# Appendix 1: Technical annex and instructions for replication

This technical annex justifies and details the methods we used to analyse female migration. It also presents the assumptions, applications, and limitations of these methods.

*A1.1 Rogers-Castro multi-exponential model migration schedule*

Following the instructions detailed in *Tools for Demographic* Estimation (Little and Dorrington 2013), we fitted a Rogers-Castro multi-exponential model migration schedule to observed migration data in order to represent typical age patterns of migration (Rogers and Castro 1981). These migration schedules range from seven to 13 parameters, depending on the model's complexity, and depict the dependency between age and migration (Little and Dorrington 2013). Checking the "shape" or age distribution of migrant flows by fitting a model migration schedule also permitted us to check our estimates of net internal female migration in section A1.3 below.

Before applying this method, we obtained migration rates for single ages, examined the population's age structure, and examined the relative completeness of the census counts. We assumed that (1) the census accurately counted the population by sub-national region and place of birth and (2) the census identified people who moved from one region to another in the time period of interest (1995-2000).

The first step in applying this method is to prepare a schedule of the observed rates. We used census data that gave the numbers of migrants who survived the five-year migration interval 1995-2000. From this data, it is possible to calculate one-year age propensities by back-casting census respondents to the region where they reported living in 1995. The age-specific out-migration propensity is calculated for each one-year age group as the ratio of migrants to the number at risk of migrating over the time period (Little and Dorrington 2013).

The second step is to decide which multi-exponential model best fits the data. As noted in our article (Section 4.2 Demographic structure of internal migrants), since retirement is not concentrated among specific ages in these data and the data may exaggerate older ages (Little

and Dorrington 2013), we adopted the standard 7-parameter model rather than the more complex 9-, 11-, or 13-parameter models.

For the third step, fitting the model using Solver, we obtained an Excel Workbook for fitting model migration schedules directly from Professor Rob Dorrington at the University of Cape Town. Our calculations for fitting this model appear in a multi-page Excel Workbook that is available upon request.

Then, in step four, we evaluated the model's fit using the mean absolute per cent error statistic. At 7% for both sexes, it is within the boundaries for achieving a reasonable fit. We also calculated the $R^2$ for males (92%) and females (89%). Both values are acceptable compared to the established threshold of 90%, indicating that the models reasonably fit the data (Little and Dorrington 2013). T-statistics are significant at the 0.05 level for all coefficients. We also checked that the age-specific migration rates were visually compatible with the Rogers-Castro model and looked for extreme values that could distort the parameters in our model.

Since we employed census data for these models, they experience the limitations of census data detailed in our article (Section 5 Discussion). Furthermore, a limitation of this method is that without accurate, well-behaved data, it is possible that the model may be over-parameterised if the model does not produce a close fit (Little and Dorrington 2013). Since the lowest parameter model best fit the data, we are not concerned about over-parameterisation.

*A1.2 Logistic regression analyses*

To examine the effects of demographic indicators on the likelihood of a girl or woman migrating internally in 2000 and 2010, we conducted logistic regression analyses using SPSS Statistics 22.0 software. Binary logistic regression modelled the effects of selected independent variables on whether or not a girl or woman was identified in the census as ever having migrated internally (see Table 2 for criteria used to classify migrants). International migrants were excluded. Selection of the independent variables was based on a literature review of push- and pull-factors of migration. We examined the following independent variables: age (in one-year and five-year age groups), education status (ever attended or

attending school), marital status, religion, ethnicity, residence (urban, rural), work status (worked for pay, profit, or family gain; did not work), relationship to household head,

These analyses assume that the census correctly identify all girls and women who have migrated within Ghana and that our dependent variable (ever having migrated internally) can be measured on a dichotomous scale (yes/no). We know, however, that the census questionnaires' understanding and measuring of migration do not capture contemporary migration patterns identified via other sources of migration data. Most movements between place of birth and current residence are missing, leading to a likely undercount of internal migrants. Improving the census's ability to capture contemporary migration patterns (e.g. cyclic migration, seasonal migration) would significantly strengthen the predictive ability of this regression model.

*A1.3 Estimates of net internal female migration from place of birth data*

To generate estimates of net internal female migration from census data, we followed the instructions detailed in *Tools for Demographic Estimation* for estimating sub-national regional net in- and out-migration from place of birth data (Dorrington 2013). This estimation required the number of females, in five-year age groups, by sub-national region in 2010 and by sub-national region at the preceding census in 2000. For estimating deaths in this period, we calculated survival factors using model life tables from GSS (GSS 2013c).

Our assumptions are as follows:

1. Ghana's censuses correctly identify region of birth and accurately count the population by sub-national region.
2. We can accurately estimate the mortality of people moving between two regions in Ghana.

Before applying the method, Dorrington (2013) warns demographers to examine the data's age structure of the population and the data's relative completeness. As noted in our article (Section 3.1 Data), we assessed data quality and completeness by (1) reviewing the post-enumeration surveys conducted to assess coverage and content errors (GSS 2003, GSS 2012) and by (2) comparing key variables between the microdata and censuses. The microdata

sample from the 2010 Census more accurately reflects the complete census than the microdata sample from 2000 in which the age structure differs slightly (Table 1). Unfortunately, the 2000 Census's post-enumeration survey data are physically missing, preventing analysis of whether or not the final census results required adjustment. The 2010 Census required no adjustments based on the low net coverage error of 1.8% at the national level (GSS 2012). Whilst these data are imperfect, they are the best currently available for estimating net internal migration in Ghana.

