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Unravelling sex ratios, what can they tell us about the Census, population estimates and recent trends in migration?

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Abstract

This paper aims to understand the sex ratio observed in England and Wales (E &W) population estimates and the extent to which its pattern could reflect recent trends in migration. In particular it looks at the changes in sex ratio patterns resulting from the population estimates derived from the 2001 Census and aims to identify plausible explanations for its subsequent trend.

In most countries, low sex ratios at younger working ages are observed in census data, which leads to questions about their plausibility. One possibility may be that geographically mobile young males are more likely to get undercounted relative to their female counterparts. Even after using statistical techniques to adjust for under enumeration a sharp drop in the sex ratio was observed in the E&W Census of 2001 around age 18 and similarly appears in the mid-2001 population estimates based on the Census. A noticeable feature of population estimates for subsequent years is that the drop observed around 2001 is ageing forward (Figure 1).

In this paper, the authors will present some of the evidence in order to help explain the sex ratio pattern in the 2001 population estimates and subsequent years. The authors use the 1981, 1991 and 2001 Census data and compare these with a 'synthetic' population of those born in E&W estimated to be alive today, created by applying historical mortality rates available from the Government Actuary's Department to births, excluding the effect of migration. Patterns in sex ratios among cohort stocks of E&W and non-E&W born migrants are presented. Additionally, migration data from other sources are used to examine the sex ratio of migrant stocks and flows. The plausibility of the developing sex ratio is considered as well as whether the sex ratio patterns between 2001 and 2006 tell us something about recent trends in migration (missing young men, flocking female immigrants, 'brain swap', hidden migratory moves).

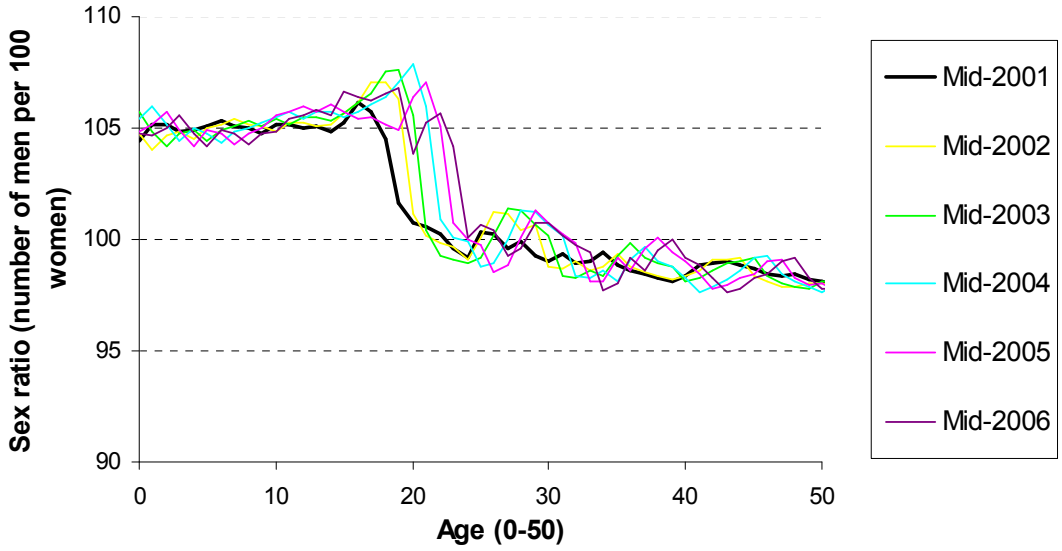
Introduction

The mid-2001 population estimates based on the 2001 Census for the population of E&W estimated the population at 1.1 million lower than the mid-year estimates rolled forward from the 1991 Census. Over half of the difference was explained by two elements: the judgement, in the light of the 2001 Census, that additions to the population as a result of under enumeration in the 1991 Census were too high; and errors in the estimation of migration to and from the UK during the 1990's.[1] Further analysis of the ONS Longitudinal Study, matching exercises in two local authorities (LAs) (Manchester and Westminster[2]) and further studies of other LAs[3] identified a further 275 thousand[4,5]. There remains an unexplained difference of 209 thousand.

However, even though much of the difference in overall numbers had been justified, the detailed age sex split of population still shows a pattern that has not been fully explained. The sex ratio (number of men per 100 women) provides a particular illustration of the remaining issues. Sex ratios are generally considered to be one of the more robust measures and evaluation tools of demographic analysis. The sex ratio in the 2001 population estimates show a 'cliff edge' around the age of 18 with the deepest point of the dip at age 24, as shown by the thick black line in Figure 1. Additionally, the population estimates for the current decade, based on the 2001 Census, show an ageing forward of this cliff edge, as well as some further changes in the sex ratio pattern.

This paper will aim to unravel the sex ratios in the 2001 and subsequent mid-year estimates and present the evidence for possible explanatory factors. This paper does not contain definitive answers but considers evidence from demographic literature, previous census data, other administrative data sets and demographic analysis to help in understanding the observed sex ratio patterns and whether they can tell us something about migration.

Figure 1: Sex ratios from population estimates mid-2001 to 2006 for England and Wales



Background

Patterns in sex ratios

The sex ratio – defined as the number of males to every 100 females - is a basic demographic statistic, often used as a measure of data quality. More boys are born than girls, and although infant and child mortality is higher among boys, the number of deaths is small and so the ratio seen at birth (105 men for every 100 women) (in the absence of migration) is maintained during childhood and is still seen in teenage years. Population estimates for E&W made prior to the 2001 Census suggested that sex ratios remained above one hundred as men continued to outnumber women until

their late forties when the sex ratio started to fall. However, estimates based on the 2001 Census showed that women have started to outnumber men as early as the age of 22. When this trend was observed in the results of the 1991 Census, there was little confidence in this finding.

Since the 2001 One Number Census (ONC) confirmed this trend, there was increased confidence in estimates of sex ratios that are low at young adult ages. In fact, the dipping trend in the sex ratios of the 2001 Census is in line with the trends observed in the 1981 and 1991 Censuses (Figure 2)[6], but unlike 1981 and 1991, the 2001 Census has been adjusted using the 'capture recapture' method to correct for under enumeration. It shows that the 2001 values continue a trend first seen in 1981. So is such a drop in the sex ratio plausible and what else can be understood from the data?

Are there missing men?

Virtually all censuses struggle with the problem of under-enumeration of young men. A recent paper focussing on South-Africa also clearly shows the undercount of young men in censuses[7]. It is assumed that mobile young men in the age groups 20 to 34 are likely to be undercounted compared to their female counterparts.

In New Zealand, the sex ratio has reversed among the prime working-age groups (20 to 49 years of age) from being male dominated to being female dominated, showing a clear imbalance between number of women and men since the early 1980's [8]. The authors identified four factors that can be attributed to the fall in the sex ratio: differential mortality between the sexes, more native-born men leaving their country; a higher number of female immigrants and, statistical conditions undercounting men becoming progressively greater over the past 20 years. Mortality rates of young men are higher than those of women but the numbers involved were still very low and so mortality was discounted as a significant cause of a low sex ratio for the younger (20-34) age groups. Migration plays a much greater role in explaining the imbalance between the sexes at prime migration ages. The authors were expecting to find evidence of there being more New Zealand born men than women in Australia (as the main country of residence for expatriate New Zealanders) and to a lesser extent in the UK. But neither the Australian nor UK census data revealed the New-Zealand born young men (no adjustments had been made for under enumeration of young men in either country). Emigration of New Zealanders until the 1990's was mainly male dominated. However, the imbalance in the sex ratio at working ages (20-49 years of age) in the resident population observed since 1991 was only to some extent explained by emigration of young males and there is no evidence of higher return migration of female New Zealand citizens. Part of the answer seemed to lie in the feminisation of immigration at key productive and reproductive ages causing the change in the gender balance in the resident population.

Similarly for E&W, mortality differences between males and females are too low to be contributing significantly to the dropping trend in the sex ratio. Detailed investigation of the migration data by researchers at the Office for National Statistics found some evidence that emigration had been underestimated in the 1990's and that the majority of the underestimation is likely to be of males [9]. However, the

underestimation did not account for all of the observed fall in the sex ratio, in particular for the younger age group 25-29.

One of the difficulties in the census is measuring the resident population for those people for whom the concept of usual residence is hard to define. The 2001 Census definition of 'usual resident' was '…someone who spends the majority of their time residing at that address'[10]. Applying this definition could have been problematic for certain population groups such as those who have no usual residence anywhere or who do not have a usual residence in any one place in E&W. This was more likely to be the case for people who were single or not part of a traditional household and consequently may not have been picked up in the census. An additional definitional issue is that a long-term migrant in the Census is defined as someone who has left their 'usual residence' for longer than 6 months whereas this cut-off point for the mid-year estimates is 12 months. If the people in these situations were disproportionately men then this would have an impact on the sex ratio in the mid-year estimates. The remainder of this paper will explore the potential hypotheses that could contribute to an explanation for the pattern in the sex ratio between 2001 and 2006 as shown in Figure 1 and whether these patterns tell us something more about migration.

Hypotheses

If the resulting sex ratio in the population estimates based on the 2001 Census and subsequent adjustments is accepted then there is a need to account for how that sex ratio was arrived at and how it has aged on in the years since 2001.

The first hypothesis is that the emigration at around ages 17-18 is a one-off event related to the period 2000-2001. For this hypothesis to be true one would expect the sex ratio pattern to age forward but to lessen because the majority of those young people are likely to have left for only one or two years.

Under a second hypothesis the sharp dip in the sex ratio around age 18 is a yearly migratory event of young men migrating around the age of 18-19. One may expect to see male migrants returning at a later age, but also a continuation of the dip at around age 18 for subsequent mid-year estimates when new generations reach that age and more men than women migrate. Under both hypotheses, the fact that we do not see young men return at a later age might indicate that the mechanisms on which mid-year estimates rely (such as the International Passenger Survey (IPS)) fail to register longer term returning migrant men sufficiently.

Thirdly, based on the literature review and evidence from Total International Migration (TIM) we suggest the model of immigration that has become increasingly female dominated and emigration increasingly male dominated which may provide a partial explanation for the deepening of the dipping trend in the sex ratio.

Finally, we explain the sex ratio pattern as a 'definitional issue' whereby young men are underestimated in the mid-2001 population estimates (census based or subsequent adjustments to get to the mid-year estimates) due to the absence of a capturing technique for short term migrants in the mid-year estimates and lack of an adjustment

mechanism which would allow for adding back short term migrants in subsequent years.

A more likely hypothesis is that the sharp drop in the sex ratio observed in the 2001 Census is a combination of different effects together with the risk that was already highlighted in previous paragraphs of the 'universal' problem of under-enumeration of young males in censuses not being fully addressed by the ONC process.

