Month of Birth and Child Height in 40 Countries

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Abstract

Lokshin and Radyakin (2012) present evidence that month of birth affects child physical growth in India. We replicate these correlations using the same data and demonstrate that they are the result of spurious correlations between month of birth, age-at-measurement and child growth patterns in developing countries. We repeat the analysis on 39 additional countries and show that there is no evidence of seasonal birth effects in child height-for-age z-score in any country. Furthermore, we demonstrate that the Demographic and Health Survey data used to estimate the correlation is not suitable for the task due to a previously unrecognized source of measurement error in child month of birth. We document results from several papers that should be re-interpreted in light of this issue.

Keywords: child health; month of birth; anthropometrics; Demographic & Health Survey

JEL Codes: I15; J13; O15

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1 Introduction

It is an odd fact about the world that month of birth correlates strongly with an incredible number of human health and development measures. A recent paper in the Journal of Human Resources (Lokshin and Radyakin, 2012, henceforth L&R) argues that month of birth affects child physical growth in India. Children born at different times of the year are exposed at different points in their developmental trajectory to the deteriorated health environment brought on each year by the monsoon rains. Thus, they argue, the appearance of correlations between month of birth and height-for-age z-score (HAZ) can be interpreted as evidence of the importance of the timing of inputs in the health production function.

While there is a long tradition across the social and biological sciences of finding robust effects of birth season on human development, there is also a history of data artifacts or selection effects being misinterpreted as effects of birth season (Lewis, 1989; Strand et al., 2011; Buckles and Hungerman, 2008; Cummins, 2013). We argue that the apparent seasonal effect documented by L&R is less likely due to exposure to any monsoon-related disease environment, and more likely a lack of exposure to survey enumerators in the period after the monsoon rains. The uneven measurement timing across the survey year, typical for Demographic and Health Survey (DHS) data collection, induces differential mean age at measurement across birth month in the sampled children. This systematic age difference is then translated into a difference in HAZ due to the shape of the HAZ-age profile. After correcting for the spurious correlation between month of birth and age at measurement, our analysis produces no evidence of month of birth effects on child growth using the Indian DHS data.

The problem of survey timing above can be corrected econometrically. However, we provide new evidence from 39 additional countries that the DHS data are not suitable for the task of estimating the effects of birth month on child health. In DHS data from almost every country, children born in December have abnormally high or the highest relative HAZ and children born in January have abnormally low or the lowest relative HAZ. The effect is visible prior to correction for the survey-timing problem, but becomes pronounced after correction. The difference in mean HAZ between children born before or after midnight on December 31 averages out to between a 0.2 and 0.3 standard deviations (sd). Either the Gregorian calendar is more intimately based in human biology than has been previously documented (or even considered plausible), or there is significant measurement error in child month of birth across the broad family of DHS datasets. The DHS itself has reported such a problem (Assaf et al., 2015), but no previous work has noted the connection to HAZ and month of birth.

We identify 5 additional papers that report correlations between measures of child health and seasonal exposures based on analysis of data from the DHS (Brainerd and Menon, 2014; Dorlien, 2015; Mulmi et al., 2016; Darrouzet-Nardi and Masters, 2015; Tiwari and Jacoby, 2013). We discuss the state of the literature in light of our findings in section 6.

2 Background

Following L&R, we use data from the 1992/1993, 1998/1999, and 2005/2006 waves of the National Family Health Survey (the Indian DHS). Sample summary statistics from the first round can be found in Table A1. While there are measurements from most rounds in most months, there are decidedly fewer measurements taken in late summer as compared to other months (see Figure 2). This coincides roughly with the period after the monsoon rains. The effect on the sample is that, on average, children born in summer before and during the monsoons were measured at older ages than children born in the dry, monsoon-less winter. This imbalance in age at measure across birth month induces the appearance of seasonality in HAZ via the HAZ-age profile.

The HAZ-age profile from our sample in India is shown in the bottom panel of Figure 1, graphing mean HAZ across age-at-measure (in months). Similar to children in many developing countries, Indian children grow more slowly than the healthy, well-nourished children in the reference population. The cumulative effects of insufficient nutrition and poor health environment lead to children falling further behind the reference population over the first two years of life.

While L&R estimate birth season effects on a number of anthropometric measures, we focus exclusively on HAZ. HAZ is a cumulative measure of early life health and nutrition, making it possible for the measure to reflect month of birth effects that occurred months or years in the past. Weight-for-age and weight-for-height z-scores fluxuate in the short term and thus contain information on both recent and past health inputs.

The effect of survey timing by birth month is shown in the bottom panel of Figure 2, which isolates survey measurements taken in March and September separately. The bar graphs reflect the effects of survey timing directly, showing mean age-at-measure and mean-HAZ (Y-axis) for children born in each month (X-axis). For the measurements taken in March, we see a minimum child age in January and February, which increases through April, and the opposite pattern for September measurements. The line graphs then show this age-at-measure effect being translated into an HAZ effect via the HAZ-age profile. The two measure months generate opposite seasonal patterns in HAZ because the entirety of the sinusoidal effect is caused by differential age at measurement across birth month. Both line graphs also hint at an unexpected upward trend in HAZ across birth month, and we return to this in section 5.

3 Econometric Problem

Consider the following regression equation, similar to that employed by L&R:

$$HAZ_{iam} = \alpha_i + \delta_m * MOB_m + X'_{iam}\beta_X + f(age) + \epsilon_{iam} \quad (1)$$

Where HAZ_{iam} is the HAZ score of child i, aged a, and born in month m. X is a vector of controls that account for maternal, household, and community characteristics. MOB_m is an indicator variable for a child's month of birth. *f(age)* is an unknown function of age representing the "natural" HAZ-age profile for the country. Since *f(age)* is unknown, we assume the researcher specifies a parametric function g(age; γ) that is intended to "control" for age. L&R, for instance, include a linear specification of g() in their regressions. Following the modeling suggestions in Cummins (2013), we show that the appearance of seasonality vanishes as we employ increasingly flexible polynomial and non-parametric specifications of g(age; γ) and thus minimize the bias.

4 Replication

Figure 3 displays the coefficient estimates for month-of-birth effects for five specifications of EQ. 1, each of which differs only in how age is modeled. The naïve estimates (bottom line, light blue) do not control for age in any way, and there appears to be a sinusoidal, seasonal relationship in the month-of-birth coefficients. Children born in summer have the lowest HAZ, and then HAZ improves for each birth month from July through December. This is the underlying effect that L&R interpret as evidence of the negative effects of being born during or after the monsoon rains.

Controlling for age linearly (as do L&R) greatly reduces the sinusoidal nature of the estimates, but the relationship remains indicative of potential birth season effects. The three final specifications are increasingly flexible in age, allowing a quadratic, cubic, and finally a completely flexible form employing age-in-month dummy variables. The apparent seasonality is continually reduced by adding flexibility, with the polynomial and dummy variable specifications effectively eliminating any trace of a sinusoidal pattern across the year.

We find no evidence of month-of-birth effects in India in the sample examined by L&R. Instead, we see what appears to be an upward "trend" from January to December. To call it a "trend", though, overlooks the sharp discontinuity that occurs when December again gives way to January, implying (if interpreted literally) that the change in the Gregorian calendar date affects child HAZ by an amount greater than the difference in India between having an illiterate mother and a mother with 6 years of completed primary education (L&R).

5 Extensions

We now repeat the preceding analysis on a set of 39 additional countries with similar DHS data, and the results are similar to those from India. A number of countries (though not all) exhibit a sinusoidal pattern in HAZ across month of birth, but this is largely driven by differences in the distribution of child age at measurement across birth months. This can be seen in the left panel of each of the country specific figures presented in Figure A2 that show age at measurement and mean HAZ by birth month (similar to the bottom panel of Figure 2).

A more surprising empirical regularity uncovered in our analysis is presented in Figure 4. We aggregate all 40 countries into three geographic regions – Africa, Asia, and Latin America – and estimate month-of-birth effects for each region. The results are striking: a near perfect linear increase in HAZ across birth month, followed by (one would assume) a large fall between December and the following January. This same upward "trend" from January to December is also visible in many of the individual countries (see the right panel of Figure A2).

It is implausible that this upward trend reflects real month of birth effects. First, within a given country and age group, December and January born children experience quite similar in utero environments, making this discontinuity questionable from a social-environmental-biological standpoint. Second, the makeup of our sample spans a broad range of cultures, geographies, climates, and economies, making the persistence of this similar trend, were it some real effect in the world, an effect of an arbitrary cut-off from year to year set by the Gregorian calendar 500 years ago. Instead, the effect must be due to measurement error in child birth.