Dorrington (2013) also warns demographers that the estimations are sensitive to census quality, inaccurately recorded place of birth (e.g., respondent may be unaware of boundary changes or may be unaware of person's place of birth), a census's ability to completely identify all migrants and from where they migrated (i.e., undercount), and net migration's underestimation of migrant flows into and out of a region.

The first step in estimating net internal migration between sub-national regions from place of birth data is to decide on survival factors. Whilst we considered survival factors generated by the 2005 life table for Ghana from the World Health Organization's (WHO) Global Health Observatory data repository (WHO 2018) (Table A1.1), we ultimately used survival factors derived from the Urban Females and Rural Females model life tables produced by Ghana Statistical Service (GSS) (2013c). Since we had reason to believe that mortality differed between regions, using the Urban Females and Rural Females life tables produced by GSS permitted us to better match the mortality profiles of each region. Ten-year survival factors determined by the Urban Females model life table were used to generate migration estimates for the Greater Accra (see "${}_5S_{x+10}$" in the fifth column of Table A1.2) and Ashanti Regions, where the majority of girls and women reside in urban areas (90.5% and 59.6% respectively) (Figure 1). We used GSS's Rural Females model life table to generate ten-year survival factors used in the estimates for the other eight regions where the rural population exceeded the urban population (see "${}_5S_{x+10}$" in the fifth column of Table A1.3). The second step is to use these survival factors to estimate the number of deaths that occurred between the 2000 and 2010 Censuses. The third step is to estimate the net number of in-migrants or out-migrants.

**Table A1.1 Comparison of overall net migration estimates based on changes to survival factors**

| Region | Overall Net Migration: As estimated with constant survival factors for all regions, based on the WHO 2005 life table for Ghana | Overall Net Migration: As estimated with separate survival factors for predominately rural or urban regions, based on Ghana's 2010 Census life tables | % difference |
|---|---|---|---|
| Western | -13,332 | -13,711 | -1.40 |
| Central | -18,117 | -16,121 | 5.83 |
| Greater Accra | 318,278 | 300,213 | 2.92 |
| Volta | -105,237 | -101,561 | 1.78 |
| Eastern | -74,510 | -71,130 | 2.32 |
| Ashanti | 106,929 | 101,431 | 2.64 |
| Brong Ahafo | -12,627 | -14,939 | -8.39 |
| Northern | -111,108 | -109,085 | 0.92 |
| Upper East | -47,941 | -47,212 | 0.77 |
| Upper West | -41,916 | -41,734 | 0.22 |

Table A1.2, below, works through these steps for estimating the net number of female in-migrants. The second and third columns show the number of girls and women living in the Greater Accra Region who were born outside the region, as counted by the 2000 and 2010 Censuses. We calculated the ten-year survival factors (${}_5S_{x+10}$) in the fifth column using data from the GSS (2013c) Urban Females model life table. The seventh column (Do) is the number of estimated deaths of in-migrants who were born outside that occurred in the ten years between censuses ($n$). We estimated deaths of people born outside the region (denoted by the superscript O) aged between $x$ and $x$ + 10 years at the time of the first census ($t$), ${}_5D_x^O$, of those aged $A$-$n$ and older at the first census, ${}_\infty D_{A-n}^O$, and of those born between the censuses, $D_B^O$, as follows:

For those born between the two censuses:

$$D_B^O = \frac{1}{2}\,({}_5N_0^O(2010)) \times ((1/S_{B,10}) - 1)$$

$$= \frac{1}{2}\,(34{,}950 \times \left(\left(\frac{1}{0.92534}\right) - 1\right)$$

$$= 1{,}410$$

For those aged 65 years and older at the time of the first census:

$$ {}_{\infty}D_{65}^{O} = \frac{1}{2}\left({}_{\infty}N_{65}^{O}(2000) \times {}_{\infty}S_{65,10} + {}_{\infty}N_{75}^{O}(2010)\right) \times \left((1/{}_{\infty}S_{65,10}) - 1\right) $$

$$ = \frac{1}{2}\left((6{,}630 + 4{,}260 + 9{,}520) \times 0.62448 + 14{,}730\right) \times \left(\left(\frac{1}{0.62448}\right) - 1\right) $$

$$ = 8{,}261 $$

For all other age groups, such as those aged 30-34 years at the time of the first census:

$$ {}_{5}D_{30}^{O} = \frac{1}{2}\left({}_{5}N_{30}^{O}(2000) \times {}_{5}S_{30,10} + {}_{5}N_{40}^{O}(2010)\right) \times \left((1/{}_{5}S_{30,10}) - 1\right) $$

$$ = \frac{1}{2}\left(53{,}230 \times 0.93040 + 57{,}480\right) \times \left(\left(\frac{1}{0.93040}\right) - 1\right) $$

$$ = 4{,}002 $$

where ${}_{5}N_{x}^{O}(t)$ represents the number of people born outside the region (by age group) according to the census at time *t* who were aged between *x* and *x* + 10 years.