Data

For the comparison with previous censuses and the demographic analysis, population data from the 1981, 1991 and 2001 Censuses split by whether the population is E&W or overseas born was used. This census information is also used to derive mid-year population estimates split by place of birth. Since 1837 every birth that occurred in E&W has been registered and this data is considered to be complete[11]. Thus a complete series of numbers of births is available relating to the E&W born population alive today. Similarly, all deaths (both E&W and non-E&W born) that occur in E&W have been registered. By combining the deaths with information on population data from censuses and, since the 1960's, population estimates, the death figures can be used to estimate a historical series of age and sex specific mortality rates for E&W.[12] These can be used with the births data to estimate what the population of E&W born people would be in 2001 if the only demographic effect was mortality and excluded migration. Of course, one has to keep in mind that these mortality rates are themselves derived using census data.

Overall mortality rates are used rather than deaths among the indigenous population (E&W born). It was assumed that mortality rates of the non-indigenous (non-E&W) population did not differ substantially from the indigenous population mortality rates. Deaths to non-E&W born make up only just over 10 per cent of deaths in E&W in 2001 so the weighting of the non-indigenous population would not be large enough to affect the overall mortality rate in particular at the younger, low-mortality ages. Even if a different method was preferred it was only from 1968 that country of birth was collected at the registration of a death for E&W therefore mortality data split by country of birth is only available for cohorts aged less than 33 in 2001. The other assumption in using the mortality rates is that the mortality of E&W born who are no longer resident is the same as the mortality of the resident population. Selection effects may suggest that emigrant mortality may be lower (fitter people migrate) but conversely emigrants may face greater risks. In the absence of any other information, and given the small number of deaths at younger ages we consider this a reasonable assumption.

For migration data, the TIM is calculated using data from the IPS, the Home Office for data on asylum seekers and the Irish Central Statistics Office for migration estimates of all citizens between the UK and the Irish Republic. We also investigate the census 'one year ago' migration question data. Furthermore we aim to investigate sex ratio patterns in other datasets such as the Patient Register Data (PRD). The data comprise patients registered with GPs to access NHS services. The population covered includes all people requiring access to NHS services through a GP, regardless of age or reason for visit; individuals staying in the UK for longer than 3 months can

register with a GP but excludes those not wishing to access NHS services from a GP and those staying in the UK for under 3 months.

Method

For the demographic analysis, the aim is to produce a comparison of the expected E&W born population still alive and compare it to those found in the census (or estimated as being part of the population estimate). We compare the population resulting from the 2001, 1991 and 1981 Census with a 'synthetic' population derived using birth data and mortality rates only. This allows estimating the stock of E&W born emigrants. Non-E&W born immigrants stocks at each age and sex are available from the census counts (and used to estimate figures based on population estimates). Thus we have estimates of the sex ratio among those migrant stocks. The method used to calculate the E&W born population from the births data is described in Annexe 1.

Differences found between the 'synthetic' population derived from births and mortality rates and the other population estimates (census or mid-year estimates) could be attributed to a number of causes: the mortality calculations; migration; errors in the census; and, for estimates, the assumptions made about country of birth, and past errors in adjusting population estimates after previous censuses. We have seen from other studies that only a very small proportion of the difference could be due to mortality calculations, at least at younger ages. A greater proportion could be due to definitional issues. Individuals who are not migrants but neither have a 'usual address' here may have been missed from the census and could contribute to the difference as well as past errors in adjusting population estimates after previous censuses. However, it is assumed that migration accounts for the bulk of the difference.

Comparisons will be made with the 2001 Census results themselves, the latest 2001 mid-year estimates, the 1991 Census, 1991 mid-year estimates, the 1981 Census and 1981 mid-year estimates[13]. For the comparison with the 1981 and 1991 Censuses, one has to bear in mind that these were not 'one number' censuses so that larger differences between the census figures and the population estimates for 1981 and 1991 would be expected[14]. Thus the assumption that the difference in population between the census and the estimate is distributed by country of birth as in the census is of greater importance for 1981 and 1991.

Results

1. Sex ratio patterns between 1971 and 2006

One of the obvious explanations for the observed pattern in the sex ratio is that it reflects the accuracy of the census coverage and the adjustments made to the population estimates thereafter. Figure 3 shows the sex ratio pattern for the calculated 'synthetic' population at 2001 (black line), the 2001 Census (orange line) and the pattern we would have observed if 2001 mid-year estimates would have been rolled forward from 1991 (dashed black line). The synthetic population gives the sex ratio for the population in E&W if mortality were the only demographic effect. The trend line of the synthetic population also shows that women start to outnumber men at a much later stage (late fifties) compared to either the estimates rolled forward from

1991 or the 2001 Census-based estimates. The line in the mid-year estimates rolled forward from 1991 also shows a dip in the sex ratio at the later age of 35 years.

Figure 4 plots the sex ratio pattern for mid-year population estimates between 2000 and 2006. The pattern for 2000, being the last year before the 2001 Census, has been rebased following the 2001 Census but differs from the pattern after 2001. For the population estimates pre-2001, one can observe a sharp drop in the sex ratio around the age of 18 followed by a fast recovery of the sex ratio in the early twenties before dropping again in the mid twenties (Figure 4). Some caution is needed in interpreting the pre-2001 sex ratio. The methods used to rebase the population between 1991 and 2001 are likely to have an effect on the pattern of the sex ratio. The pre-2001 patterns may also reflect that the revisions to 1991 may not have been optimal by age and sex. In contrast, the patterns after 2001 show a peak at age 17, a cliff edge at about age 18 onwards with its deepest point at age 24 and a recovery of the sex ratio at age 25 in 2001 and age 29 in 2006. In figure 5 the different mid-year population estimates are plotted 'on top of each other' by making the sex ratios for the different years correspond with the ages the population would have been in 2001. This illustrates what is happening to the sex ratios of cohorts and suggests that although the sex ratio introduced by the 2001 Census dominates there has not been a simple ageing forward of the drop in the sex ratio. It also emerges that the 2006 MYEs stop ageing forward and suggest a fairly different pattern compared to the previous years. The lines seem to diverge for cohorts aged 20 and over in 2001 with a deepening of the dip over the years.

The observed features of the sex ratio charts can now be considered in terms of the composition of migrant stocks, both the stock of non E&W born found in E&W and derived stocks of E&W born who are not enumerated as being in E&W.

2. Comparing census and mid-year population estimates with the 'synthetic' population (England and Wales births moved forward)

Comparison with the 2001 Census

The calculation presented in Annexe 1 resulted in the population distribution shown in Figure 6. The population of E&W born alive in 2001 is estimated to be 50.8 million, around 1.5 million lower than the latest population estimate for residents in E&W in mid-2001. This is a clear indication of a positive net migration. For the synthetic population, the data also reflect a sex ratio that shows males outnumbering females up until the age of 59, a pattern one would expect based on sex ratios at birth and lower life expectancy among males (Figure 2).

Figure 7a and Table 2 give an indication of some of the issues that the 2001 Census has raised about the E&W population. At ages under 18 and above 50 there are similar patterns of difference in the numbers of males and females between the 'synthetic' estimated E&W born population and the 2001 Census results (Figure 7a). This is true for both the total census population and the census E&W born population. Between the ages 19 to 50, the comparison with the total population shows the population of males is around the same size as would be expected given births and mortality only, so net emigration of E&W born has been matched by the net

immigration of those born elsewhere. For females the story is different in that the net immigration of those born elsewhere outweighs the net emigration of the E&W born by around one million.

Figure 7b shows that although the numerical differences between the census and the 'synthetic' estimate for the E&W born population become smaller at older ages, proportionately the decline is less steep. Similarly for the comparison with the total population, although the numerical difference is not nearly as great at ages 60 to 80, proportionately these differences are nearly as large as those at younger ages.

Table 2 shows some of the differences disaggregated between E&W born and non-E&W born (foreign born) population comparing with the 2001 ONC results (explanations of the calculations of Tables 2 to 4 can be found in Annexe 2). If migration sex ratios mirrored population sex ratios at the peak migration ages it would be expected that around 103-105 men would migrate for every 100 women. Thus men would be slightly more prevalent in both inflow and outflow of E&W born migrants and migrants born elsewhere. However, in reality migration flows are very much marked by gender [15]. For the peak migration ages (20 to 30) the table shows that for the foreign born population net migration is weighted towards females with a resulting stock of only around 9 foreign born men being in the population for every 10 foreign women. For the E&W born population the pattern of migration by sex appears to be strongly in the opposite direction. The ONC data suggest that for the population aged 20-24 the number of men that have left has been half as many again compared with women. At age 25-29 there have been almost double the number of men as women have left (193 for every 100 women), with the ratio at 30-34 being only a little lower at 180.5 men having left per 100 women.

Comparison with the latest 2001 mid-year estimates

The analysis above is based purely on the results from the ONC. The following section reflects the subsequent work which addressed the need to adjust the ONC numbers for population estimate purposes. Table 2 also compares the synthetic population estimate using birth and mortality with the latest estimate for mid 2001. In order to make this comparison two assumptions have to be made. The first is that the changes to the population between census day and mid-year are in proportion to the country of birth data recorded in the census. The second assumption that has to be made is that the additional population added to the 2001 mid-year estimate in September 2003 has the same country of birth characteristics as the population measured in the census (in the census 92 per cent of the population was E&W born). There is some evidence from the Longitudinal Study (LS) that for the unlinked population for the 2001 Census that around only 80 per cent were E&W born [16]. However, the unlinked will reflect both unmeasured migration and those who may not have been included in the 2001 Census for definitional or other reasons. Analysis using alternative assumptions for the percentage E&W born separately for males and females suggested that plausible alternative assumptions did not change our conclusions.

Table 2 still shows that positive net-migration among the foreign-born population is still female dominated at the peak migrant ages. It also shows that a greater proportion of E&W born men than women have emigrated. However, as compared with the

Census, the effect of adding back some men has meant that the sex ratios are not nearly as extreme for net migration figures for the E&W born population with between 130 and 150 men having emigrated for every 100 women at ages 15-49, compared with 150 to 190 when using the census estimates. This suggests that mid-year estimates for 2001 provide a more plausible sex ratio pattern.

Comparison with the 1991 Census and 1991 mid-year population estimates

Table 3 for 1991 shows similar data to those of Table 2 for 2001. The original mid-year estimates (Table 4) made after the 1991 Census had over-estimated the population by an estimated 351,000 and the great majority of these were young men. Table 3 shows comparison for the 1991 Census and rebased mid-year estimates; Table 4 shows a comparison for the 1991 Census with the original estimates made at the time. Comparing columns between Table 3 and Table 4 show slightly more foreign born women than men immigrating. For the E&W born we see large differences. For ages 16-24 the original additions to the population after the 1991 Census changed the sex ratio so that more E&W born women than men had emigrated (Table 4). The subsequent revisions to the 1991 estimates following the 2001 Census moved the sex ratio back closer to that found in the census results. At age 25-44 the revised 1991 estimate show sex ratios for net E&W born emigration that are closer to those implied by the 1991 Census (Table 3) and very different from the initial 1991 mid-year estimates (Table 4).