6 Affected Literature

The seasonal effects papers we discuss in this section employ one of two analytic frameworks: 1) estimating the effects of month of birth directly; 2) estimating group differences in seasonal exposures across time and/or space.

Category 1 analyses were the main focus of the discussion above. These analyses suffer from both the timing artifact bias described in Cummins (2013) and from systematic measurement error of age across birth month discussed in the preceding section. The month of birth estimates in L&R should be considered proven spurious. Similarly, the discussion of seasonal stunting patterns in Dorlien (2015) appears to misinterpret its results .

The analyses in category 2 rely on comparing changes in seasonal patterns across groups and/or time to identify the effect of interest, which is not month of birth directly but instead some exposure in the world that is changing with month of birth. In other parts of l&R and in Tiwari and Jacoby (2013), the timing of monsoon onset lets the authors claim to differentiate abstract month of birth effects from the health environment changes induced by the rains and/or income effects from the agricultural production cycle. In Darrouzet-Nardi and Masters (2015), seasonal differences across the equator and between rural and urban households identify the effect of market access on consumption smoothing. In Brainerd and Menon (2014), the authors rely on differential intensity in seasonal rain across cohorts and regions to generate within-birth-month exposures to toxic runoff in India. A key, but often unmentioned, identifying assumption in these models is the equality of measurement error in child birth date across treatment groups.

7 Conclusion

We have demonstrated two problems in the analysis of seasonal birth patterns using DHS HAZ data. First, we have shown that survey timing is the main determinant of the appearance of month of birth effects in DHS data across 40 countries. Second, we have shown that any attempt to directly estimate true season of birth effects on HAZ using DHS data is inherently impossible; the child birthdate data is not of sufficient quality to make such an analysis possible. We hope that our efforts will focus attention on the need for improved measurement in child birth date when conducting large-scale health and demographic surveys in developing countries.

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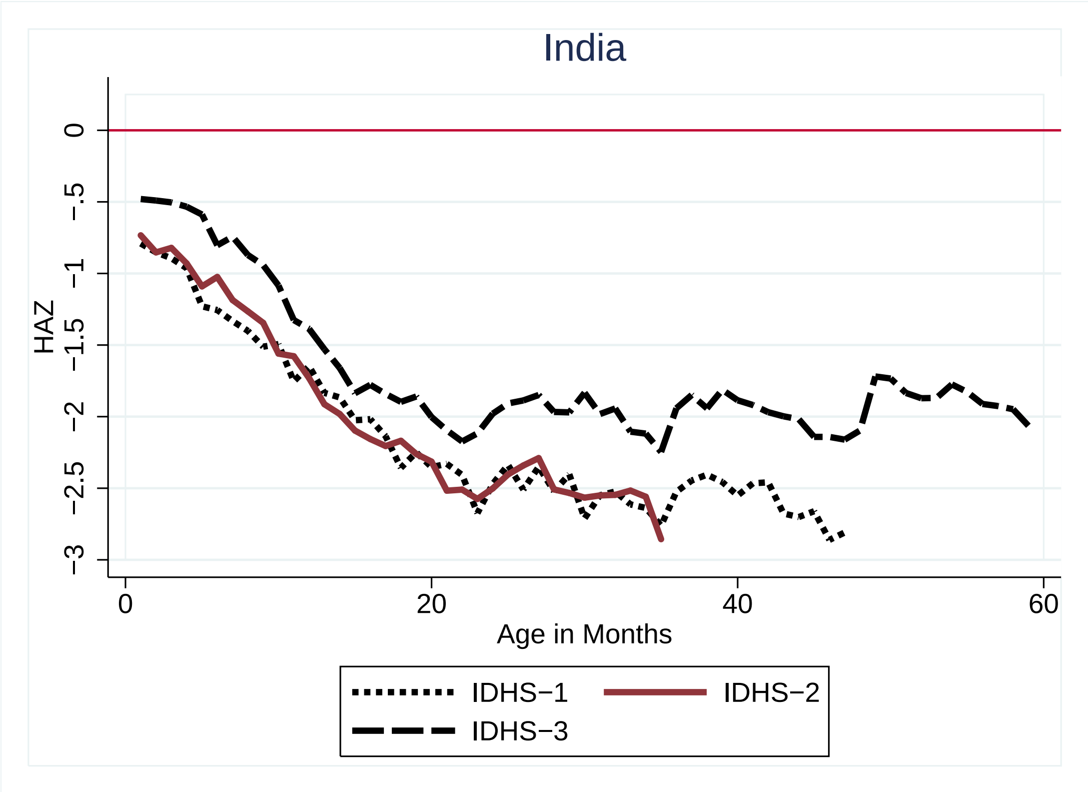
Results



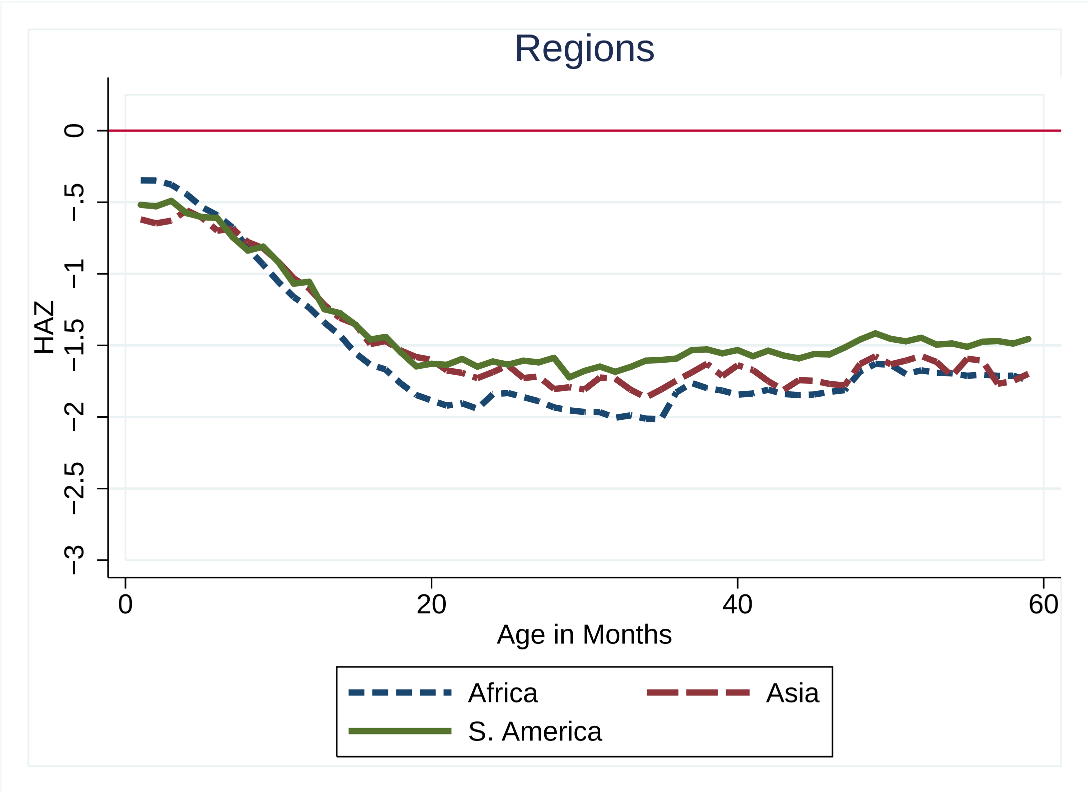


Figure 1: HAZ-Age Profile (India and other regions)