The final column (Net M (born out)) shows the net numbers of female migrants into the Greater Accra Region who were born in regions other than the Greater Accra Region for each five-year age group. From 2000 to 2010, a total of 371,632 girls and women born outside the Greater Accra Region moved to the Greater Accra Region (after excluding those who moved out).

**Table A1.2: Estimation of the net number of female in-migrants of those born outside by age group, Greater Accra Region, Ghana, 2000-2010**

| Age | 2000 | 2010 | x | ${}_5S_{x+10}$ | Age at 2nd census | Do | Net M (born out) |
|---|---|---|---|---|---|---|---|
| | | | B | 0.92534 | | | |
| 0-4 | 30,390 | 34,950 | 0 | 0.98072 | 0-4 | 1,410 | 36,360 |
| 5-9 | 38,460 | 40,280 | 5 | 0.98272 | 5-9 | 1,625 | 11,515 |
| 10-14 | 46,270 | 60,730 | 10 | 0.97981 | 10-14 | 890 | 23,160 |
| 15-19 | 63,980 | 79,870 | 15 | 0.97245 | 15-19 | 1,034 | 34,634 |
| 20-24 | 68,690 | 117,250 | 20 | 0.96188 | 20-24 | 1,675 | 54,945 |
| 25-29 | 69,260 | 119,690 | 25 | 0.94706 | 25-29 | 2,576 | 53,576 |
| 30-34 | 53,230 | 93,920 | 30 | 0.93040 | 30-34 | 3,170 | 27,830 |
| 35-39 | 45,660 | 74,330 | 35 | 0.91571 | 35-39 | 3,910 | 25,010 |
| 40-44 | 35,430 | 57,480 | 40 | 0.90525 | 40-44 | 4,002 | 15,822 |
| 45-49 | 26,190 | 44,490 | 45 | 0.89823 | 45-49 | 3,972 | 13,032 |
| 50-54 | 19,130 | 39,350 | 50 | 0.88747 | 50-54 | 3,738 | 16,898 |
| 55-59 | 12,360 | 25,560 | 55 | 0.86645 | 55-59 | 2,781 | 9,211 |
| 60-64 | 9,170 | 19,100 | 60 | 0.83183 | 60-64 | 2,287 | 9,027 |
| 65-69 | 6,630 | 11,640 | 65+ | 0.62448 | 65-69 | 1,722 | 4,192 |
| 70-74 | 4,260 | 10,740 | | | 70-74 | 1,857 | 5,967 |
| 75+ | 9,520 | 14,730 | | | 75+ | 8,261 | 9,211 |
| Total | 538,630 | 844,110 | | | Total | 44,911 | 350,391 |

Table A1.3, below, works through the steps for estimating the net number of female out-migrants. The second and third columns show the number of girls and women living in regions other than Ghana's Upper East Region who were born in the Upper East Region, as counted by the 2000 and 2010 Censuses. We calculated the survival factors (${}_5S_{x+10}$) in the fifth column using data from the GSS Rural Females model life table (2013c). The seventh column (Di) is the number of estimated deaths of out-migrants who were born inside that occurred in the ten years between censuses. It is calculated in the same manner as the deaths of in-migrants who were born outside of the region (Do). The final column (Net M (born in)) shows the net numbers of female out-migrants of those born in the Upper East Region (i.e., the number of girls and women born in the Upper East Region who moved out, less those who have returned). From 2000 to 2010, a total of 54,966 girls and women born in the Upper East Region moved out of the Upper East Region (after excluding those who moved in).

**Table A1.3: Estimation of the net number of female out-migrants of those born inside by age group, Upper East Region, Ghana, 2000-2010**

| Age | 2000 | 2010 | x | ${}_5S_{x+10}$ | Age at 2nd census | Di | Net M (born in) |
|---|---|---|---|---|---|---|---|
| | | | B | 0.92197 | | | |
| 0-4 | 10,900 | 8,030 | 0 | 0.96465 | 0-4 | 340 | 8,370 |
| 5-9 | 12,660 | 9,050 | 5 | 0.98064 | 5-9 | 383 | -1,467 |
| 10-14 | 11,270 | 12,680 | 10 | 0.98033 | 10-14 | 425 | 445 |
| 15-19 | 12,240 | 16,370 | 15 | 0.96941 | 15-19 | 284 | 5,384 |
| 20-24 | 14,640 | 25,790 | 20 | 0.95095 | 20-24 | 370 | 13,920 |
| 25-29 | 14,630 | 23,970 | 25 | 0.93235 | 25-29 | 565 | 9,895 |
| 30-34 | 11,390 | 17,340 | 30 | 0.92103 | 30-34 | 806 | 3,516 |
| 35-39 | 9,160 | 13,470 | 35 | 0.91866 | 35-39 | 984 | 3,064 |
| 40-44 | 5,900 | 9,240 | 40 | 0.91618 | 40-44 | 846 | 926 |
| 45-49 | 4,680 | 6,670 | 45 | 0.90422 | 45-49 | 668 | 1,438 |
| 50-54 | 3,330 | 5,570 | 50 | 0.86801 | 50-54 | 502 | 1,392 |
| 55-59 | 2,160 | 2,560 | 55 | 0.78906 | 55-59 | 360 | -410 |
| 60-64 | 2,050 | 2,770 | 60 | 0.66829 | 60-64 | 430 | 1,040 |
| 65-69 | 1,300 | 1,880 | 65+ | 0.32150 | 65-69 | 479 | 309 |
| 70-74 | 1,100 | 2,290 | | | 70-74 | 908 | 1,898 |
| 75+ | 2,110 | 3,370 | | | 75+ | 5,086 | 5,246 |
| Total | 119,520 | 161,050 | | | Total | 13,436 | 54,966 |