Comparison with 1981 Census population and latest 1981 mid-year estimate.

Similar to the tables for 1991 and 2001, Table 5 shows the 1981 Census and estimates data for the key migration ages. The sex ratios among E&W born and foreign migrants are broadly the same in both datasets, reflecting the adjustment for the Census to the estimate added in both men and women. The table shows that for foreign born migrants (net migration) there are in the population a greater number of women than men, as we have seen for both 1991 and 2001. Among the E&W born migrants (net migration) the ratios are in the region of five males for every four females. This is a considerably lower ratio to that which is inferred by the original population estimates made after the 1991 Census and is much closer to the ratio inferred from the revised 1991 estimates and the latest 2001 population estimates.

Comparing the sex ratio data for 1981, 1991 and 2001

The cohort analysis in Table 6 brings together the sex ratios among migrant stocks (non-E&W born resident in E&W and E&W born residents who are abroad) derived from the 2001 Census, mid year estimates and the synthetic population (Tables 2 to 5). The table is divided in three sections with the first (left) section showing the sex ratios based on the 2001 Census. Sections two and three (middle and right column) are based on the latest mid-year estimates and the mid-year estimates before the adjustments made after the 2001 Census respectively.

The cohorts can be followed in the rows of the tables; ages shown are those in 1981 and thus that group is 10 years older at the 1991 Census and 20 years older at the 2001 Census. The top three tables reflecting sex ratios among the stock of non-E&W born immigrants is generally female dominated whereas in the bottom three tables the

sex ratios among the E&W born emigrant stock is male dominated. This trend can be observed in all three census years from the ages above 19. Analysis of the figures in this way also suggests that the pre-2001 ONC 1991 population estimates are not consistent with the 2001 estimates and thus the original adjustments in 1991 were likely to have been overestimated (too many young men had been added in).

The female dominated sex ratios among the immigrant stock are based on census data whereas the male dominated sex ratios among the emigrant stock are derived by subtracting the synthetic population from the census population. Both are likely the result of a combination of several effects of which the two most important ones could be female dominated immigration and under-enumeration of migrating young men.

The results of this analysis should be treated with caution. A number of assumptions have had to be made in producing the data, based on migration stocks. Migrant-stocks are the result of much larger migrant flows. Migration estimates based on those stocks and derived from censuses and surveys omit repeated movements[17] . Sex ratios observed in those migrant-stocks will be biased by those hidden moves that aren't picked up in the census or surveys. The research findings suggest that migration data derived from census may be distorted, and further points out the evidence from the literature on repeated movement that 'the proportion of hidden movement is likely to vary still more between subgroups of the population, such as age groups'[18]. Therefore, hidden movement at crucial migration ages will differ between gender groups and could partly be responsible for the sex ratio pattern observed in Figure 4.

3. Sex ratio patterns in other administrative datasets: Patient Register Data

Patient register data (PRD) covers the whole of the E&W population and was therefore identified as a possible administrative data source for informing us about the sex ratio in the population for E&W. Figure 8 and 9 illustrate the sex ratio in the 2001 and 2006 PRD as compared to the 2001 and 2006 mid-year estimates. In 2001 and up to the age of 25 PRD and MYEs are roughly following the same pattern for the patterns to diverge after that. Indeed the PRD was mentioned as one of the corroborating sources for the 2001 ONC[19]. However, the lines diverge quite dramatically after the age of 25 and there is no evidence to suggest which one is reflecting the 'true' sex ratio of the population. Figure 9 shows that between 2001 and 2006 the PRD have not moved forward as have the MYE.

When looking at the trend in the PRD separately between the ages 16 and 30, one can see a deepening of the dip between 2001 and 2006 (Figure 10). The deepening of the dip in the sex ratio could be due to younger men failing to register at their local G.P. (in the area where they moved to) or move abroad after leaving the parental home address. For this to cause the sex ratio to drop (and young men to be underrepresented on G.P. lists between the ages 20 and 24), it would require them to deregister with the G.P. at their original (parental) health centre or the centre to clear them of their list of patients. The increase in the sex ratio after the drop indicates the men reappearing on G.P. lists as soon as they are faced with a medical need or when returning from abroad.

Registration and deregistration are an automatic process whereby the old notes of the newly registered patient are being sent automatically to the new G.P. practice. This

process is centrally coordinated by the local health authority and takes roughly six weeks. Anecdotal evidence from conversations with administrators of two G.P. practices report that young men are indeed less likely to register with a G.P. as compared to their female counterparts until they face a medical problem. Young men are also less compliant and responsive to recall letters from their G.P. practice which would result in them being removed from their G.P. list at their original home address. Anecdotal evidence suggests that young men may appear with a serious health problem at health centres claiming they are not registered anywhere (they may be still registered at their home address but are not aware of it or that they have indeed been removed from the G.P. registration list for failing to respond to letters from the practice). Females are reported to be more compliant with administrative duties. They also have more incentive to register with a G.P. as soon as they arrive at the new location for family planning and gynaeco-obstetric reasons. Double counting of females (being still registered at their home address and the new address) should be rare as the centralized system uses a unique identifier (NHS number) to facilitate the automatic removal from the old G.P. list.

The deepening of the drop between 2001 and 2006 (Figure 10) could also be due to increasing numbers of overseas students and predominantly male migrants in that age group failing to register with a G.P. when they arrive in the UK (and female migrants, as their E&W counterparts, being more likely to register at the local G.P. upon arrival), the number of registered patients at those ages becomes predominantly female. The bulging pattern in the PRD (Figure 9) after the age of 30 could be due to increasing numbers of male migrants eventually registering at a G.P. practice.

4. Sex ratio patterns in migration data

The stocks of net E&W born migrants abroad and non-E&W born migrants in E&W are the result of the flows of migrants. However, robust migration flow data by individual age and sex further split by country of birth is not readily available. In the latest published report of the TIM data it states that "there is a continuing trend for more males to emigrate from the UK than females". However, contrary to our own findings, the report also suggest that "the same trend is true for immigration, but by a smaller ratio. For instance, for every 10 men that left the UK in 2005, 7 women left while for every 10 men that migrated to the UK, 8 women also migrated." [20] Similarly, the latest Accession Monitoring Report on recent but overall migration trends from the ten accession countries joining the European Union on 1 May 2004 (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia with Malta, Cyprus excluded from the report) [21] for the period May 2004 to March 2007 reports the male to female ratio for those who applied to be around 130 men for every one hundred women. The Accession Monitoring Report gets updated every three months. For the earliest period (May 2004- March 2005) the gender ratio was 127 males for every one hundred female migrants.

In contrast, when looking at age specific migratory patterns, data from the IPS show that at the peak migration ages (20-29) net immigration is much higher for women than for men (at around 6 men for every 10 women) in the period 1991-2000. Although the net figure is still higher for women for the period, 2001 to 2006 this has

changed to 9 men for every 10 women. From 1991 to 2004, sex ratios were equally low for the inflow of migrants among the younger age group (15-24 year olds) whereas for the older ages (25-44 year olds) the sex ratio among the inflow was high again, potentially reflecting the past gender migration pattern (whereby migration was predominantly male dominated) (Figure 11). Small sample numbers at higher ages means the ratios fluctuate widely and are therefore not shown. Outflow data suggest that overall both among the younger (15-24) and older (25-44) age groups more males than females have left the country between 1991 and 2004. However, the IPS does not cover all migrants and the data have been shown to be female biased as they would tend to pick up wives joining their partners who might have come to the UK as asylum seekers. We therefore looked at the data for asylum seekers and whether they could possible influence or even reverse the sex ratio. Specifically looking at principal applicants (rather than dependents) because they tend to be mainly male we found for the years 2003-2005 that the sex ratios in the IPS inflow data remained below 100 even when taking into account the sex ratio among asylum seekers,.

Further analysis was undertaken using 2001 census data by comparing migration rates derived from place of residence one year earlier. For E&W born and foreign born migrants within the UK migratory rates are highest between the ages 18 and 35 (Figure 12); a similar pattern occurs for moves from outside the UK (not shown). The patterns reflect a decrease in migration between the very young ages (0 to 5 years of age) when very young children move with their parents and the teenage years when migratory moves are low before peaking at 18-19. Migration rates remain high until the age of 30 and drop quite steeply from the age of 35 onwards. This seems to be the pattern independently of whether the movers are E&W or foreign born, coming from within or outside the UK one year before. Sex ratios patterns among those movers consistently show dips in the sex ratio at the start of the migration-peak ages (Figure 13).

Cross border migration had been suggested as an explanation for the 'missing' young men who could have migrated from E&W to Scotland and Ireland. However, census data for Scotland and Northern Ireland showed similar dips in the sex ratio as for E&W suggesting young males equally go 'missing' in those countries. Similarly cross border migration based on patient register data between E&W, Scotland and Northern Ireland show a fluctuating sex ratio pattern with a dipping sex ratio between the ages 16 and 28 for outflow and inflow data. These observations and small numbers in cross-border migration suggest that these movements are unlikely to have a strong effect on the sex ratio pattern at the national level for E&W.

Discussion

The plausibility of the previously suggested hypotheses can now be assessed in view of the presented evidence. Under the first hypothesis with emigration at around age 18 as a one-off event related to the period 2000-2001, one would have expected the moving forward of the cliff-edge but the dip to lessen because of returning young people who left for only one or two years. Under a second hypothesis the sharp dip in the sex ratio around age 18 is a yearly migratory event of young men migrating. One may expect to see male migrants returning at a later age, but also a continuation of the dip at around age 18 for subsequent mid-year estimates when new generations reach that age and more men than women migrate. Under both hypotheses, the fact that we

do not see young men return at a later age might indicate that the mechanisms on which mid-year estimates rely (such as the IPS) fail to register and allow for (longer term) returning migrants men to be put back in the mid-year estimates.

We have also shown that there is evidence of more men than women emigrating and more women than men immigrating, which could provide a partial explanation for the deepening of the dip in the sex ratio. The sex ratio trend line in Figure 3 of the 'synthetic' population (where mortality is the only demographic effect) shows that women start to outnumber men at a much later stage (late fifties) compared to the 1991 and 2001 census-based estimates suggesting predominantly females immigrate (and/or male emigrate). The demographic analysis and investigation of the country of birth characteristics also suggest that in particular around the peak migration ages, the 'excess' of female immigrant stock becomes apparent (Figures 7 a and b). The high sex ratios among the emigrant stock and low sex ratios among the immigrant stock was found consistently across comparisons between the synthetic population and the census and mid-year estimates of 1981, 1991 and 2001. In figure 5 where the different mid-year population estimates are plotted 'on top of each other', the overlap between the lines is explained by the cliff edge now moved backward to 2001. However, the lines seem to diverge after the age of 20, with a deepening of the dip between 2001 and 2006. The growing influx of young female migrants such as au-pairs, auxiliary health care staff in the NHS could partly explain the deepening of the dip in the sex ratio. However, the subsequent recovery of the sex ratio at the end of the twenties also seems to get more pronounced over time between 2001 and 2006, perhaps an indication of returning migrant men.