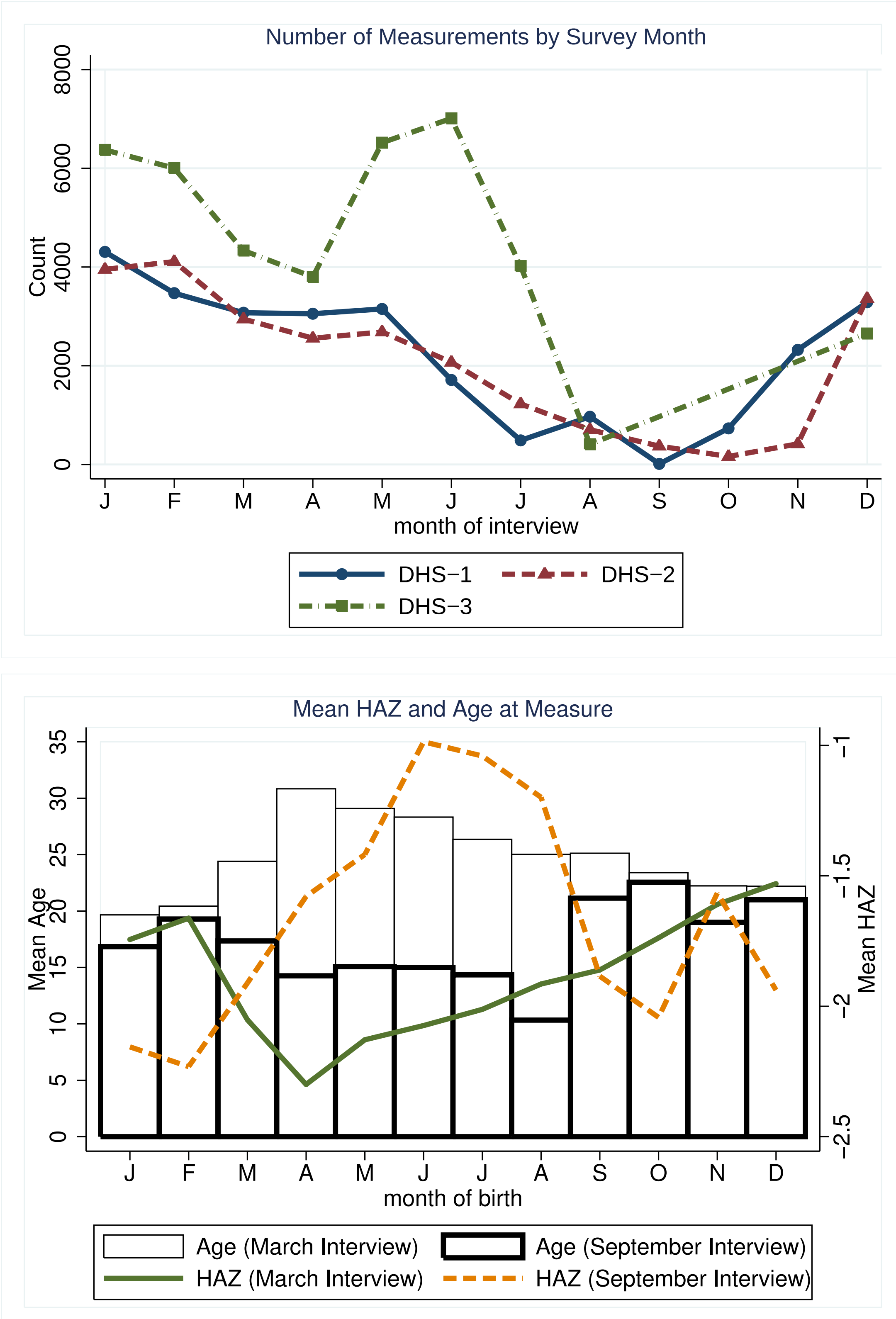


Figure 2: Count, Mean Age and HAZ (India)

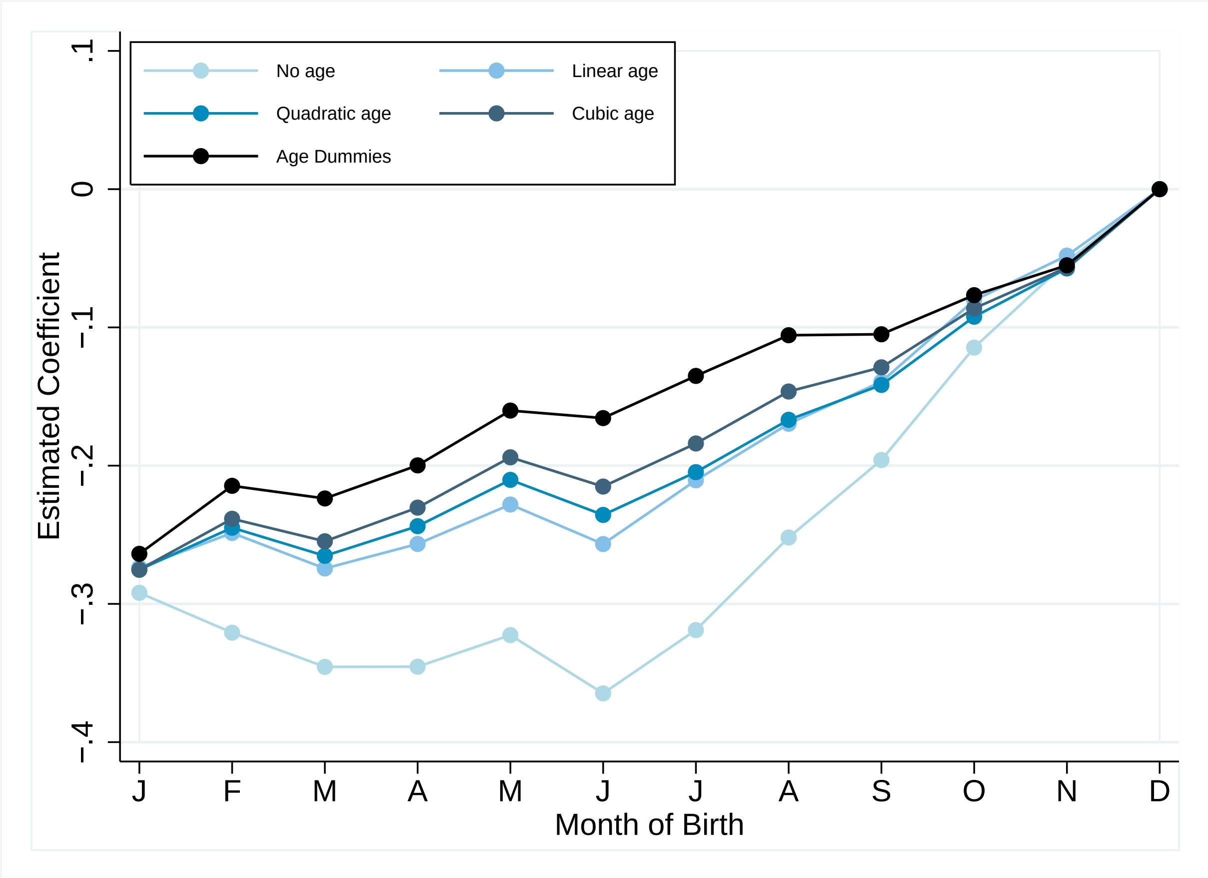


Figure 3: MOB and HAZ (India)

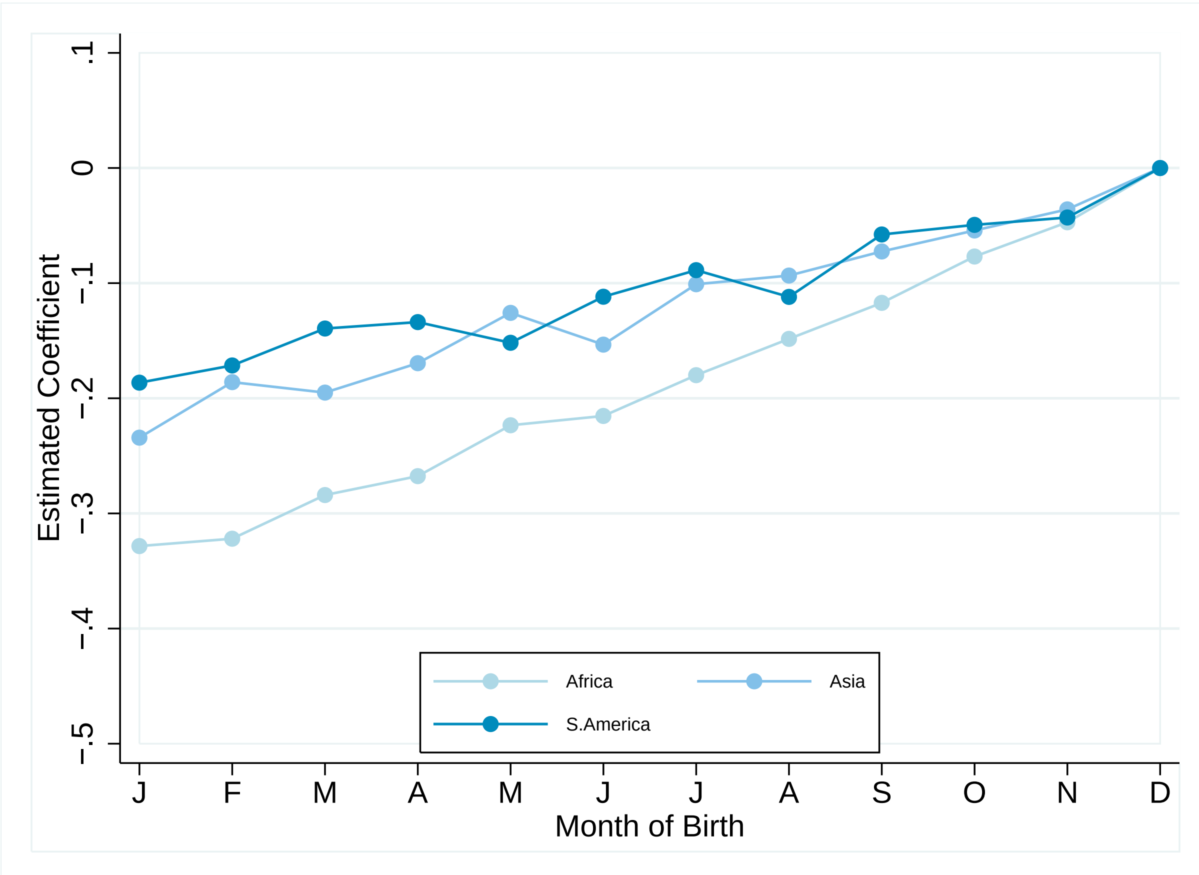


Figure 4: MOB and HAZ (Regions)

