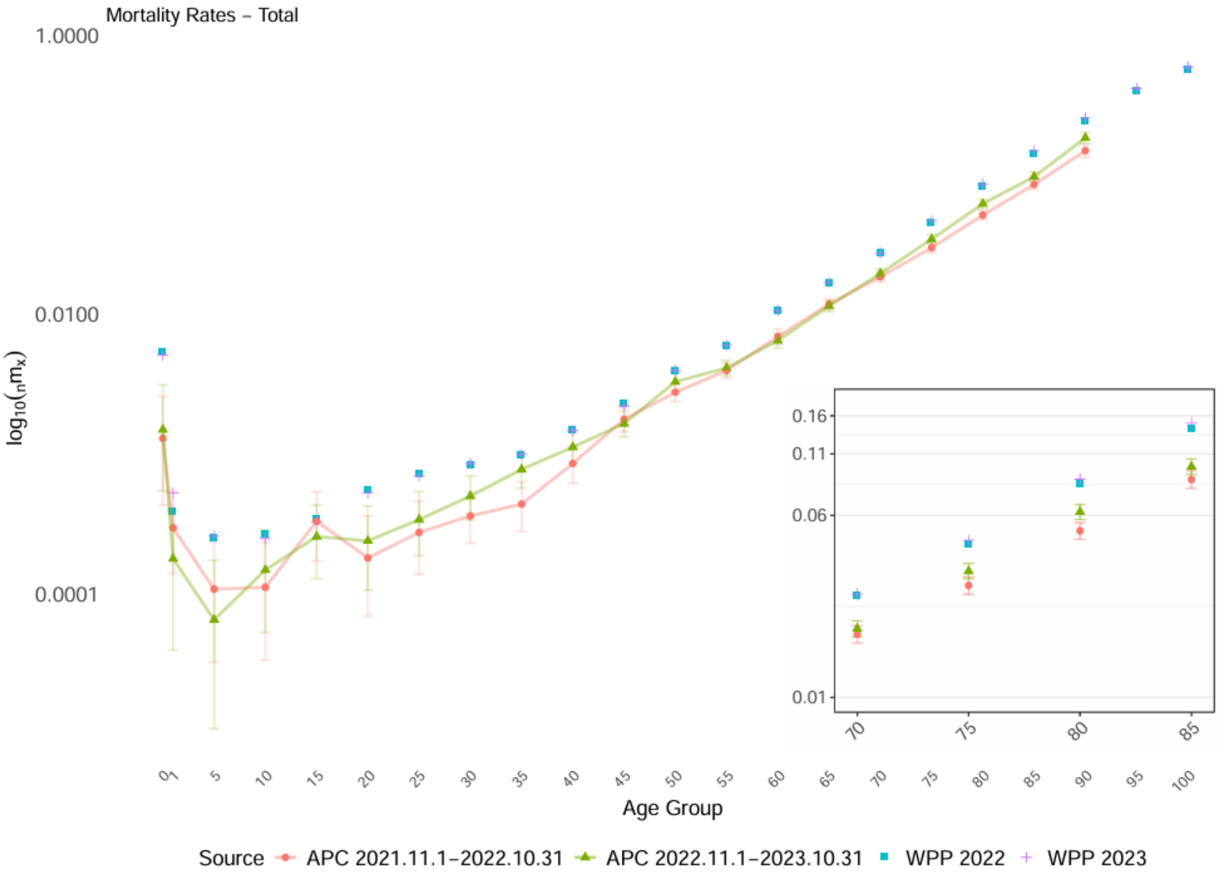

Figure 3. Estimated Adult Mortality Probabilities (45q15) from APC/WPP by Gender

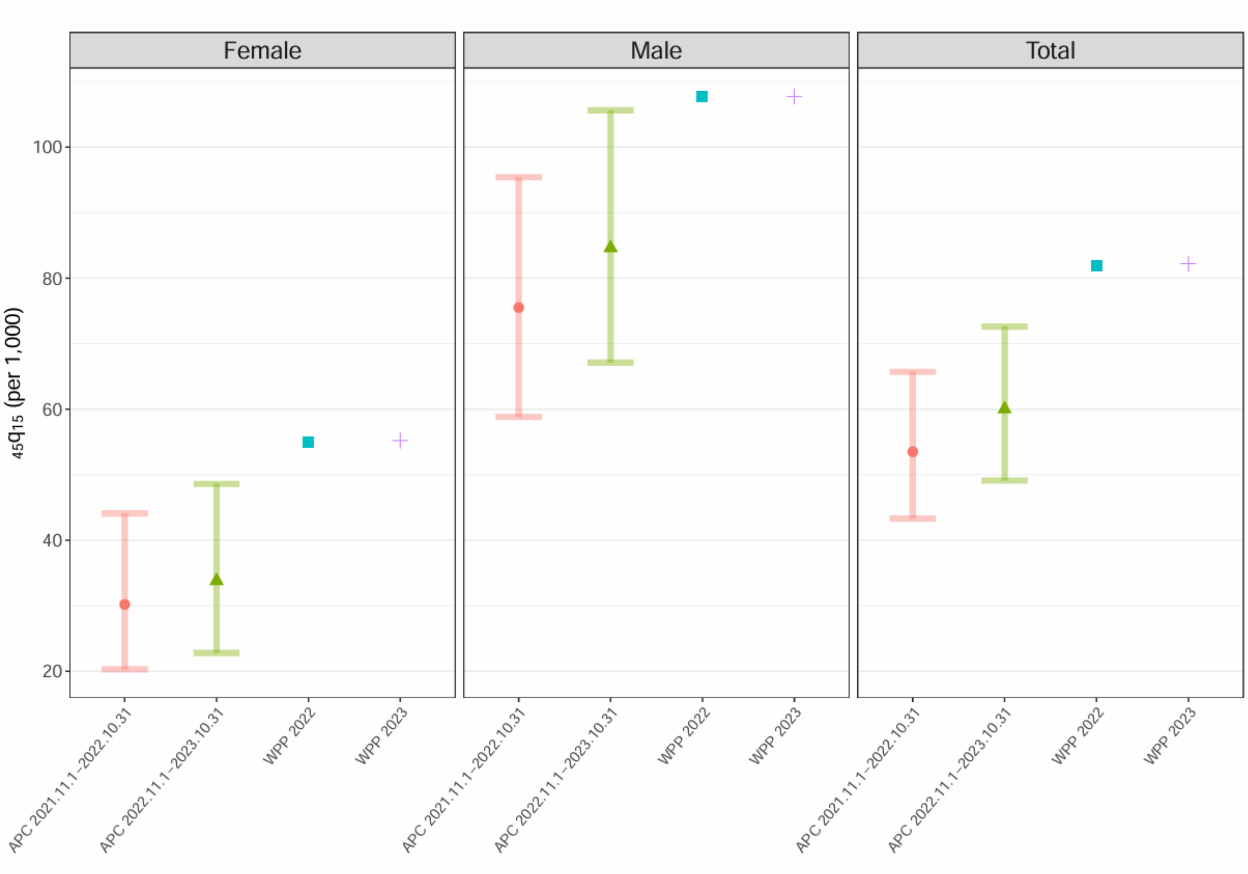

Figure 4. Arriaga's Decomposition of Age-Group Contributions to Changes in Life Expectancy at Birth Before and After the Policy Change