Are migration flows of the overseas born becoming increasingly female dominated? There is some evidence of female dominating emigration streams from countries such as East Germany. The study 'Not am Mann' reports a sex ratio of 100 men for every 80 women for the region, a surplus of men which is among the highest in the whole of Europe[22]. Young women are reported to be better educated and in search of better opportunities abroad. Added to this, is that, despite many young men also having left East Germany in search for better jobs, the return-flow of migrants is dominated by males with men being disappointed after having failed to find work or make social contacts. In the case of East-Germany one can assume a vast proportion of these workers go to West-Germany; however, for some, better job prospects in the UK than elsewhere in Europe have also been an attraction. The outflow of higher educated women corresponds with the observation in the study of New Zealand where in-migrants tend to be female-dominated and well-educated[23] and suggests the possibility of a 'brain swap' (well educated female immigrants for well educated emigrant men) instead of a 'brain drain'. Migration flows to the United States, Canada, Australia and New Zealand have always been dominated by males. The current large migration flows of women may reflect changes in industrial demand on the international labour market[31]. Similarly, the yearly migration report 'International Migration Outlook' produced by the Organisation for Economic Co-operation and Development (OECD) highlights the increased immigration from India, China, Eastern Europe and Africa into OECD countries and confirms the tendency towards the feminisation of this movement [24]. The latest edition for 2007 focuses on the employment situation and the participation rate of immigrants. The report indicates that immigrants have been particularly recruited in jobs in the services sector, a phenomenon which could partly explain migration patterns in the UK.

The One Number Census approach was designed to handle under enumeration. Therefore explanations relating to the methodology around the 2001 Census need to be considered. In order to adjust for the undercount independence is assumed between the Post-Enumeration Surveys (PES) within strata by age-sex-geography and other variables. However, problems arise when this independence assumption does not hold and if capture probabilities in the PES are heterogeneous across individuals[25]. The bias is usually downwards and leads to potential underestimation, in particular of the male population. An adjustment for 'correlation bias' between households was made to the 2001 Census [26]. The ONS had planned to use the method suggested by Bell[27] using sex ratios in demographic analysis in order to make the inter-censal adjustment more gender sensitive, but no reliable sex ratios were available at the time. The lack of an adjustment for within household dependency (subsequently effectively addressed by adjustments made to population estimates using the LS) and possibly different assumptions in the between household adjustment to increase the ratio of men added back may have helped produce a more plausible sex ratio pattern.

The more likely hypothesis is that the sharp drop in the sex ratio observed in the 2001 Census is a combination of different effects. The literature seems to suggest that under-enumeration of men at younger ages is observed in almost every census and could be considered a 'universal' census problem [28,29,30,31]. Young men reaching prime working and migration ages are more likely to migrate than their female counterparts[32]. At age 18, most young men and women will have finalised secondary education. Young men are also more likely than their female counterparts to shun data collection exercises such as the census and less likely to engage with administrative processes such as registering with their local G.P. The analysis of the PRD seems to confirm all these observation by showing a dip in the sex ratio pattern around migration ages. The deepening of the dip in the PRD sex ratio suggests that immigrant males might be equally less likely to register compared to their female migrant counterparts upon arrival in E&W; double counting of females is less plausible as an explanation for this pattern. The comparison with the mid-year estimates does however not allow drawing a conclusion about which sex ratio reflects the 'true' sex ratio in the population.

This study raises some interesting questions. Why has there been over the last three censuses consistent evidence that at key migration ages of 20 to 34 more foreign-born women than men are in the population stock? Why do we observe that males are more likely to emigrate compared to their female counterparts in the E&W born population? And at what point does this sex ratio based on the subtraction of the census and the synthetic population become implausible? The findings of our analysis suggest that none of the suggested hypotheses provide a full explanation of the moving forward trend in the sex ratio of the 2001 Census.

Census under-enumeration among young males at migratory ages is a universal problem and the adjustments made to population estimates following the census results suggest that the One Number Census process might not have entirely addressed this issue. Furthermore, the pattern in the sex and age structure in the population estimates for subsequent years needs further explanation. The moving forward of the cliff-edge in the sex ratio is potentially explained by national (cross-border) and international migration by young males not being registered by the

designed survey data sources such as the IPS or due to definitional differences of short-term migration between the census and population estimates.

Recent literature seems to suggest a feminisation of international migration which, for the UK could represent the feminisation of immigrant flows, predominantly towards better paid jobs in the service and health care sector. The combination of the effects of high sex ratios in emigration stocks and low sex ratios in immigration stocks with undercounting of males may explain the sex ratios for recent years. The lack of migration flow data with sufficient precision to be disaggregated and analysed by age, sex and country of birth make it difficult to track the sex ratio changes. Unmeasured migratory flows could further explain why there is further 'noise' and movement added to the moving forward of the cliff-edge in subsequent mid-year estimates.

Further research

The demographic accounting methods used here are helpful in understanding the sex ratio pattern produced by the 2001 Census. The analysis confirms a long term slight female bias in the stocks of overseas born, but shows a strong male bias in the implied stocks of the E&W born who are abroad. Both of these effects contribute towards the sex ratio pattern observed in the population. However, the fact that those sex ratios are observed across different age groups and in the different censuses demands further investigation.

Further research should focus on migration data and explore whether sex ratio imbalances can be observed in other datasets. The finding that the sex ratio in the PRD does not age forward needs further investigation but may suggest that it provides a more plausible sex ratio pattern. Further analysis will be carried out to understand the flows on and off of the register by age and sex. We need to decide whether the sex ratio pattern is an artefact or in some way reflecting real population changes caused by migration. Further consideration also needs to be given to finding data sources which may provide evidence of the population sex ratio at national but also sub-national level so that under- enumeration adjustments for dependency could be made which are made gender sensitive and based on plausible sex ratios.

Figure 2: Sex ratio patterns for England and Wales: Census and Mid-year estimates for 1971, 1981, 1991 and 2001

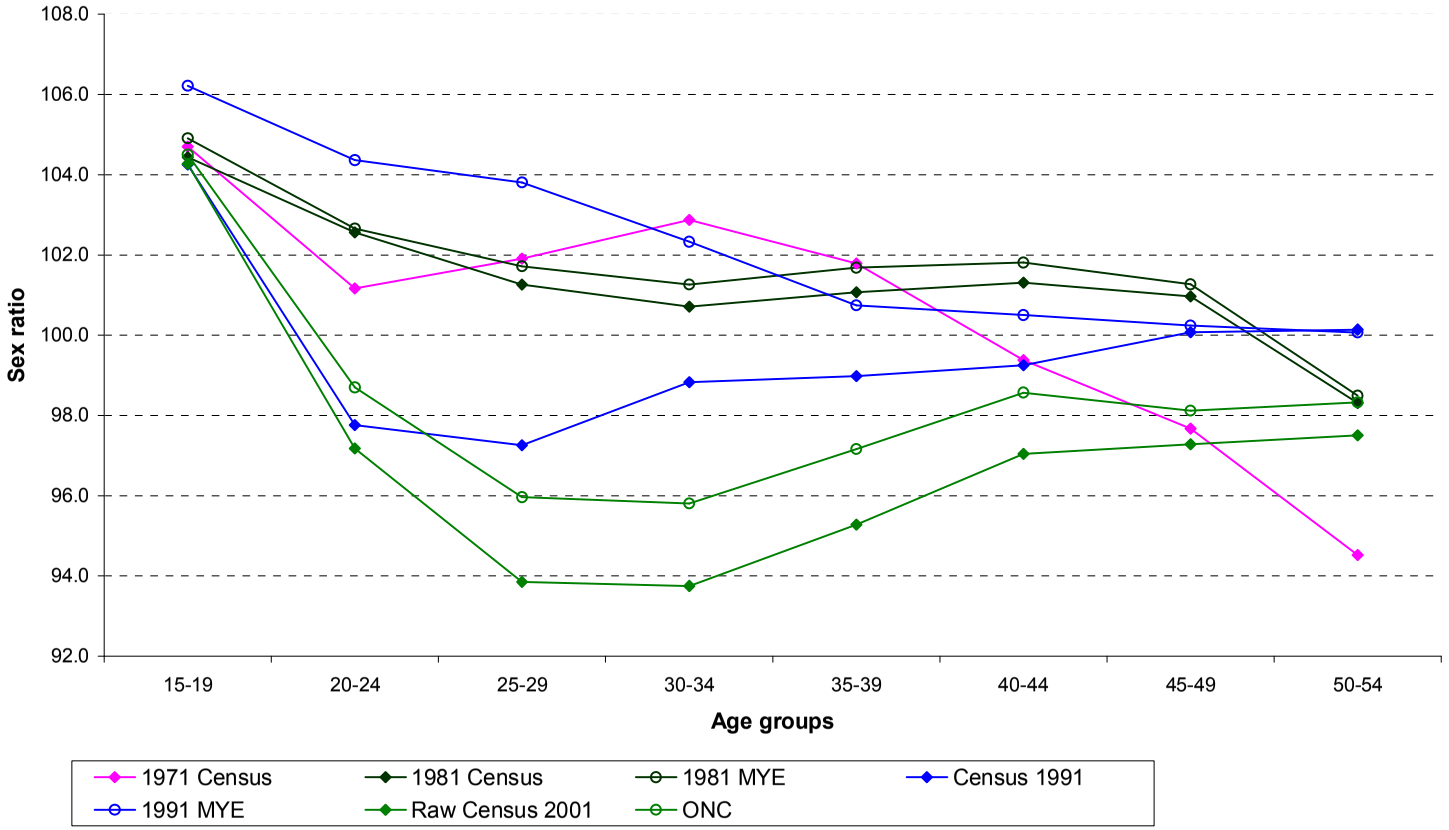


Figure 3: Sex ratio patterns for England and Wales: different 2001 population estimates