8 Appendix

Table A1: Summary statistics (India DHS)

	Mean	Std.Deviation
Household size	7.26	3.41
Mother age in years	26.32	5.45
Mother education in years	4.48	5.77
Working Mother	0.28	0.45
Male child	0.52	0.50
Child age in months	24.72	15.36
Birth Order	2.74	1.86
Rural	0.68	0.47
Observations	92262	

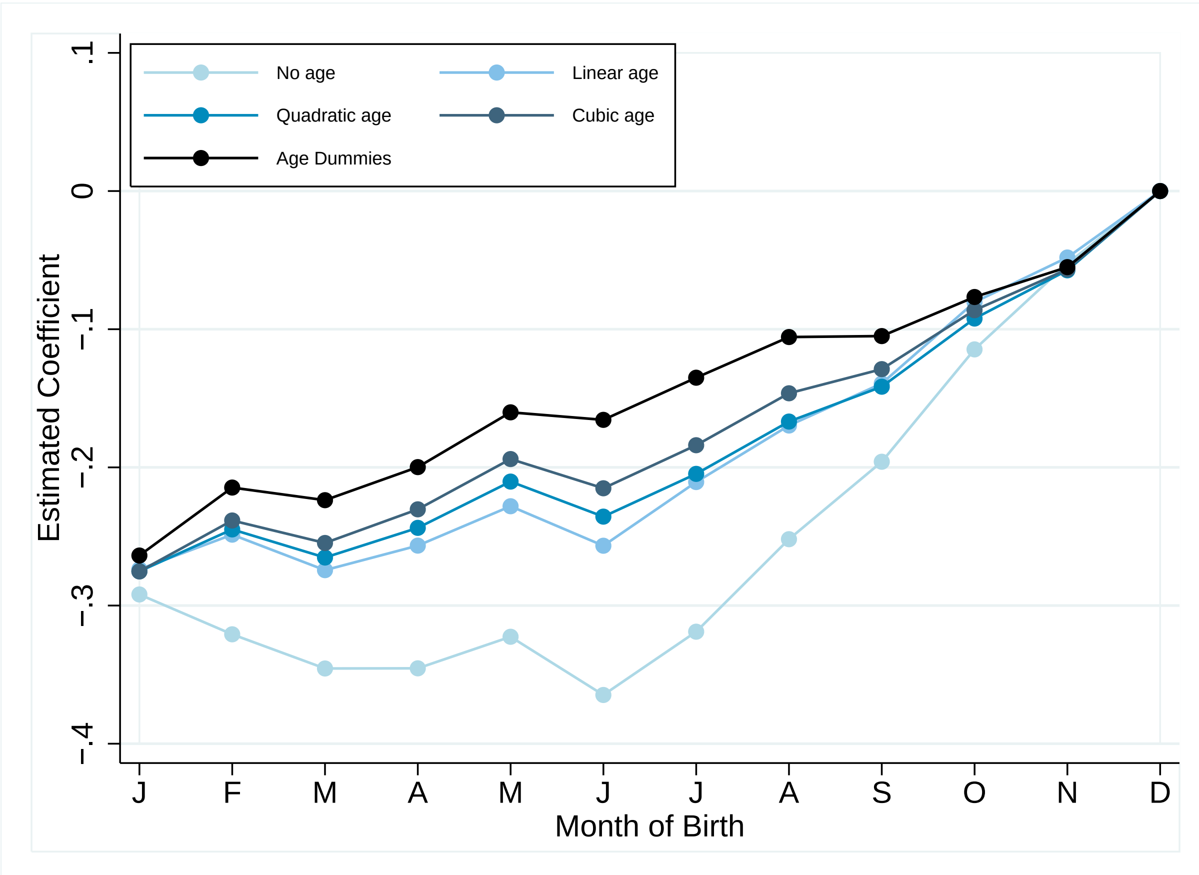


Figure A1: MOB and HAZ with household fixed effects (India)