After estimating net female in-migration and out-migration for each of Ghana's ten regions, we combined these estimates into Table 7 of our article. Whilst these estimations are currently the most accurate available based on existing data, they have several limitations. As previously mentioned, the quality of census data affects these estimates. Censuses may not identify all migrants and may suffer from undercount. Additionally, place of birth and place of residence data are affected by misreporting if boundaries change between rounds or if respondents are ignorant of the boundaries.

*A1.4 Estimates of net female migration using the cohort component method*

To strengthen our confidence in our estimates of net internal female migration from census data (section A1.2), we compared these estimates to those generated by the cohort component method (Spoorenberg 2015). This estimation required us to first forward project the female population

enumerated in the 2000 Census to 2005, based on estimated levels of age-specific fertility and mortality rates. We then forward projected the estimated female population in 2005 to compare it with the actual female population enumerated in the 2010 Census. Without accurate vital registration statistics on fertility and mortality during these periods, we relied on estimations. For estimating fertility, we used age-specific fertility rates (ASFRs) for women aged 15-49 years (in five-year age groups) produced by the 2003 Ghana Demographic and Household Survey (GDHS) (GSS, NMIMR et al. 2004) and the 2008 GDHS (GSS, GHS et al. 2009). We applied the urban ASFRs to the Greater Accra and Ashanti Regions, and we applied the rural ASFRs to the eight remaining regions. For estimating deaths in this period, we calculated survival factors using WHO model life tables for Ghana (WHO 2018). For 2000-2005, we used the life table for 2003. For 2005-2010, we used the life table for 2008.

Our assumptions are as follows:

1. Life table survival rates are representative of mortality conditions during the intercensal period, and we can accurately estimate mortality.
2. Fertility rates are representative of fertility during the intercensal period, and we can accurately estimate fertility.
3. Female migrants have the same fertility and mortality levels as the enumerated population.
4. The distribution of net migrants is equal across years during the intercensal period.
5. Differences between our projected population in 2010 and the population enumerated in the 2010 Census result from migration.

The first step in estimating net migration using this method is to survive the females enumerated in the 2000 Census forward five years to 2005 (Table A1.4). Next, we estimated the total number of surviving female births from 2000-2005 (Table A1.5). Then, we repeated the process by surviving the projected female population in 2005 forward to 2010 and estimating surviving female births from 2005-2010. Finally, we compared our estimated female population in 2010 to the actual enumerated female population in 2010. Differences between these figures imply in-migration or out-migration.

Table A1.4, below, works through the steps for surviving the female population in the projection intervals. The first column after age group shows the female population (in five-year age groups) residing in the Upper East Region, as counted by the 2000 Census. The next column lists the five-year survival factors that we derived from the WHO life table for Ghana in 2003. The product of these two

columns is the projected population in 2005; however, there is one exception. The projected population for the age group 0-4 years comes from Table A1.5 in which we estimated female births surviving the projection interval 2000-2005. We repeat these steps once more to project the 2005 population forward to 2010. Finally, we estimate net female migration by subtracting the projected population in 2010 from the population enumerated in the 2010 Census. From 2000 to 2010, the Upper East Region experienced negative net migration with a total of 75,346 girls and women moving out of the region.

**Table A1.4: Estimating net intercensal female migration by age (birth) cohorts, according to the cohort component method, in the Upper East Region, Ghana: 2000-2010**

