# Introduction

Since the end of Word War 2, Europe has experienced an unprecedented period of peace, prosperity, cooperation and good health. People in European nations are living longer, with drops in mortality rates at all ages. If we imagine a mortality rate as a hurdle of a given height, and the life course as a race course in which we must clear each hurdle to continue on our journey, then the recent demographic history of Europe has been one in which the journey gets a little easier, the hurdles a little further spaced apart, for each successive generation that travels it. [REFERENCES]

This research began with a concern: could some of this apparent good health be a statistical artefact? More specifically, could the rate at which mortality reduces for some age groups be related to how hard these age groups are to measure, and to how this difficulty in measurement changes over time? Although we as researchers are inclined to believe population counts and death counts are amongst the most robust, comparable and consistent ‘social facts’ that social scientists and health scientists can use, we know they are not infallible. Like other data, there emerge from a data collection process, a set of conventions, behaviours, processes and procedures that lead to people being known by the governments of different territories to exist, to *be* in the eyes of the state; and to then, sometime later, *cease to be*. In recent research, we used these aggregations of these two social facts, numbers dead and numbers alive, to produce age, year, gender and country specific mortality rates, and to plot these rates on Lexis surfaces, showing complex patterns in the relationship between mortality and age and year, and how long term trends have changed these relationships over time. [REFERENCES]

## Vital Numerators and Denominators

A mortality rate is a simple product of a numerator – the counts of people who, of this age, this gender, this year and in this country, died – and a denominator – the counts of people who, being this age, this gender, this year and in this country, exist. Of these two social facts, it is likely that the numerator is the more reliable, and has consistently been so. When someone dies in a modern country, the fact of their passing is likely to become known to the state, and to add one to the appropriate numerator, within a matter of days rather than hours. By contrast, the denominator, the fact of simply being, is less an event that needs immediate attention, and more something that could pass unnoticed for years. Most European nations have censuses, attempting to produce comprehensive head counts, but even censuses cannot claim to count everyone, and more importantly they take place only rarely, every 10 years in the UK [other countries; frequency periods in different nations]. They are snapshots of population dynamics that are constantly in flux. As a result, the more dynamic a population, the faster the estimates from census counts become outdated and unreliable. There are other ways that people come to be known to exist: they could get a job and pay tax, claim a benefit, register with a doctor, get married, get arrested. However, despite the concerns about an integrated and ever-knowing state expressed by some researchers and activists, such records are likely to be, in comparison with death certificates, relatively fragmented, outdated, unrepresentative and inconsistent over time and state.

## Denominator Inflation and Statistical Ghosts

Our concern when we began this research was that, if the denominators had become more unreliable, then so had the mortality rates, and if the mortality rates had become more unreliable, then some of the apparent health gains made within Europe have been fictitious. Instead, some of the apparent mortality reductions could be the result of denominator inflation: people appearing to exist in two or more countries at once.

As an example of how this could happen, consider the following scenario: a twenty four year old, university educated single man with no children has been out of work in his country of origin for more than six months, but knows a couple of university friends in a second country who have been able to find decently paid work. Both countries are within the European Union (EU), and so migration between countries is relatively straightforward, and without strong family ties back home, he decides to move. Within a few weeks he finds a job in the second country for which he pays tax, and as a result comes to be known to ‘exist’ by the second country’s government, adding to that country’s denominator. However, in his country of origin he had been relying on his family to support him rather than on the relatively meager support provided by the state. Because of this, when he left the country of origin no state records about him were amended.

In terms of the records kept in both countries, this man has copied himself. He has come to exist in the second country, but a ghostly impression of him still appears to live in the first country. As a result, without any concern for eating healthily or driving safely, he has apparently helped to improve the health of people in Europe, by inflating the denominators used to calculate a large number of important mortality and morbidity rates. As his statistical ghost can never die, it will continue to dilute the rate estimates, and help to give the impression that people are dying at less than the true rate. When the next census of the country of origin takes place, the records are likely to be corrected and the ghost will cease to be, but until that happens both the man and his ghost will continue to exist in different countries.