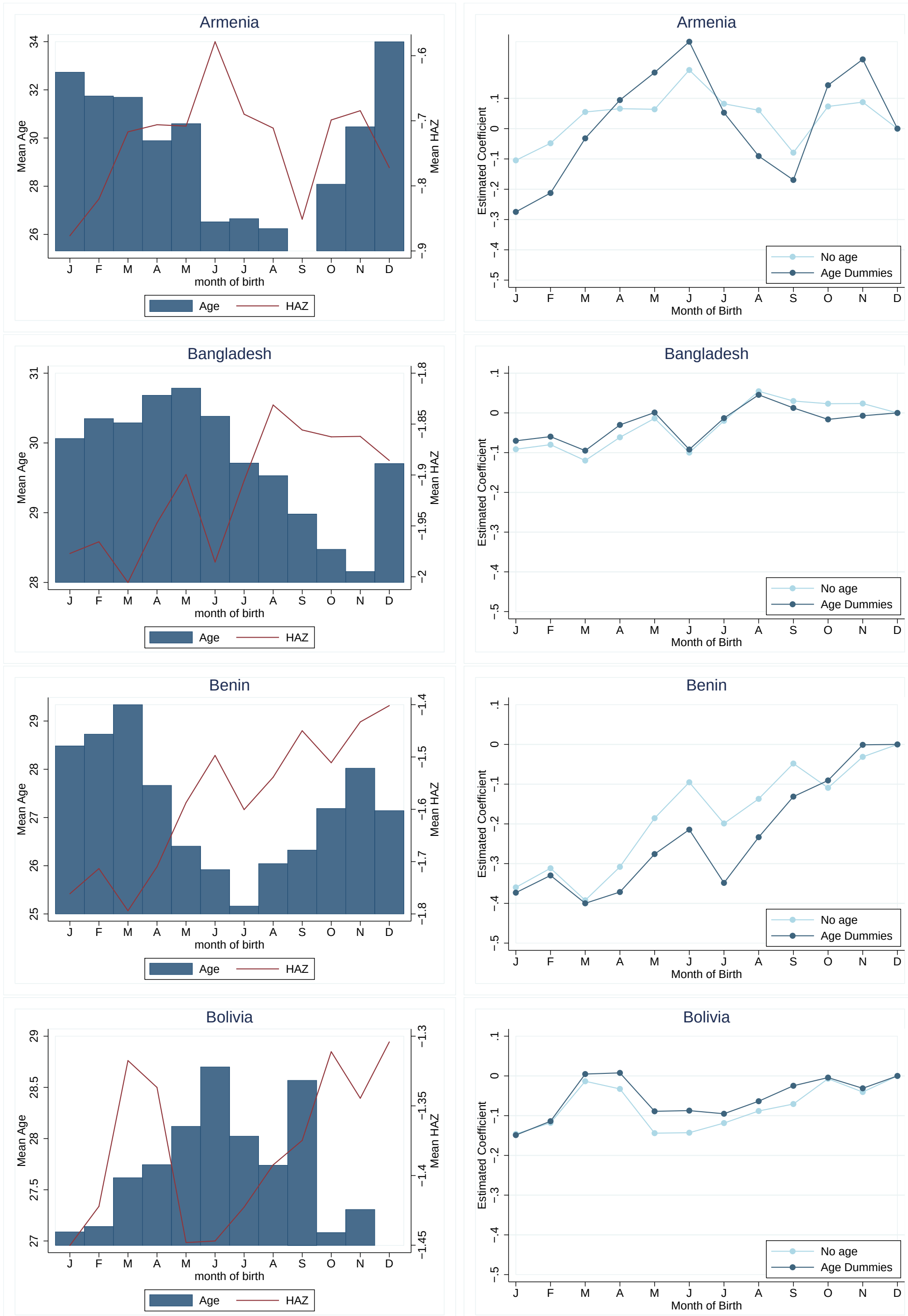
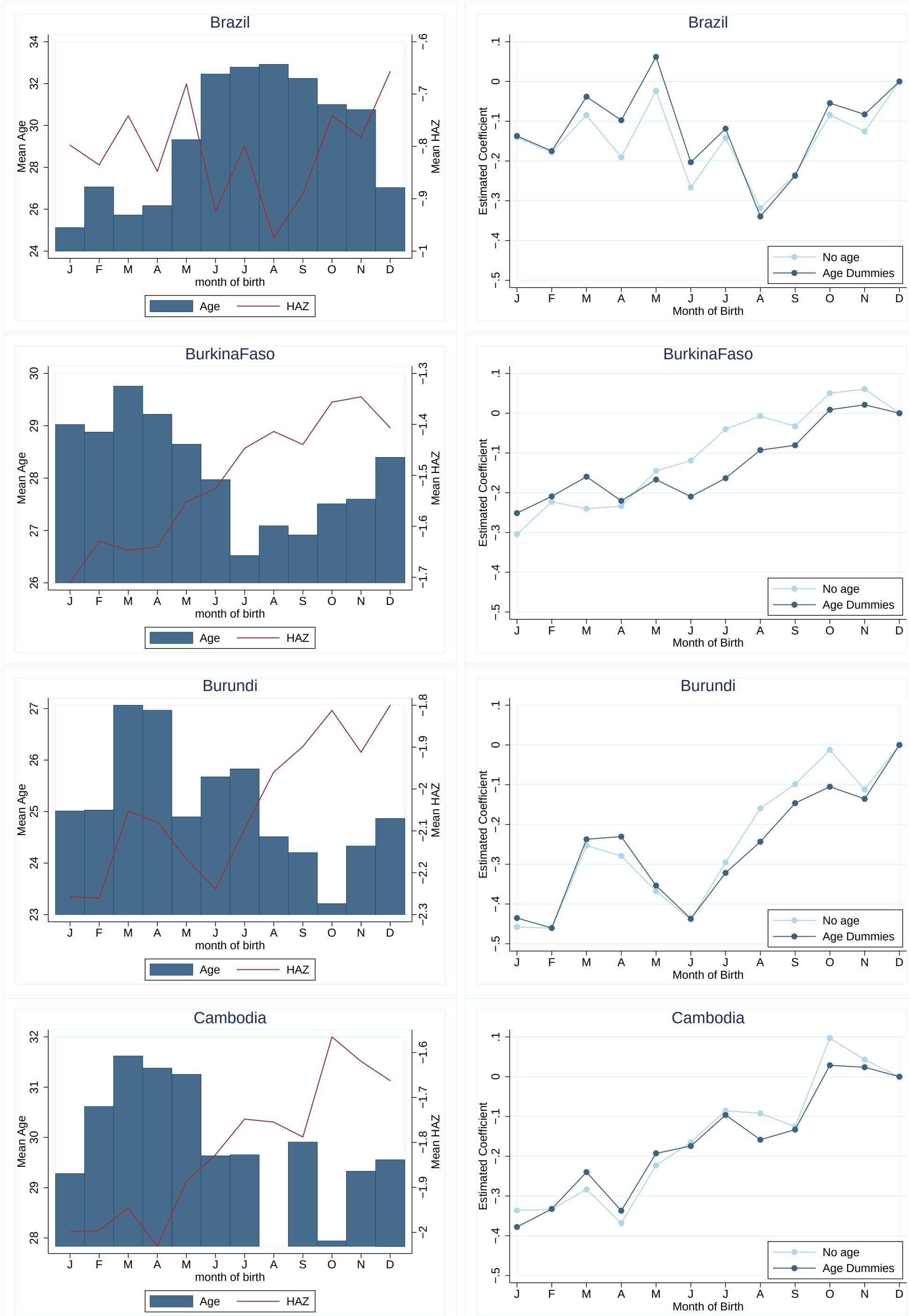


Figure A2: MOB, Age and HAZ (by country)



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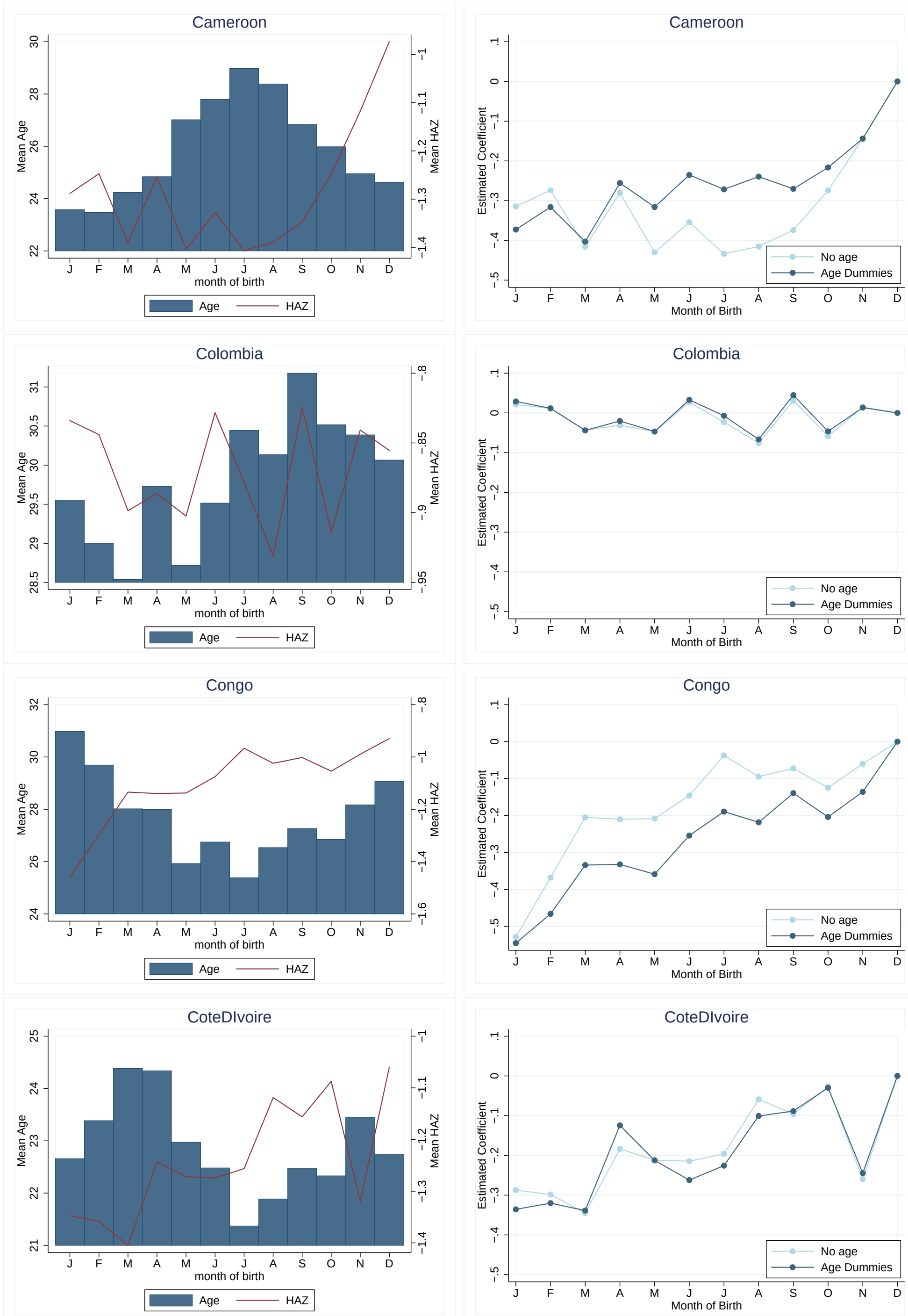