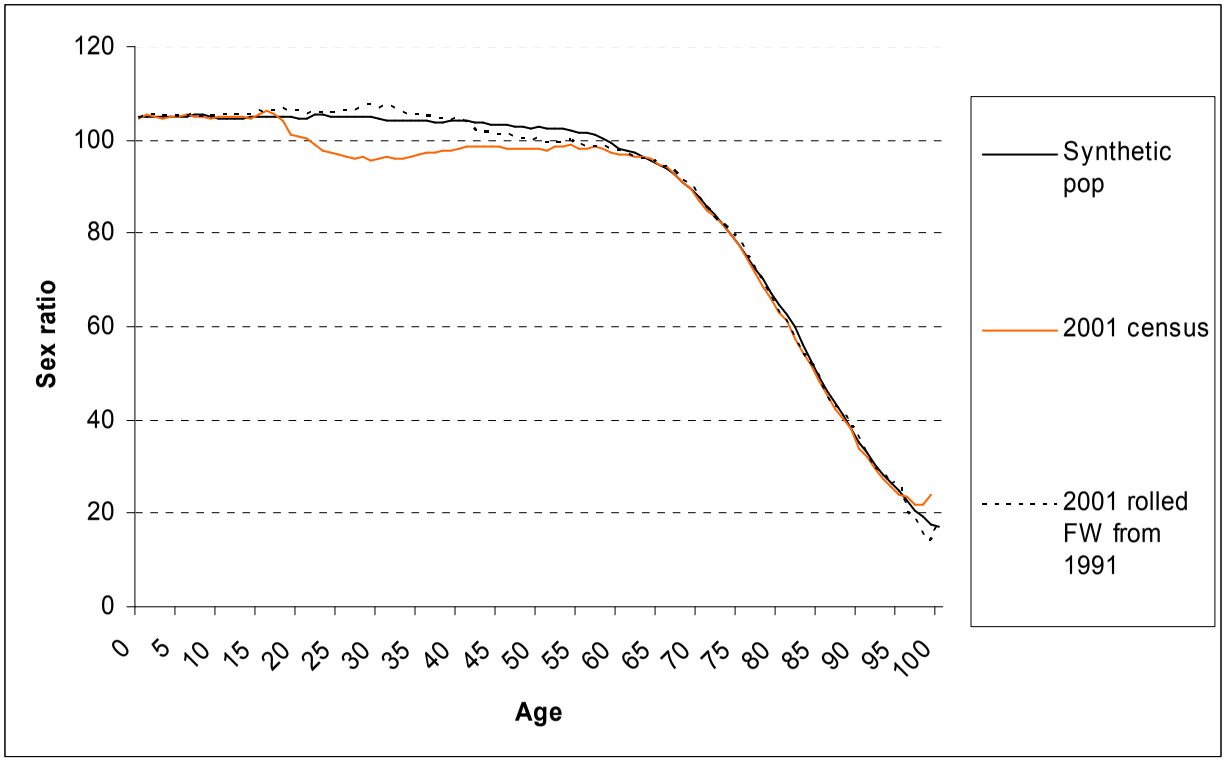


Figure 4: Sex ratio patterns for England and Wales: Mid-year estimates between 2000 and 2006

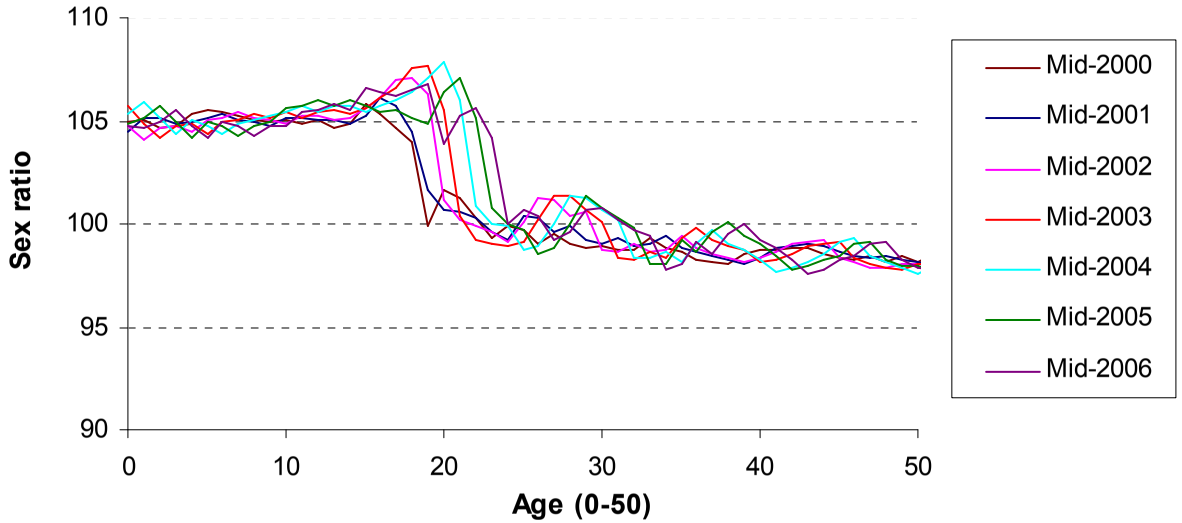


Figure 5: Sex ratio patterns for England and Wales: Mid-year estimates between 2001, 2002 aged back one year, 2003 aged back 2 years, 2004 aged back 3 years, 2005 aged back 4 years and 2006 aged back 5 years

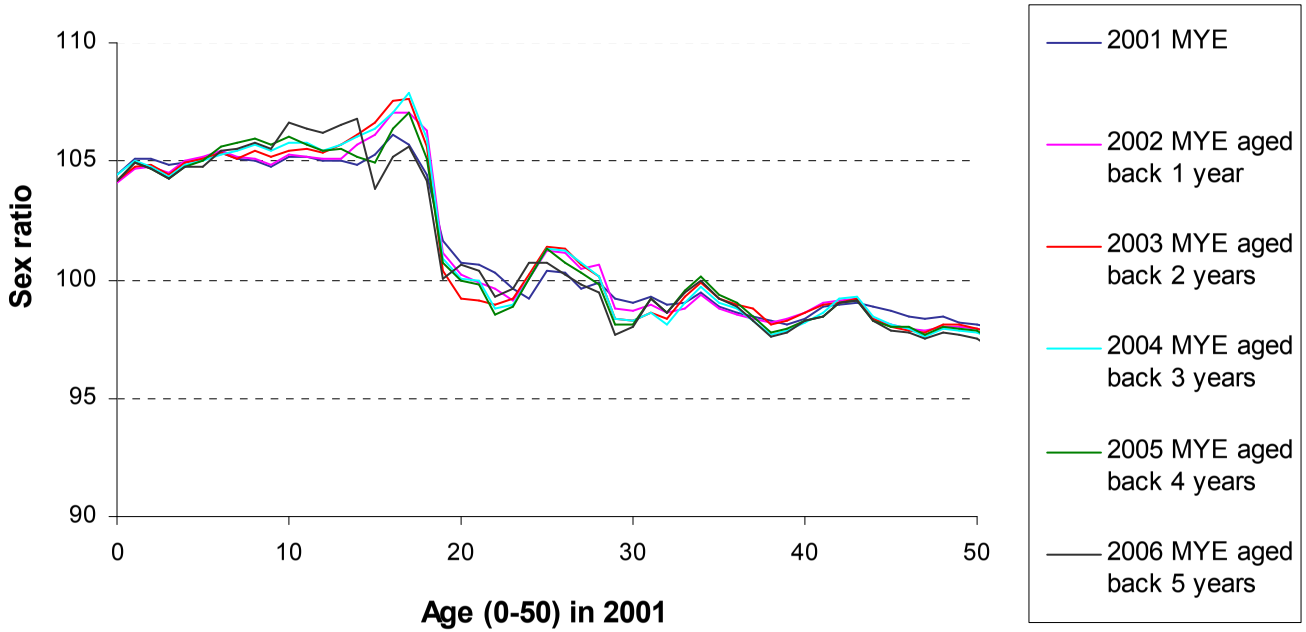


Figure 6: England and Wales born mid-2001 population derived from births and mortality rates (synthetic population)