In the scenario laid out about the creation of the statistical ghost may result from a complex combination of social, political and economic push and pull factors. If the economic conditions were not as difficult in the country of origin he might have found a job there and not moved. If he did not have an education through which he came to know and develop friendships with people in other countries he might not have heard of the opportunities and had social support networks to rely on in the second country. If the system of formal social security in the country of origin were more attractive, perhaps less meager or slow or punitive in the associated conditionality attached to claims, then he might have stayed in touch with the state better, resulting in better record keeping overall. If there was less freedom to travel between the countries then he may have stayed, unemployed, in the country of origin.

The purpose of this paper is to investigate how much of a cause for concern the kind of scenario indicated above represents both for researchers and practitioners concerned with accurately measuring changes in population health, and for those simply concerned with accurately knowing how many people live in different places.

# Method

In order to explore the issues introduced above, we needed to operationalise the following questions:

1. Have there been changes over time in terms of how difficult it is to accurately count different sub-populations within Europe?
2. If there have been changes in terms of the difficulty of counting different sub-populations within Europe, then do these changes in measurement difficulty help to explain changes in the mortality rates for different sub-populations?

The working hypotheses as they relate to these questions are 1) there have been; and 2) they do. These hypotheses will be tested both informally through visual inspected and formally through statistical testing. Further details are provided later in this section.

In order to operationalise the first question a comparable estimate of measurement difficulty was needed. This estimate was produced by calculating, for each sub-population and for each year, the difference between the expected and reported population counts, as a proportion of the reported population counts; this was considered to be an estimate of the degree of error associated with accurately measuring the size of that particular sub-population, with the sign of the error indicating whether the true population sizes are likely to be less than or greater than the reported population counts. A full definition of the error metric and its calculation is provided later in this section. The second question simply needs estimates population specific mortality alongside population error scores.

In order to look for the presence and magnitude of the effects described above, data from the Human Mortality Database (HMD) was used. The HMD includes estimates of the population and death counts, for males and females separately, for each age from 0 to 110 years old. The range of years for which data are available differs by country, with records dating back over two centuries for some countries and just a few years for others. Most of the countries included in the HMD are European, and so population count and death count data from European countries can be aggregated to produce estimates of death rates and other demographic for Europe as a whole.

A total of 26 datasets identified in the HMD were classified as part of Europe. Some care had to be taken in order to avoid double counting, and to identify those countries where the effects of increased European integration are most likely to be experienced. For some countries, like France and England & Wales, population counts were presented separately for the total population and the civilian population; for these countries only the total population count datasets were used. Data for East and West Germany are presented in addition to Germany, and only data from the Germany dataset were used. A number of East European countries were included in the European population count, such as Bulgaria and the Czech Republic, but not less integrated countries like Belarus, as the higher barriers to migration are likely to mask any more general effect. Table 1 lists the countries included in the analyses, as well as those excluded, and the reasons for exclusion. Because there is an expectation that the recent recession will have had a continuing effect of the propensity of people to migrate between countries within Europe, we focused on a subset of those European countries where data are available for 2011 and onwards. This subset of countries is indicated with asterisks in Table 1. With the exception of Germany, which did not exist in its present form prior to 1990, data for each of the countries marked with an asterisk were available from at least 1970.