| Age group (in years) | Population, 2000 Census | 5-year life table survival ratio* | Projected population, 2005 | 5-year life table survival ratio** | Projected population, 2010 | Population, 2010 Census | Estimated net migrants |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) = (1) x (2) | (4) | (5) = (3) x (4) | (6) | (7) = (6) - (5) |
| 0-4 | 66,440 | 0.93043 | **85,338** | 0.93923 | **96,152** | 68,450 | -27,702 |
| 5-9 | 75,250 | 0.97342 | 61,818 | 0.97818 | 80,152 | 73,600 | -6,552 |
| 10-14 | 51,260 | 0.98795 | 73,250 | 0.99020 | 60,469 | 64,850 | 4,381 |
| 15-19 | 40,840 | 0.99121 | 50,643 | 0.99181 | 72,532 | 54,020 | -18,512 |
| 20-24 | 33,840 | 0.98779 | 40,481 | 0.98901 | 50,228 | 42,050 | -8,178 |
| 25-29 | 35,770 | 0.97855 | 33,427 | 0.98357 | 40,036 | 37,640 | -2,396 |
| 30-34 | 29,190 | 0.96822 | 35,003 | 0.97475 | 32,878 | 32,840 | -38 |
| 35-39 | 26,830 | 0.96136 | 28,262 | 0.96519 | 34,119 | 29,180 | -4,939 |
| 40-44 | 23,800 | 0.95851 | 25,793 | 0.96027 | 27,278 | 26,570 | -708 |
| 45-49 | 21,870 | 0.95902 | 22,813 | 0.96067 | 24,769 | 20,340 | -4,429 |
| 50-54 | 18,020 | 0.95498 | 20,974 | 0.95746 | 21,915 | 19,450 | -2,465 |
| 55-59 | 11,990 | 0.94552 | 17,209 | 0.94846 | 20,081 | 11,510 | -8,571 |
| 60-64 | 13,240 | 0.91340 | 11,337 | 0.92161 | 16,322 | 14,580 | -1,742 |
| 65-69 | 8,980 | 0.85251 | 12,093 | 0.86934 | 10,448 | 9,350 | -1,098 |
| 70+ | 19,670 | 0.61137 | 19,681 | 0.62723 | 22,858 | 30,460 | 7,602 |
| Total | 476,990 | | 538,121 | | 610,236 | 534,890 | -75,346 |

Note: Figures in **bold** were produced using the estimation method for female births surviving the projection interval, as shown in table A1.5.

Table A1.5, below, works through the steps for estimating female births surviving the projection intervals. The first column shows the female population aged 15-49 years (in five-year age groups) residing in the Upper East Region, as counted by the 2000 Census. The second column shows the projected female population in 2005, based on our calculations in Table A1.4. The third column calculates the mid-period female population as an average of the sum of the populations in columns

one and two. ASFRs in the fourth column come directly from the 2003 GDHS, in this example, and are those used for rural areas. The final column, estimated births (2000-2005), is the product of the female mid-period population and the ASFRs multiplied by five (years) to account for the period 2000-2005. For the first interval (2000-2005), we used a sex ratio of 105.0 for both urban and rural areas based on the 2000 Census report (GSS 2003). For the second interval (2005-2010), we used rural (103.1) and urban (101.2) sex ratios from the 2010 Census report on fertility (GSS 2014c). We generated newborn five-year survival ratios using the WHO 2003 and 2008 life tables for Ghana (WHO 2018). From 2000 to 2005, we estimated 85,338 surviving female births in the Upper East Region. This figure goes into the first row (age group 0-4 years) of the fourth column (Projected population, 2005) in Table A1.4.

**Table A1.5: Estimation of female births surviving the projection interval, Upper East Region, Ghana: 2000-2005**

| Age group (in years) | Female population, 2000 census | Female population, 2005 projected | Female population, mid-period | Age-specific fertility rates | Estimated births (2000-2005) |
|---|---|---|---|---|---|
| | (1) | (2) | (3) = ((1) + (2)) / 2 | (4) | (5) = 5 x ((3) x (4)) |
| 15-19 | 40,840 | 50,643 | 45,741 | 0.113 | 25,844 |
| 20-24 | 33,840 | 40,481 | 37,161 | 0.225 | 41,806 |
| 25-29 | 35,770 | 33,427 | 34,598 | 0.256 | 44,286 |
| 30-34 | 29,190 | 35,003 | 32,096 | 0.213 | 34,183 |
| 35-39 | 26,830 | 28,262 | 27,546 | 0.179 | 24,654 |
| 40-44 | 23,800 | 25,793 | 24,797 | 0.095 | 11,778 |
| 45-49 | 21,870 | 22,813 | 22,341 | 0.049 | 5,474 |
| Total births | | | | | 188,024 |
| Proportion of female births (sex ratio, rural = 105.0) | | | | | 0.488 |
| Total female births (2000-2005) | | | | | 91,719 |
| Average 5-year survival ratio of newborns | | | | | 0.930 |
| Expected deaths among female births (2000-2005) | | | | | 6,381 |
| Total surviving female births | | | | | 85,338 |

The estimates produced using the cohort component method have several limitations beyond the quality of census data. This method is incredibly sensitive to our estimated fertility and mortality rates. Using ASFRs from the GDHS and censuses produced drastically different estimates (Table A1.6). ASFRs from the GDHS produced overall net out-migration in six of Ghana's ten regions, whereas

ASFRs from the censuses produced overall net out-migration in only two of Ghana's ten regions. Since measures between the 2008 GDHS and 2010 Census indicate misreporting of births in the census and census fertility data of questionable reliability, we felt the GDHS ASFRs produced more robust estimates. The mortality rates illustrated less significant swings in the estimates produced using the cohort component method, depending on where we generated the survival rates from. For this reason, we consider our estimations of sub-national regional net in- and out-migration from place of birth data (section A1.3) to be more robust, as they are affected only by mortality estimates.