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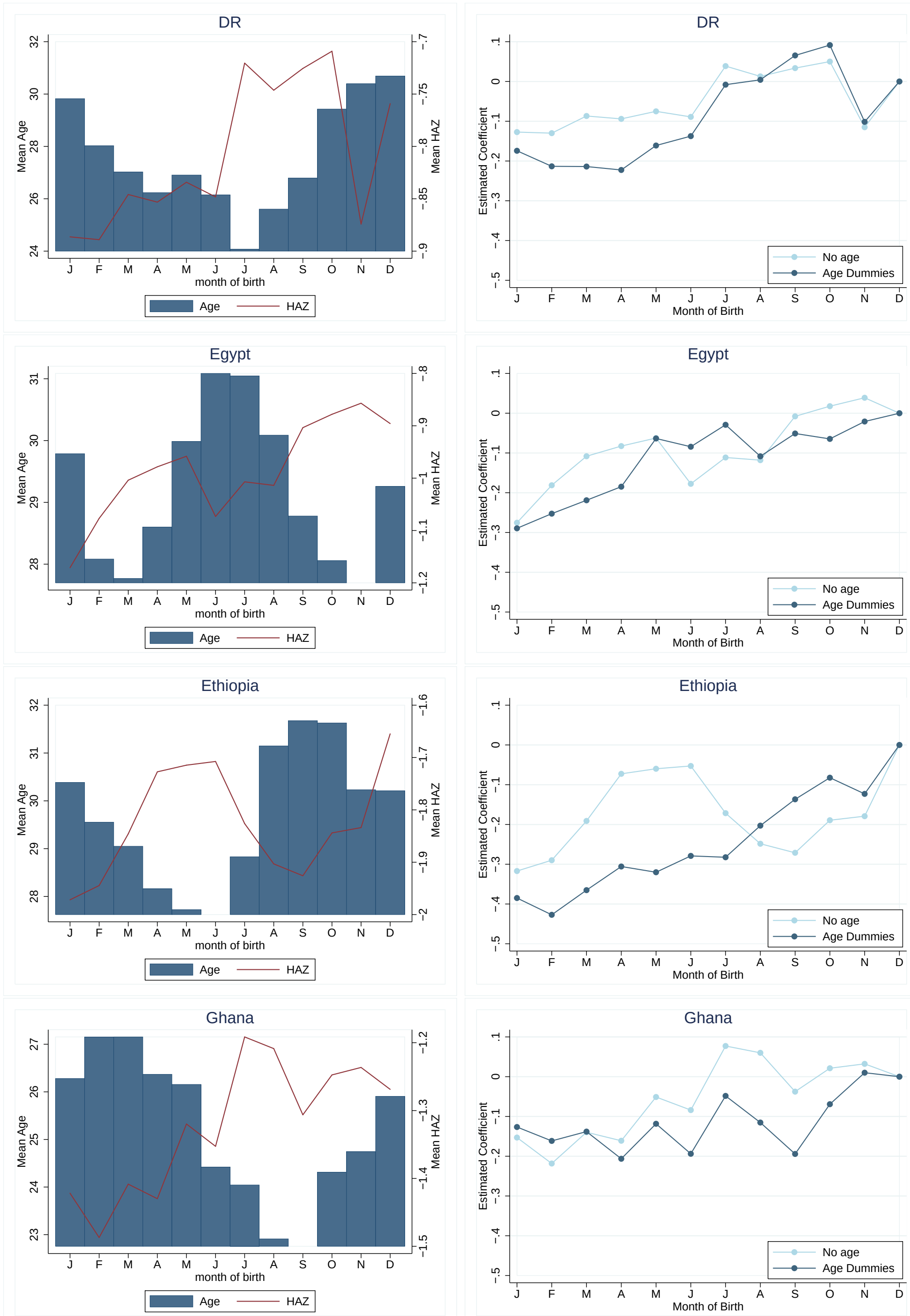

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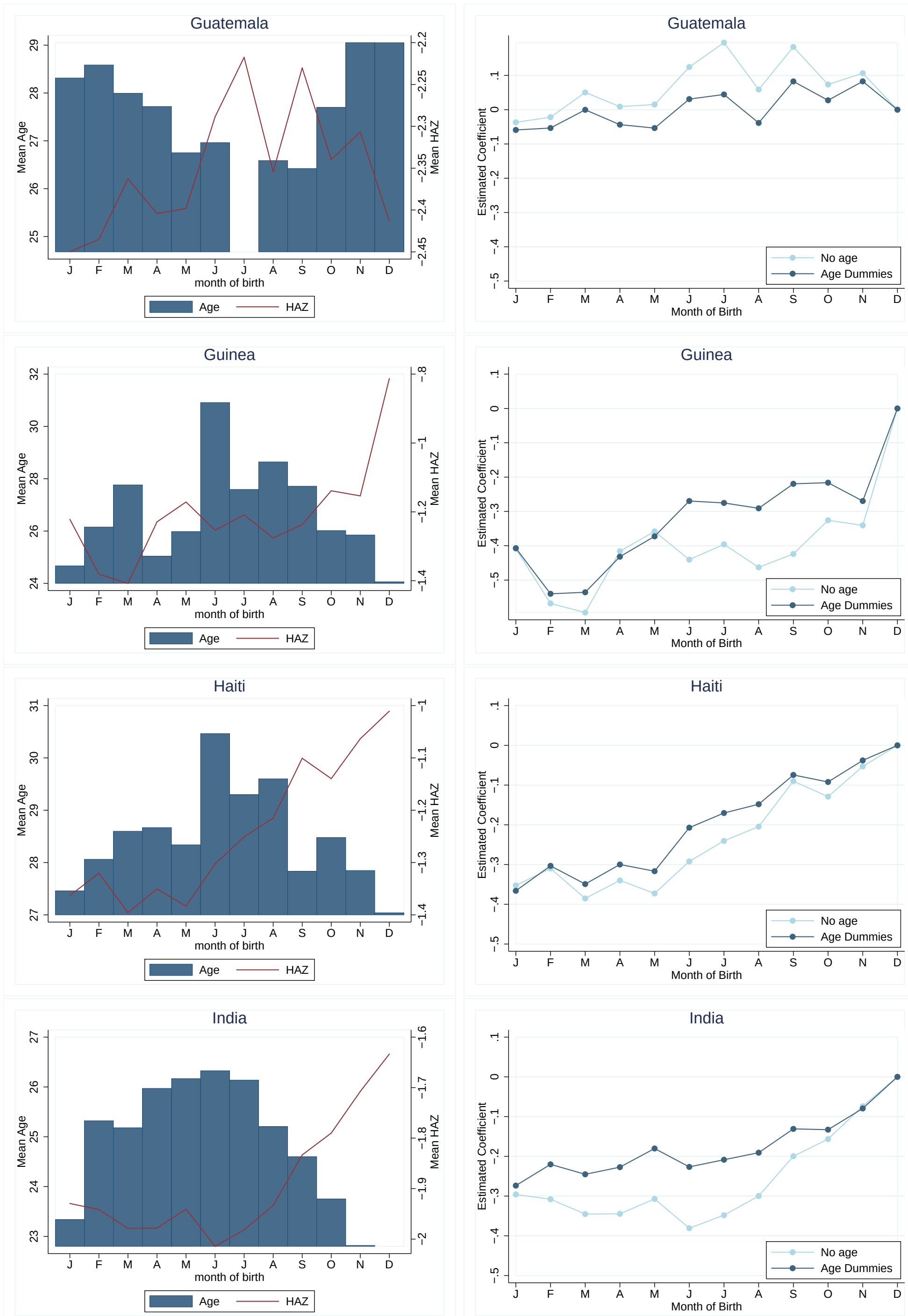