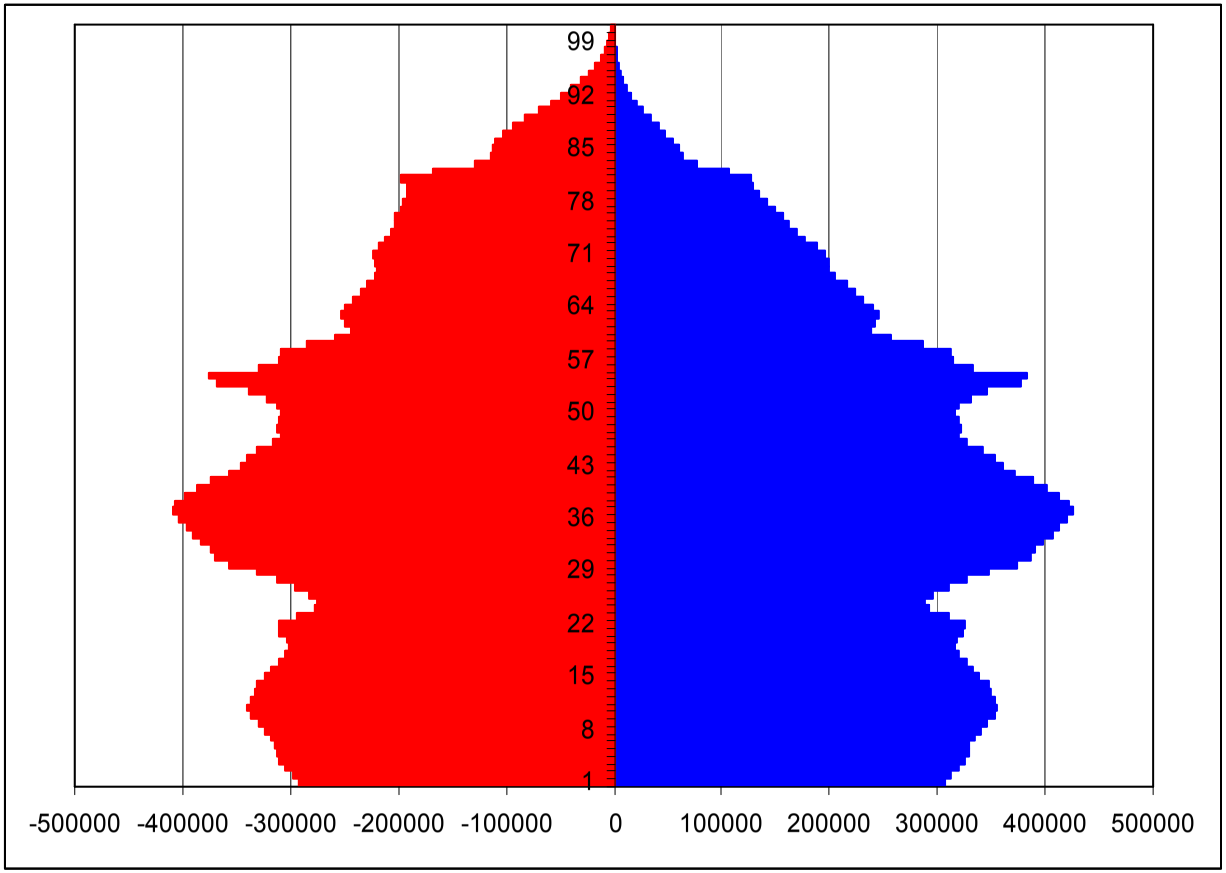
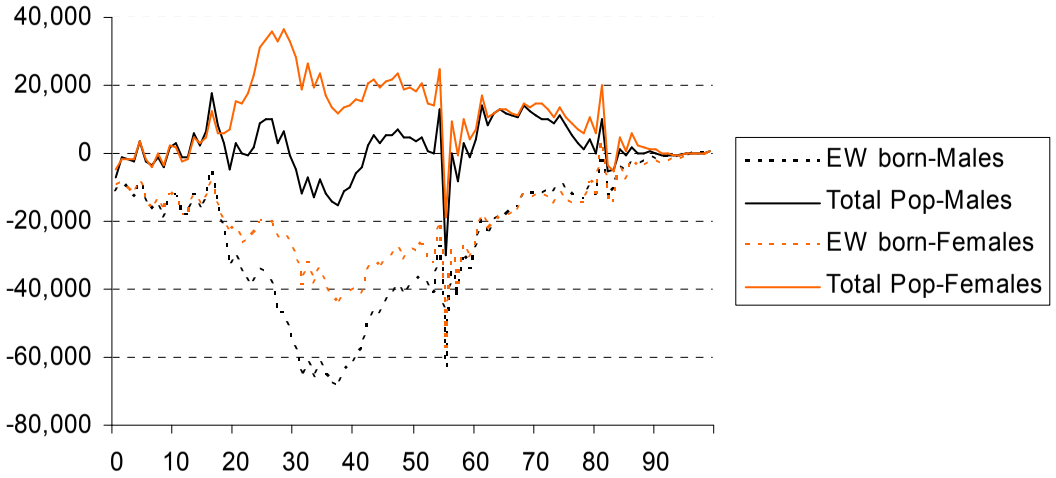
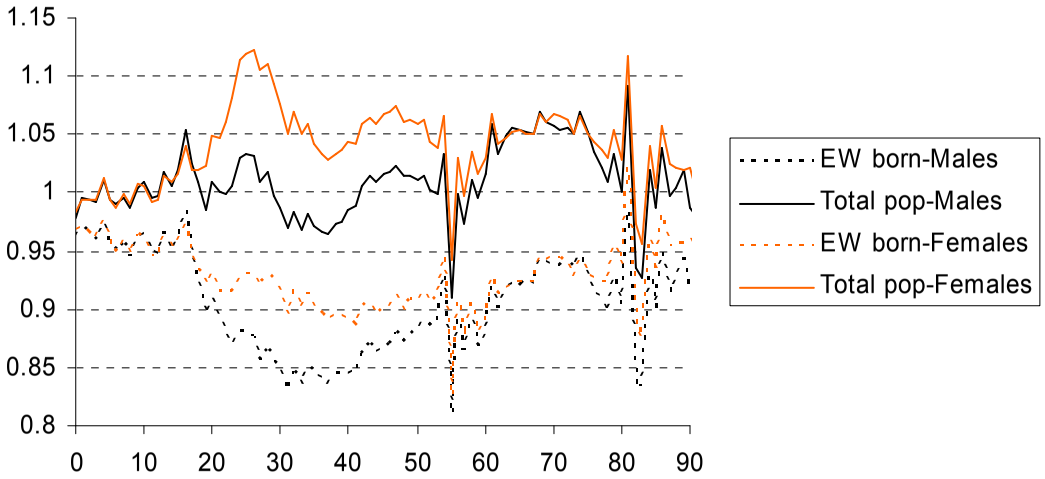


Figure 7: Difference between the 'synthetic' estimated England and Wales (EW) born population and the 2001 total census population versus England and Wales born census population

(a) Numerical difference



(b) Proportionate difference



Tables 2: Disaggregating the population by country of birth at key migration ages using the 2001 Census and mid-year estimate (MYE) and the estimated EW born population from births and mortality at 2001 Census-approximate figures

	Number 2001 EW expected from births and mortality (000's)	*Number EW born in 2001 Census (000's)*	*Number foreign born in 2001 Census (000's)*	*Sex ratio foreign born in 2001 Census*	*Net number EW emigrated from 2001 Census (000's)*	*Sex ratio EW emigrated 2001 Census*	*Number EW born in 2001 MYE (000's)*	*Number foreign born in 2001MYE (000's)*	*Sex ratio foreign born in 2001 MYE*	*Net number EW emigrated from 2001 MYE (000's)*	*Sex ratio EW emigrated 2001 MYE*
	A	**B**			**A-B**		**C**			**A-C**	
At age 15-19											
Males	1,613	1,522	128	106.7	91	112.4	1,527	123	104.2	86	108.9
Females	1,537	1,456	120		81		1,458	118		79	
At age 20-24											
Males	1,540	1,366	193	87.5	174	149.5	1,372	188	86.0	168	149.1
Females	1,467	1,351	220		116		1,354	219		113	
At age 25-29											
Males	1,657	1,435	241	87.4	222	192.6	1,495	260	91.1	161	131.4
Females	1,578	1,463	276		115		1,455	285		123	
At age 30-34											
Males	1,997	1,683	267	93.4	313	180.5	1,751	280	96.9	246	140.4
Females	1,915	1,742	286		173		1,740	289		175	
At age 35-39											
Males	2,082	1,753	270	95.5	329	156.5	1,767	268	96.1	315	1.5
Females	2,004	1,795	282		209		1,800	279		204	
At age 40-44											
Males	1,815	1,555	269	95.2	260	143.8	1,569	263	95.5	245	142.5
Females	1,748	1,568	283		181		1,576	275		172	
At age 45-49											
Males	1,605	1,402	235	91.7	203	137.9	1,412	232	91.9	193	134.1
Females	1,559	1,411	256		148		1,415	253		144	
At age 50-54											
Males	1,759	1,578	190	86.4	181	130.0	1,567	202	87.3	192	127.8
Females	1,718	1,578	219		140		1,568	231		150	
At age 55-59											
Males	1,504	1,300	189	91.4	204	112.4	1,320	170	90.3	184	113.8
Females	1,492	1,310	207		182		1,330	188		162	
At age 60-64											
Males	1,199	1,089	160	96.6	110	103.1	1,090	160	96.9	109	103.6
Females	1,236	1,130	165		106		1,131	165		105	

Tables 3: Disaggregating the population by country of birth at key migration ages using the 1991 Census and mid-year estimate (MYE) and the estimated EW born population from births and mortality at 1991 Census-approximate figures

	Number 1991 EW expected from births and mortality (000's)	*Number EW born in 1991 Census (000's)*	*Number foreign born in 1991 Census (000's)*	*Sex ratio foreign born in 1991 Census*	*Net number EW emigrated from 1991 Census (000's)*	*Sex ratio EW emigrated 1991 Census*	*Number EW born in 1991 MYE (000's)*	*Number foreign born in 1991MYE (000's)*	*Sex ratio foreign born in 1991 MYE*	*Net number EW emigrated from 1991 MYE (000's)*	*Sex ratio EW emigrated 1991 MYE*
	A	**B**			**A-B**		**C**			**A-C**	
At age 15-19											
Males	1,671	1,540	96	102.2	131	121.4	1,569	98	103.0	102	110.8
Females	1,583	1,475	94		108		1,491	95		92	
At age 20-24											
Males	2,015	1,690	155	87.4	325	153.2	1,806	165	90.8	210	128.1
Females	1,922	1,710	177		212		1,759	182		164	
At age 25-29											
Males	2,104	1,743	215	93.4	361	156.1	1,844	227	95.5	261	154.1
Females	2,014	1,783	230		231		1,845	238		169	
At age 30-34											
Males	1,840	1,565	236	96.5	275	148.5	1,607	242	97.1	233	152.5
Females	1,763	1,578	244		185		1,610	249		153	
At age 35-39											
Males	1,639	1,423	223	95.3	216	143.2	1,440	225	95.8	199	140.1
Females	1,580	1,429	234		151		1,438	235		142	
At age 40-44											
Males	1,816	1,622	202	90.5	194	138.1	1,636	204	90.9	180	134.0
Females	1,755	1,615	223		140		1,621	224		134	
At age 45-49											
Males	1,586	1,364	173	94.1	222	116.1	1,387	176	94.3	199	116.6
Females	1,544	1,352	184		191		1,372	187		171	
At age 50-54											
Males	1,314	1,186	175	103.6	128	109.8	1,182	174	103.5	132	110.2
Females	1,307	1,190	169		116		1,187	168		120	
At age 55-59											
Males	1,217	1,119	156	103.8	98	103.4	1,123	156	104.1	94	100.4
Females	1,237	1,142	150		95		1,143	150		94	
At age 60-64											
Males	1,172	1,097	139	93.9	75	102.2	1,095	139	94.0	77	99.9
Females	1,249	1,175	148		74		1,172	148		77	

Table 4: Disaggregating the population by country of birth at key migration ages using the 1991 Census and the original mid-1991 estimates and the estimated EW born population from births and mortality at 1991 Census-approximate figures

	Number 1991 EW expected from births and mortality (000's)	*Number EW born in 1991 Census (000's)*	*Number foreign born in 1991 Census (000's)*	*Sex ratio foreign born in 1991 Census*	*Net number EW emigrated from 1991 Census (000's)*	*Sex ratio EW emigrated 1991 Census*	*Number EW born in original 1991 MYE (000's)*	*Number foreign born in original 1991MYE (000's)*	*Sex ratio foreign born in original 1991 MYE*	*Net number EW emigrated from orig. 1991 MYE (000's)*	*Sex ratio EW emigrated original 1991 MYE*
	A	**B**			**A-B**		**C**			**A-C**	
At age 15-19											
Males	1,671	1,540	96	102.2	131	121.4	1,586	99	104.1	85	92.4
Females	1,583	1,475	94		108		1,491	95		92	
At age 20-24											
Males	2,015	1,690	155	87.4	325	153.2	1,856	170	93.3	160	97.6
Females	1,922	1,710	177		212		1,759	182		164	
At age 25-29											
Males	2,104	1,743	215	93.4	361	156.1	1,925	237	99.7	179	105.8
Females	2,014	1,783	230		231		1,845	238		169	
At age 30-34											
Males	1,840	1,565	236	96.5	275	148.5	1,654	249	99.9	186	121.9
Females	1,763	1,578	244		185		1,610	249		153	
At age 35-39											
Males	1,639	1,423	223	95.3	216	143.2	1,457	228	97.0	182	127.9
Females	1,580	1,429	234		151		1,438	235		142	
At age 40-44											
Males	1,816	1,622	202	90.5	194	138.1	1,649	205	91.6	167	124.4
Females	1,755	1,615	223		140		1,621	224		134	
At age 45-49											
Males	1,586	1,364	173	94.1	222	116.1	1,387	176	94.3	199	116.6
Females	1,544	1,352	184		191		1,372	187		171	
At age 50-54											
Males	1,314	1,186	175	103.6	128	109.8	1,182	174	103.5	132	110.2
Females	1,307	1,190	169		116		1,187	168		120	
At age 55-59											
Males	1,217	1,119	156	103.8	98	103.4	1,123	156	104.1	94	100.4
Females	1,237	1,142	150		95		1,143	150		94	
At age 60-64											
Males	1,172	1,097	139	93.9	75	102.2	1,095	139	94.0	77	99.9