**Table A1.6: Comparison of estimates of net female migration in Ghana produced using different methods**

| | Overall Net Female Migration | | | |
|---|---|---|---|---|
| Region | As estimated with the cohort component method using ASFRs from the 2000 and 2010 Censuses | As estimated with the cohort component method using urban/rural ASFRs from the 2003 and 2008 GDHS | As estimated with the cohort component method using ASFRs from the 2003 and 2008 GDHS with additional modifications* | As estimated with place of birth data (section A1.3) |
| Western | 332 | -80,102 | -80,102 | -13,711 |
| Central | 118,650 | 51,291 | 33,360 | -16,121 |
| Greater Accra | 367,656 | 308,633 | 308,633 | 300,213 |
| Volta | 54,411 | -13,143 | -13,143 | -101,561 |
| Eastern | 27,725 | -57,576 | -57,576 | -71,130 |
| Ashanti | 456,663 | 389,721 | 389,721 | 101,431 |
| Brong Ahafo | 42,939 | -33,492 | -33,492 | -14,939 |
| Northern | 132,650 | 70,086 | -44,247 | -109,085 |
| Upper East | -40,570 | -75,346 | -75,346 | -47,212 |
| Upper West | -24,367 | -47,997 | -47,997 | -41,734 |

*Women in the Northern Region have the highest total fertility rate (TFR) in Ghana, with 7.0 children per woman in 2003 and 6.8 children per woman in 2008 (GSS, NMIMR et al. 2004, GSS, GHS et al. 2009). The Central Region also experiences above average fertility with TFRs of 5.0 children per woman in 2003 and 5.4 children per woman in 2008 (GSS, NMIMR et al. 2004, GSS, GHS et al. 2009). To improve the accuracy of our migration estimates using the cohort component method, we adjusted the ASFR upwards when estimating births in these two regions. For estimating births from 2005-2010, we multiplied the rural ASFRs by a factor of 1.39 for the Northern Region and a factor of 1.10 for the Central Region. These factors are the ratio of each region's TFR to Ghana's overall rural TFR of 4.9. For estimating births from 2000-2005, we adjusted the Northern Region's ASFRs upward using a factor of 1.25.

# Appendix 2: Supplementary Tables

**Table A2.1: Migrants identified by Ghana census questions on migration, 2000 and 2010 (10% microdata)**

| 2000 Census Questions | Migrants Identified in 2000 (%), by sex | 2010 Census Questions | Migrants Identified in 2010 (%), by sex |
|---|---|---|---|
| P06a BORN IN THIS TOWN / VILLAGE: Was (NAME) born in this town or village? If YES go to P07.<br>[Note: Only asked of respondents who were Ghanaian by birth.] | 335,951 of 955,504 females (35.2%)<br>Ghanaian female migrants = 274,167 (81.6%)<br>International foreign female migrants = 61,784 (18.4%)<br>349,023 of 935,654 males (37.3%)<br>Ghanaian male migrants = 262,911 (75.3%)<br>International foreign male migrants = 86,112 (24.7%) | P05 BIRTHPLACE: Was [NAME] born in this village/town? If Yes, go to P07. | 450,071 of 1,262,598 females (35.6%)<br>412,035 of 1,203,691 males (34.2%) |
| P06b BIRTHPLACE OUTSIDE THIS TOWN / VILLAGE: In what region or country was (NAME) born?<br>[Note: Only asked of respondents who were Ghanaian by birth.] | 274,167 of 274,167 females (100%)<br>Female internal migrants = 265,153 (96.7%)<br>Female (Ghanaian) international migrants = 9,014 (3.3%)<br>262,911 of 262,911 males (100%)<br>Male internal migrants = 254,048 (96.6%)<br>Male (Ghanaian) international migrants = 8,863 (3.4%) | P06 BIRTHPLACE: In what region or country was [NAME] born? | 450,071 of 450,071 females (100.0%)<br>Female internal migrants = 434,948 (96.6%)<br>Female international migrants = 15,123 (3.4%)<br>412,035 of 412,035 males (100.0%)<br>Male internal migrants = 394,703 (95.8%)<br>Male international migrants = 17,332 (4.2%) |

| 2000 Census Questions | Migrants Identified in 2000 (%), by sex | 2010 Census Questions | Migrants Identified in 2010 (%), by sex |
|---|---|---|---|
| P07 USUAL PLACE OF RESIDENCE: In what district is (NAME'S) usual residence? | 28,679 of 955,504 females (3.0%)<br>Female internal migrants = 28,329 (98.8%)<br>Female international migrants = 350 (1.2%)<br>29,797 of 935,654 males (3.2%)<br>Male internal migrants = 29,338 (98.5%)<br>Male international migrants = 459 (1.5%) | P07 LIVING IN THIS VILLAGE / TOWN: Has [NAME] been living in this village or town since birth? If Yes, go to P09. | 478,783 of 1,262,598 females (37.9%)<br>439,930 of 1,203,691 males (36.5%) |
| P08 PLACE OF RESIDENCE 5 YEARS AGO: IF (NAME) IS 5 YEARS OR OLDER – In what district was (NAME'S) usual place of residence 5 years ago? | 187,027 of 816,989 females (19.6%)<br>Female internal migrants = 185,228 (99.0%)<br>Female international migrants = 1,799 (1.0%)<br>189,490 of 935,654 males (20.3%)<br>Male internal migrants = 187,194 (98.8%)<br>Male international migrants = 2,296 (1.2%) | P08 NUMBER OF YEARS LIVED IN THIS VILLAGE / TOWN: For how long has [NAME] been living in this village or town? | 451,686 of 1,262,598 females (35.8%)<br>413,681 of 1,203,691 males (34.4%) |
| | Total number of migrants identified in 2000 microdata, by sex:<br>359,960 of 955,504 females (37.7%)<br>Female internal migrants = 297,031 (31.1%) of all females<br>Female international migrants = 62,929 (6.6%) of all females<br>371,577 of 935,654 males (39.7%)<br>Male internal migrants = 284,269 (30.4%) of all males<br>Male international migrants = 87,308 (9.3%) of all males | | Total number of migrants identified in 2010 microdata, by sex:<br>487,376 of 1,262,598 females (38.6%)<br>Female internal migrants = 472,253 (37.4%) of all females<br>Female international migrants = 15,123 (1.2%) of all females<br>447,485 of 1,203,691 males (37.2%)<br>Male internal migrants = 430,153 (35.7%) of all males<br>Male international migrants = 17,332 (1.4%) of all males |