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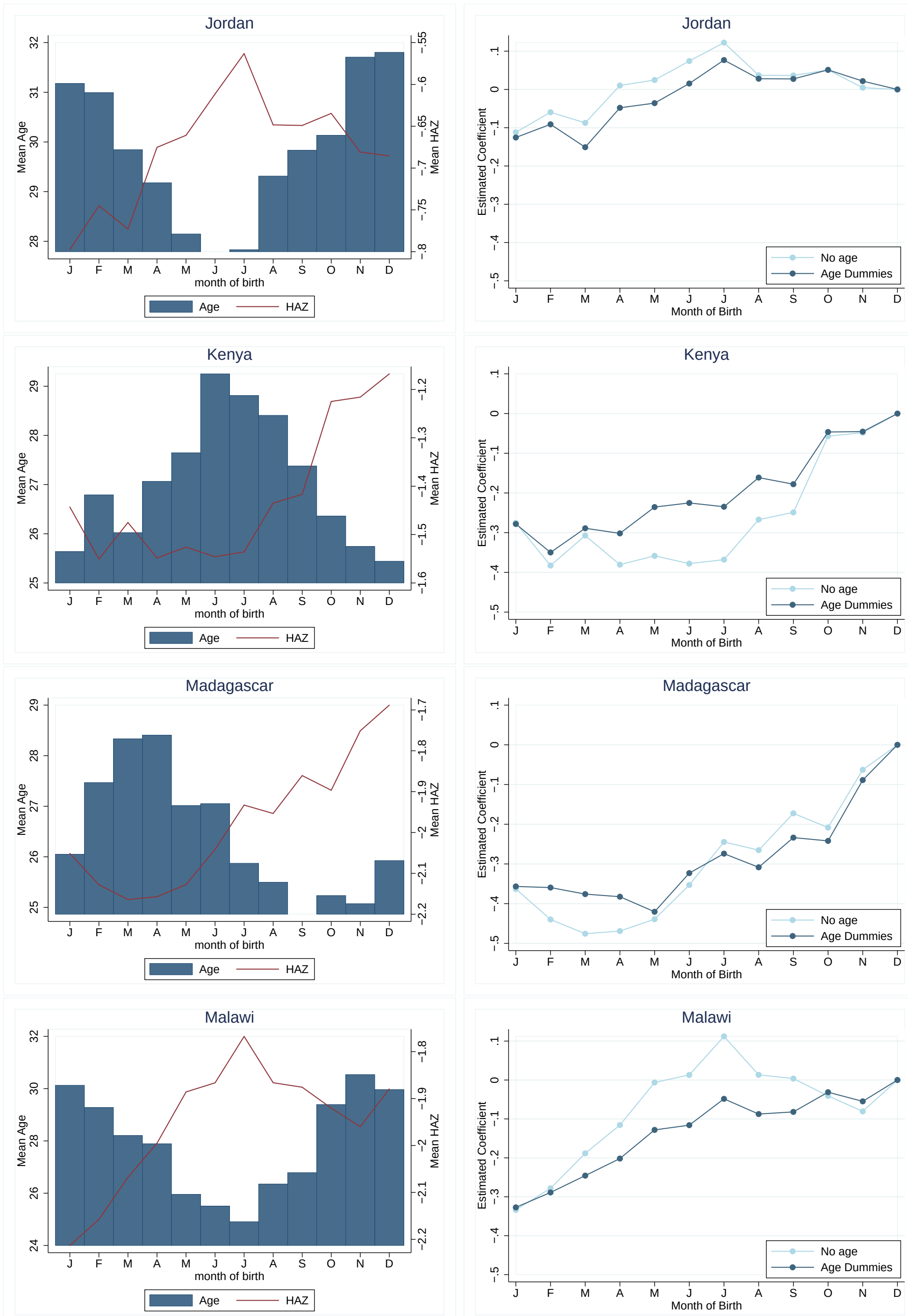

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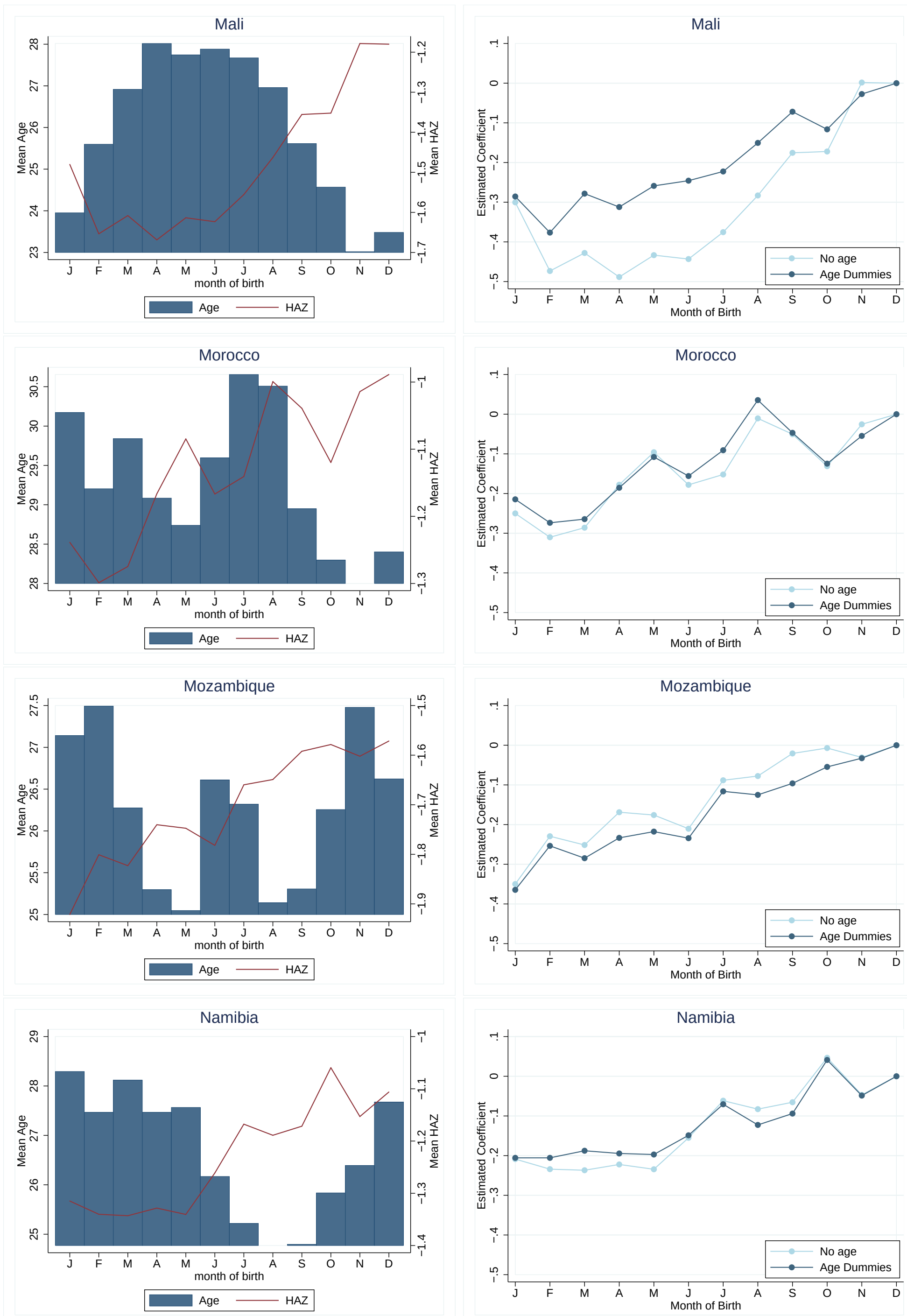

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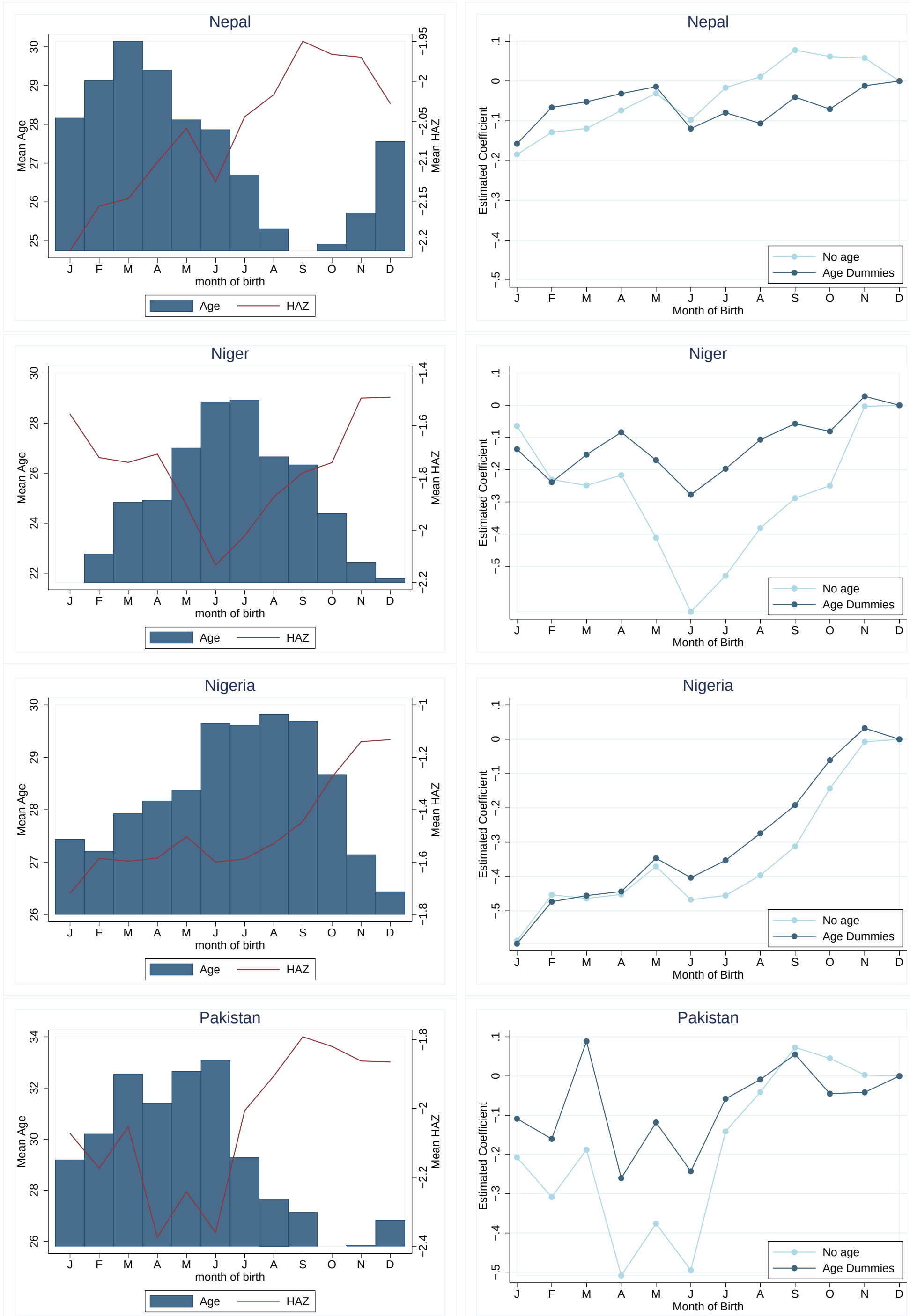