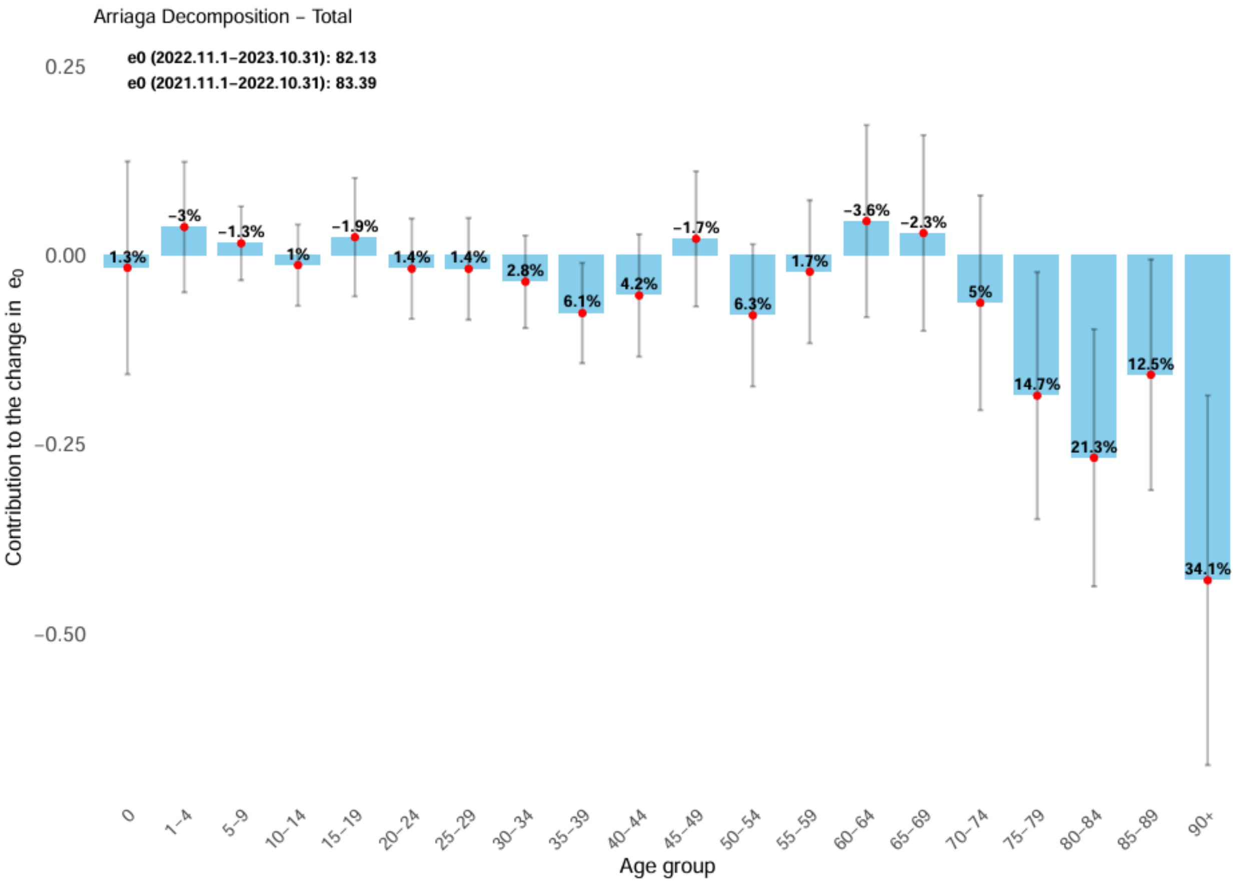

Table 1. Life Expectancies at Birth

	Methods/Source	2022	2023	Gap
Total				
	WPP	78.20	77.95	0.25
	APC	83.39	82.13	1.26
	APC-Model			
	APC-Model-Adjust			
Male				
	WPP	75.47	75.20	0.27
	APC	80.38	79.31	1.06
	APC-Model	82.70	82.22	0.48
	APC-Model-Adjust	78.01	77.10	0.92
Female				
	WPP	81.13	80.93	0.21
	APC	86.69	85.30	1.39
	APC-Model	88.56	87.61	0.95
	APC-Model-Adjust	87.45	86.66	0.78