Females	1,249	1,175	148	74	1,172	148	77

Table 5: Disaggregating the population by country of birth at key migration ages using the 1981 Census and mid-year estimate (MYE) and the estimated EW born population from births and mortality at 1981 Census-approximate figures

	Number 1981 EW expected from births and mortality (000's)	*Number EW born in 1981 Census (000's)*	*Number foreign born in 1981 Census (000's)*	*Sex ratio foreign born in 1981 Census*	*Net number EW emigrated from 1981 Census (000's)*	*Sex ratio EW emigrated 1981 Census*	*Number EW born in 1981 MYE (000's)*	*Number foreign born in 1981MYE (000's)*	*Sex ratio foreign born in 1981 MYE*	*Net number EW emigrated from 1981 MYE (000's)*	*Sex ratio EW emigrated 1981 MYE*
	A	**B**			**A-B**		**C**			**A-C**	
At age 15-19											
Males	1,695	1,534	105	106.6	160	113.2	1,586	108	107.1	109	110.2
Females	1,614	1,472	98		142		1,515	101		99	
At age 20-24											
Males	1,856	1,615	189	98.0	240	117.8	1,697	199	98.0	158	125.8
Females	1,770	1,566	193		204		1,644	203		126	
At age 25-29											
Males	1,656	1,435	212	98.0	220	123.3	1,481	219	98.5	175	124.5
Females	1,589	1,411	217		179		1,449	222		140	
At age 30-34											
Males	1,841	1,630	204	94.0	210	126.2	1,661	208	94.5	180	123.7
Females	1,771	1,604	217		167		1,626	220		145	
At age 35-39											
Males	1,622	1,375	180	97.4	247	116.0	1,420	186	98.0	201	114.1
Females	1,567	1,354	184		213		1,390	189		177	
At age 40-44											
Males	1,367	1,220	185	106.2	147	115.1	1,231	187	106.7	135	110.7
Females	1,340	1,213	174				1,218	175		122	

Table 6: Sex ratios in cohort order for the Census and mid-year estimates 1981, 1991 and 2001

	Cohort summary - Census			**Cohort summary - latest mid year estimates**			**Cohort summary - latest mid year estimates but 1991 (old)**		
	1981	1991	2001	1981	1991	2001	1981	1991	2001
Age in 1981	**Outside England and Wales born**			**Outside England and Wales born**			**Outside England and Wales born**		
(age 5-9 in 1991)			106.7			104.2			104.2
0-4	-		87.5			86.0			86.0
5-9	-	102.2	87.4		103.0	91.1		104.1	91.1
10-14	-	87.4	93.4		90.8	96.9		93.3	96.9
*15-19**	106.6	93.4	95.5	107.1	95.5	96.1	107.1	99.7	96.1
20-24	98.0	96.5	95.2	98.0	97.1	95.5	98.0	99.9	95.5
25-29	98.0	95.3	91.7	98.5	95.8	91.9	98.5	97.0	91.9
30-34	94.0	90.5	86.4	94.5	90.9	87.3	94.5	91.6	87.3
35-39	97.4	94.1	91.4	98.0	94.3	90.3	98.0	94.3	90.3
40-44	106.2	103.6	96.6	106.7	103.5	96.9	106.7	103.5	96.9
	England and Wales born emigrant stock			**England and Wales born emigrant stock**			**England and Wales born emigrant stock**		
(age 5-9 in 1991)			112.4			108.9			108.9
0-4	-		149.5	-	-	149.1	-		149.1
5-9	-	121.4	192.6	-	110.8	131.4	-	92.4	131.4
10-14	-	153.2	180.5	-	128.1	140.4	-	97.6	140.4
*15-19**	113.2	156.1	156.5	110.2	154.1	154.3	110.2	105.8	154.3
20-24	117.8	148.5	143.8	125.8	152.5	142.5	125.8	121.9	142.5
25-29	123.3	143.2	137.9	124.5	140.1	134.1	124.5	127.9	134.1
30-34	126.2	138.1	130.0	123.7	134.0	127.8	123.7	124.4	127.8
35-39	116.0	116.1	112.4	114.1	116.6	113.8	114.1	116.6	113.8
40-44	115.1	109.8	103.1	110.7	110.2	103.6	110.7	110.2	103.6
* figure for 16-19 shown for 1981, but 25-29 shown for 1991 and 35-39 shown for 2001									

Figure 8: Sex ratio pattern for the Patient Register Data and the Mid-Year Estimates for 2001

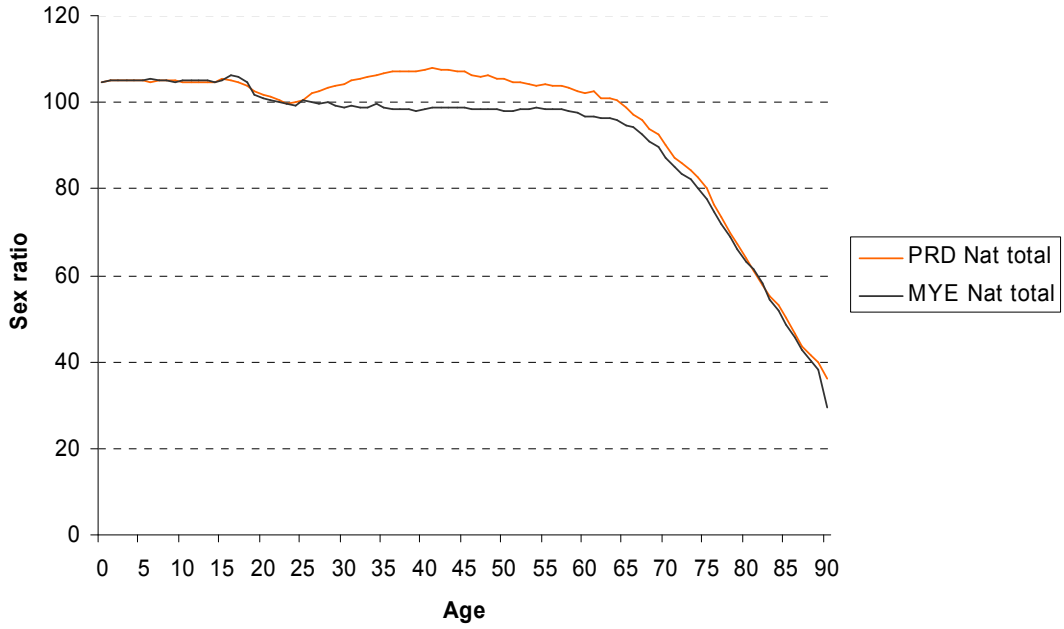


Figure 9: Sex ratio pattern for the Patient Register Data and the Mid-Year Estimates for 2006

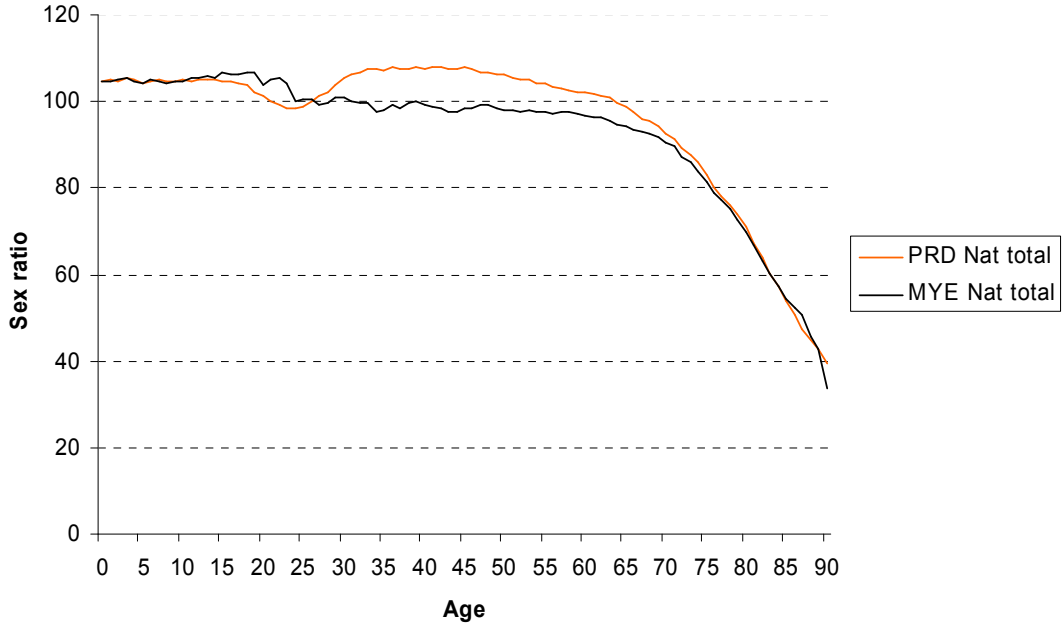


Figure 10: Sex ratio pattern in the Patient Register Data between 2001 and 2006

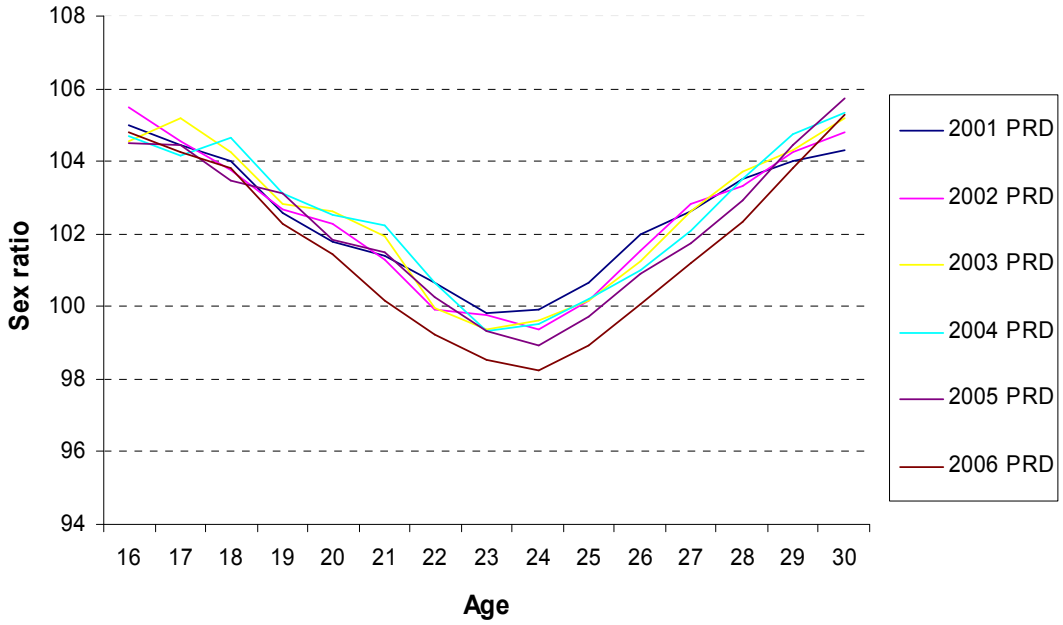


Figure 11: International Passenger Survey inflow data between 1991 and 2005, selected age groups