**Table A2.2: Lifetime female in-migrants by region of origin, out-migrants by region of destination, and net lifetime migration streams, Ghana, 2000 and 2010**

| | 2000 Census | | | 2010 Census | | |
|---|---|---|---|---|---|---|
| Region of origin and destination | Lifetime in-migrants | Lifetime out-migrants | Net lifetime migration | Lifetime in-migrants | Lifetime out-migrants | Net lifetime migration |
| Western | 239,600 | 87,570 | 152,030 | 260,940 | 145,370 | 115,570 |
| Central | 93,920 | 239,510 | -145,590 | 185,660 | 318,530 | -132,870 |
| Greater Accra | 548,090 | 99,020 | 449,070 | 844,110 | 156,690 | 687,420 |
| Volta | 55,310 | 263,130 | -207,820 | 73,670 | 343,070 | -269,400 |
| Eastern | 157,800 | 276,400 | -118,600 | 207,770 | 388,770 | -181,000 |
| Ashanti | 275,470 | 221,720 | 53,750 | 432,430 | 302,070 | 130,360 |
| Brong Ahafo | 168,770 | 102,940 | 65,830 | 217,110 | 172,800 | 44,310 |
| Northern | 54,980 | 121,000 | -66,020 | 52,900 | 214,690 | -161,790 |
| Upper East | 24,390 | 118,540 | -94,150 | 30,640 | 161,050 | -130,410 |
| Upper West | 18,140 | 106,640 | -88,500 | 21,630 | 123,820 | -102,190 |
| Total | 1,636,470 | 1,636,470 | 0 | 2,326,860 | 2,326,860 | 0 |

**Table A2.3: Lifetime male in-migrants by region of origin, out-migrants by region of destination, and net lifetime migration streams, Ghana, 2000 and 2010**

| | 2000 Census | | | 2010 Census | | |
|---|---|---|---|---|---|---|
| Region of origin and destination | Lifetime in-migrants | Lifetime out-migrants | Net lifetime migration | Lifetime in-migrants | Lifetime out-migrants | Net lifetime migration |
| Western | 262,520 | 81,550 | 180,970 | 300,660 | 130,280 | 170,380 |
| Central | 92,160 | 234,820 | -142,660 | 186,880 | 292,890 | -106,010 |
| Greater Accra | 530,700 | 106,930 | 423,770 | 756,850 | 164,430 | 592,420 |
| Volta | 54,470 | 265,580 | -211,110 | 71,190 | 340,920 | -269,730 |
| Eastern | 156,980 | 270,710 | -113,730 | 206,480 | 359,620 | -153,140 |
| Ashanti | 296,640 | 222,440 | 74,200 | 418,030 | 313,050 | 104,980 |
| Brong Ahafo | 191,180 | 104,720 | 86,460 | 242,520 | 164,200 | 78,320 |
| Northern | 53,650 | 133,190 | -79,540 | 48,160 | 222,990 | -174,830 |
| Upper East | 25,040 | 136,250 | -111,210 | 31,000 | 167,780 | -136,780 |
| Upper West | 15,490 | 122,640 | -107,150 | 21,840 | 127,450 | -105,610 |
| Total | 1,678,830 | 1,678,830 | 0 | 2,283,610 | 2,283,610 | 0 |