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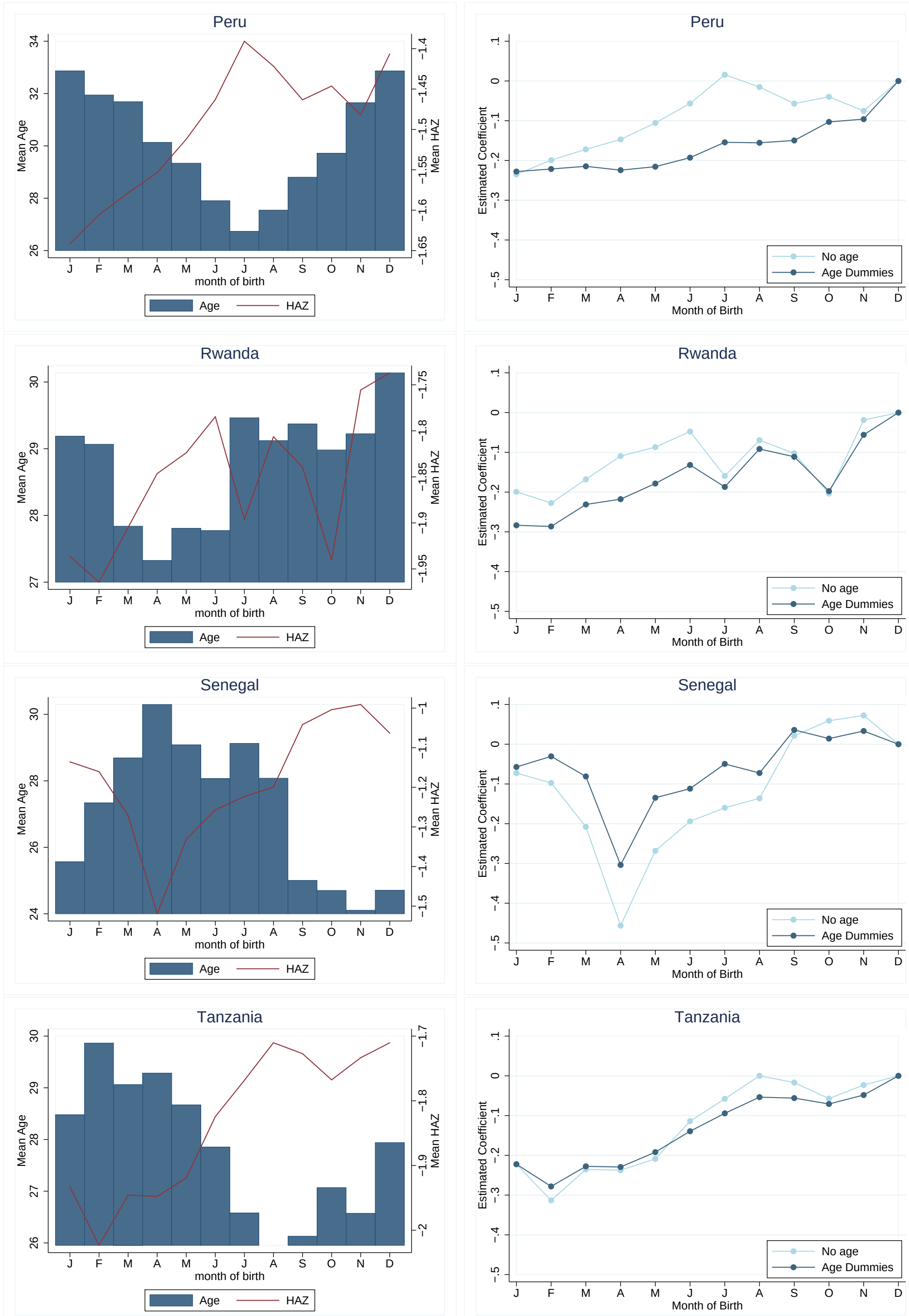

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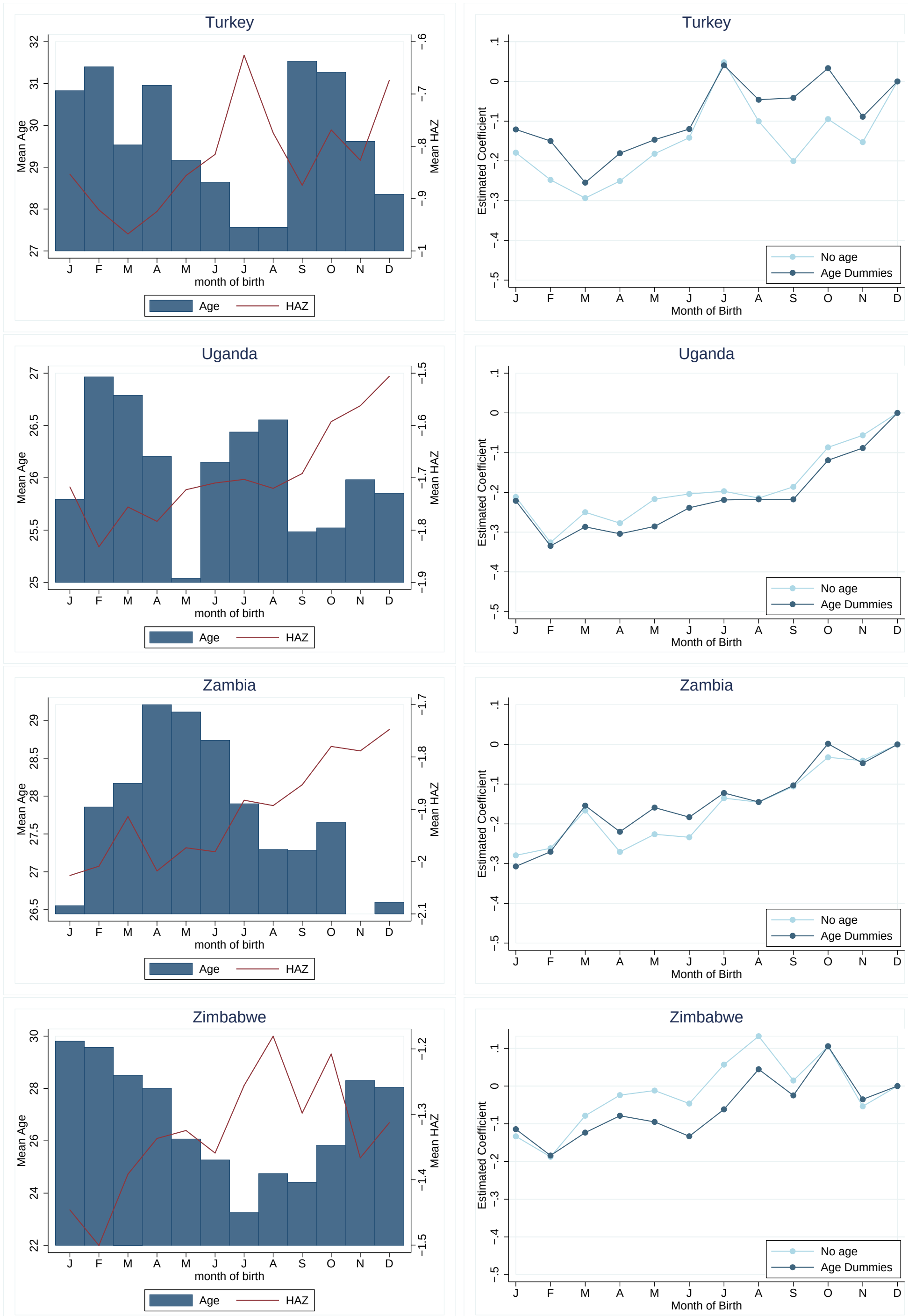

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