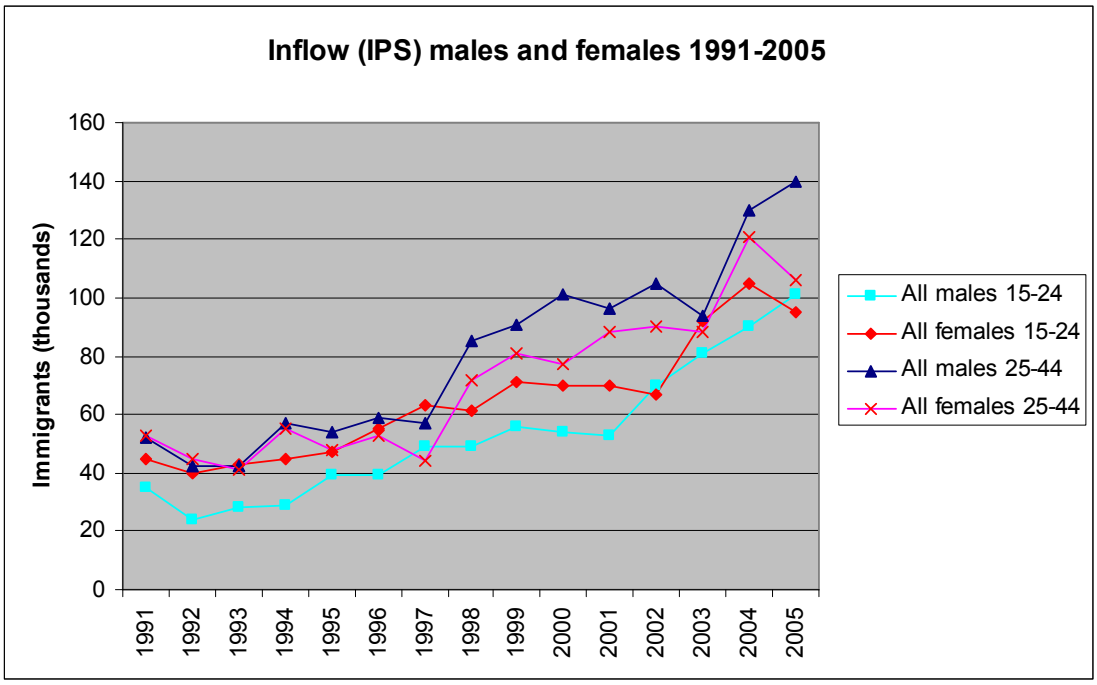


Figure 12: Migration rates per 2001 stock by age, England and Wales and non-England and Wales born migrants from within the UK one year ago

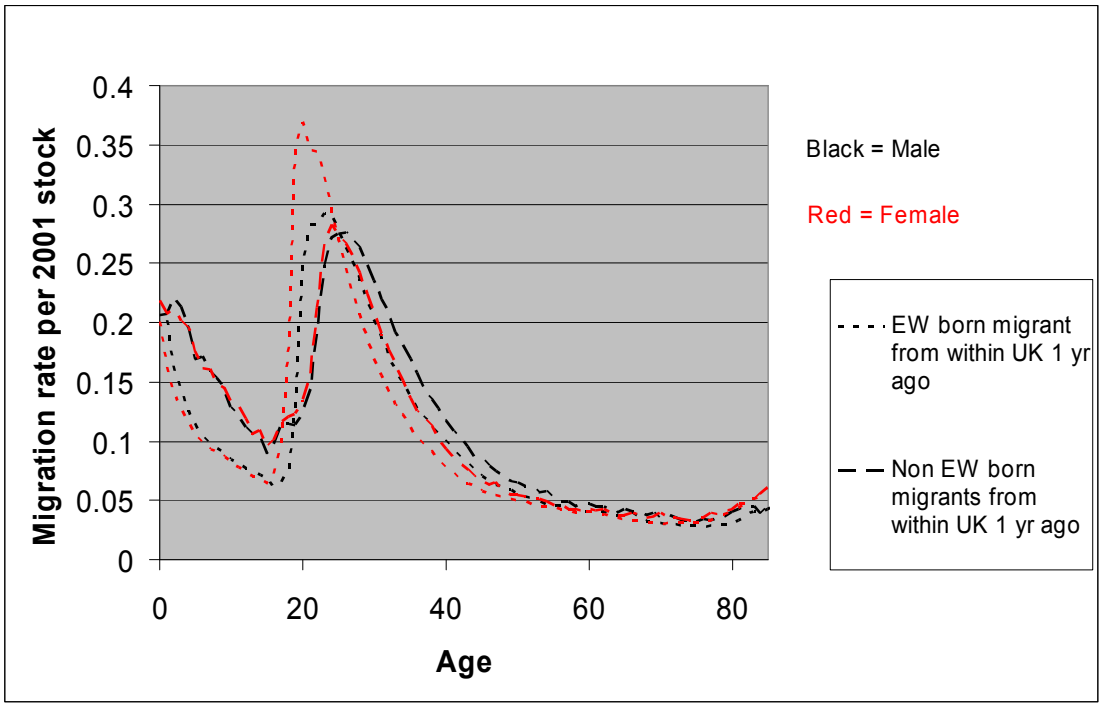
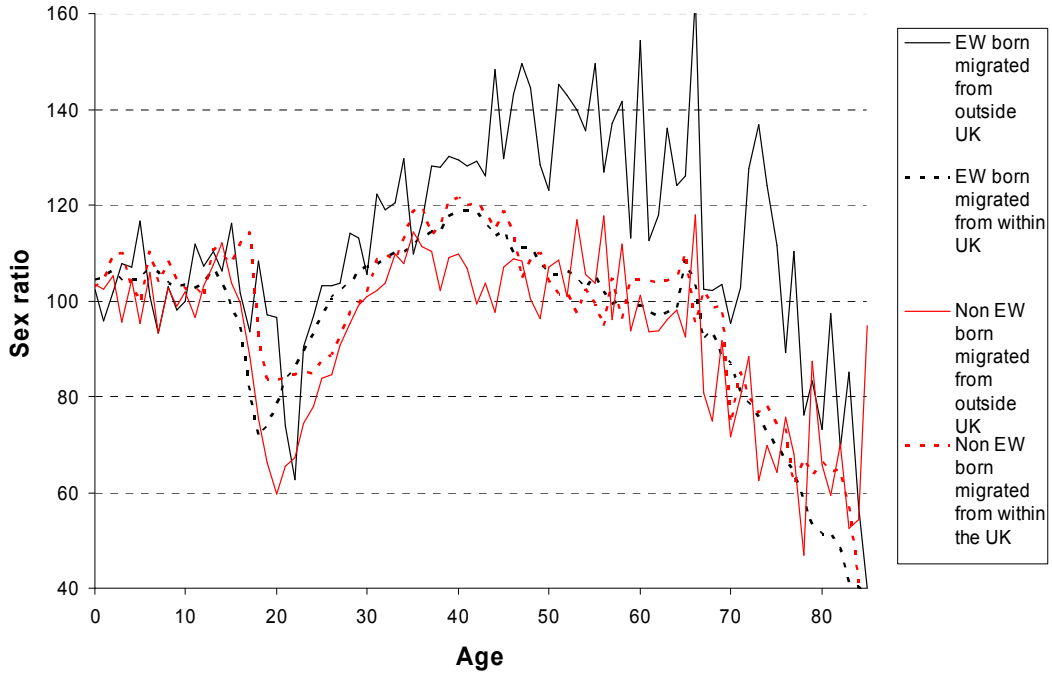


Figure 13: Sex ratios among England and Wales and foreign born movers within and from out side the UK, 2001 Census



Annexe 1

Calculation of England and Wales born population from births and mortality rates

B_y= Births in year y

$P_{x,y}$= Population exact age x in year y

$q_{x,y}$ = probability of dying between exact age x and exact age x+1 in year y

An estimated population at exact age is produced by first taking births to produce a population age 1 one year on.

$P_{1,y+1} = B_y - B_y \times q_{0,y}$

Subsequent populations in the cohort are then produced such that.

$P_{x,y+x} = P_{x-1,y+x-1} - P_{x-1,y+x-1} \times q_{0,y+x-1}$

In order to produce the appropriate mid-year age last birthday population four adjacent populations are averaged. For example,

Mid year population in 2001 aged 20 = $(P_{20,2000} + P_{20,2001}+P_{21,2000}+P_{21,2001})/4$

Effectively the average of the 1980 cohort aged exactly 20 and exactly 21 and the 1981 cohort aged exactly 20 and exactly 21.

Annexe 2

Calculation of Tables 2 to 4

Tables 2 to 4 give for the key migration ages of 20-34 estimates of sex ratios of net immigration of non-England and Wales born population and net emigration of England and Wales born population. Each table is based on the estimated England and Wales born population calculated using births and mortality (as described in box one). This is then compared to either a census population or population estimate. For the former the census gives both the total population and the England and Wales born population. For the later the England and Wales born population has been estimated using the ratio of England and Wales born to total population in the relevant census.

The first column of the table gives the estimated population using births and mortality.
The second column gives the England and Wales born population from the census or population estimate.

The third column estimates by subtracting the England and Wales born population in the census or estimate from the total population in the census or estimate (not shown in the table) the number of non-England and Wales (foreign) born in the population.

The fourth column then gives the sex ratio for the foreign born.

The fifth column calculates the number England and Wales born who have emigrated by subtracting the data in column two from that in column one.

The fifth column gives the sex ratio for the England and Wales born who have emigrated.

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