**Table A2.4: Estimates of the net number of female in-migrants of those born outside by age group, Ghana, 2000-2010**

| Age | Net In-Migration by Region | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Western* | *Central* | *Greater Accra* | *Volta* | *Eastern* | *Ashanti* | *Brong Ahafo* | *Northern* | *Upper East* | *Upper West* |
| 0 to 4 | 14,435 | 12,723 | 36,360 | 6,209 | 10,905 | 22,305 | 12,166 | 4,150 | 2,973 | 2,028 |
| 5 to 9 | -4,145 | 4,389 | 11,515 | -202 | 1,934 | -2,869 | 383 | -1,771 | 234 | -1,753 |
| 10 to 14 | -3,555 | 6,799 | 23,160 | -338 | 3,252 | 7,882 | 532 | -2,841 | -82 | -2,158 |
| 15-19 | -996 | 12,709 | 34,634 | -362 | 8,352 | 18,632 | 4,793 | -275 | 1,324 | -1,561 |
| 20-24 | 11,244 | 12,676 | 54,945 | 71 | 7,763 | 34,082 | 11,923 | 656 | 196 | -374 |
| 25-29 | 8,227 | 10,342 | 53,576 | 747 | 7,080 | 28,664 | 10,100 | 771 | 825 | -1,482 |
| 30-34 | 1,106 | 6,620 | 27,830 | 368 | 3,714 | 17,041 | 4,532 | -195 | 324 | -1,117 |
| 35-39 | 2,434 | 6,133 | 25,010 | -255 | 4,713 | 13,139 | 3,773 | -531 | 416 | -1,602 |
| 40-44 | 1,112 | 4,223 | 15,822 | 633 | 4,970 | 9,440 | 3,183 | -115 | 176 | -1,048 |
| 45-49 | 3,190 | 3,853 | 13,032 | -110 | 4,104 | 6,666 | 2,561 | -383 | 46 | -552 |
| 50-54 | 3,690 | 4,033 | 16,898 | 876 | 4,687 | 7,931 | 3,306 | 518 | 233 | -438 |
| 55-59 | -505 | 1,237 | 9,211 | -404 | 985 | 2,741 | -34 | -459 | -70 | -461 |
| 60-64 | 1,930 | 2,191 | 9,027 | 475 | 2,364 | 4,056 | 2,304 | 359 | 208 | -115 |
| 65-69 | 98 | 796 | 4,192 | -351 | 189 | 577 | -136 | -141 | 14 | -337 |
| 70-74 | 1,776 | 1,470 | 5,967 | 409 | 2,371 | 4,894 | 2,968 | 347 | 79 | -229 |
| 75+ | 2,166 | 1,579 | 9,211 | 419 | 3,624 | 5,592 | 2,280 | 571 | -72 | -643 |
| TOTAL | 42,208 | 91,774 | 350,391 | 8,186 | 71,007 | 180,774 | 64,635 | 662 | 6,823 | -11,844 |

**Table A2.5: Estimates of the net number of female out-migrants by region of birth and age group, Ghana, 2000-2010**

| Age | Net Out-Migration by Region | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Western* | *Central* | *Greater Accra* | *Volta* | *Eastern* | *Ashanti* | *Brong Ahafo* | *Northern* | *Upper East* | *Upper West* |
| 0 to 4 | 8,804 | 15,223 | 14,731 | 14,866 | 17,387 | 17,114 | 10,317 | 11,588 | 8,436 | 6,051 |
| 5 to 9 | 1,376 | 244 | 2,739 | -1,250 | 1,899 | 577 | 3,340 | 2,173 | -1,392 | -1,762 |
| 10 to 14 | 4,221 | 4,451 | 2,044 | 3,305 | 6,238 | 2,865 | 4,857 | 5,955 | 380 | -1,272 |
| 15-19 | 7,113 | 8,556 | 5,448 | 8,451 | 9,453 | 5,384 | 7,094 | 14,071 | 5,542 | 3,033 |
| 20-24 | 9,215 | 14,769 | 6,808 | 14,832 | 18,058 | 14,897 | 13,556 | 20,691 | 14,284 | 7,567 |
| 25-29 | 6,734 | 13,343 | 5,101 | 17,184 | 21,035 | 11,459 | 12,956 | 16,897 | 10,333 | 6,055 |
| 30-34 | 3,871 | 7,619 | 2,524 | 9,009 | 11,223 | 4,429 | 6,432 | 11,386 | 3,884 | 2,276 |
| 35-39 | 3,505 | 9,254 | 3,189 | 7,274 | 9,337 | 4,314 | 6,513 | 6,710 | 3,375 | 2,110 |
| 40-44 | 1,939 | 6,155 | 3,170 | 5,856 | 8,351 | 2,910 | 3,993 | 5,775 | 1,204 | 817 |
| 45-49 | 1,814 | 4,646 | 2,108 | 5,289 | 7,786 | 2,959 | 3,616 | 3,260 | 1,741 | 441 |
| 50-54 | 2,407 | 7,506 | 1,588 | 7,300 | 9,104 | 5,416 | 3,108 | 3,467 | 1,661 | 1,265 |
| 55-59 | 1,490 | 2,234 | -79 | 2,327 | 4,471 | 1,080 | 1,273 | 291 | -264 | 271 |
| 60-64 | 1,470 | 3,902 | 420 | 4,105 | 5,750 | 2,693 | 816 | 1,911 | 1,078 | 1,268 |
| 65-69 | 176 | 1,311 | -332 | 1,511 | 1,843 | 265 | 454 | -26 | 189 | -95 |
| 70-74 | 3,006 | 3,362 | 783 | 3,917 | 4,193 | 1,859 | 694 | 2,202 | 1,463 | 1,037 |
| 75+ | -1,221 | 5,320 | -63 | 5,769 | 5,758 | 1,124 | 556 | 3,396 | 2,120 | 828 |
| TOTAL | 55,919 | 107,894 | 50,179 | 109,747 | 141,887 | 79,344 | 79,573 | 109,747 | 54,035 | 29,890 |

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