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| Countries included (HMD code) | Excluded (HMD code) |
| Austria (AUT)  Belgium (BEL)\*  Bulgaria (BGR)  Czech Republic (CZE)\*  Germany (DEUTNP)\*  Denmark (DNK)\*  Spain (ESP)\*  Estonia (EST)\*  Finland (FIN)  France (FRATNP)\*  Northern Ireland (GBR\_NIR)\*  Scotland (GBR\_SCO)\*  England and Wales (GBRTENW)\*  Hungary (HUN)  Ireland (IRL)  Italy (ITA)  Lithuania (LTU)\*  Luxembourg (LUX)  Latvia (LVA)\*  Netherlands (NLD)  Norway (NOR)  Poland (POL)  Portugal (PRT)\*  Slovakia (SVK)  Slovenia (SVN)  Sweden (SWE)\* | **Clearly not in Europe**  Australia (AUS)  Canada (CAN)  Chile (CHL)  Iceland (ISL)  Israel (ISR)  Japan (JPN)  New Zealand – Maori (NZL\_MA), Non-Maori (NZL\_NM) and Total (NZL\_NP)  Taiwan (TWN)  United States of America (USA)  **High migration barriers**  Belarus (BLR)  Switzerland (CHE) – THIS SEEMS WRONG TO ME  Russia (RUS)  Ukraine (UKR)  **Duplicates included datasets**  East Germany (DEUTE)  West Germany (DEUTW)  France – Civilian (FRACNP)  United Kingdom (GBR\_NP)  England and Wales – Civilian (GBRCENW) |

Table 1 Datasets from the Human Mortality Database included in and excluded from the analyses, with reasons for exclusion. Asterisks indicate those countries for which data were available for 2011.

**ACTION:** Review earlier emails on the reason for treating Switzerland as not part of Europe.

## Calculation of population residual proportions

For each of the included countries, the expected population counts for each gender, age and year, , were calculated from the counts of number of people one year younger the previous year, less the number aged one year younger who died the previous year, i.e.

Where the c subscript indexes the country, i subscripts age in years, t subscripts year, P indicates the population counts and D indicates the death counts. Year, age and gender specific estimates of the proportion by which the expected and recorded population counts differed was calculated by aggregating both the expected and recorded population counts for all countries and dividing the expected by the recorded counts, i.e.

Where indicates the subset of countries being included.

We expect that the relationship between how difficult it is for countries to measure people will tend to be related to their age, with younger adults less more likely to choose to migrate longer distances in search of work and other opportunities than older adults. In order to reduce the number of age groups to compare, even though population and death counts are available within the HMD for each year of age, we aggregated expected and actual population counts into the following age group categories: 20-24 years, 25-29 years, 30-34 years, 35-39 years, 40-44 years, and 45-49 years. These age group aggregations were performed after the expected population counts were produced, so that the expected counts do not depend on the age group categories used.

The death rates for all of the countries included in the analyses were calculated simply by aggregating the sums of the population counts and the sums of the death counts, i.e.

## Analyses

For each of the gender and age groups considered, the residual proportions () were plotted against the death rates (). Each data point is indicated with a small vertical segment, and the years from which the observations were taken are indicated through the gradient of line segments which link the data points, with darker colours indicating observations from further back in the time series, and lighter colours indicating more recent observations.

# Results

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# Discussion

Our results indicate that the people most likely to make use of the increased freedom of labour offered by membership of the EU are also the hardest to count, and so provide supporting evidence for the first of the two hypotheses considered here. Fortunately, our results do not appear to support the second of the two hypotheses: that apparent improvements in some populations’ mortality rates could in fact be a statistical artefact caused by denominator inflation (dying once but living twice). This is because, although some population groups appeared harder to measure than others, all population groups appear to have experienced qualitatively similar reductions in mortality. This seems to be fundamentally good news, as it suggests such improvements in public health are likely to be genuine. As Minton (2013, 2014) has suggested, trends towards lower mortality risks at any age appear to be continuing within most of Europe as they have for many generations.

With the notable exception of the UK, most nations within Europe are generally supportive of greater levels of European integration, agreeing on and enforcing basic standards of occupational health, the number of hours worked, pay and conditions, and so on. At its best, the enforcement of such standards helps to ensure that nations within Europe compete on the basis of the quality of their goods and services, rather than on their willingness to pay people ever less, offer them less job security, and for states to reduce taxes by cutting ever more holes into social security nets. Establishing such standards helps to prevent the quality of the work that employers offer to prospective employees from deteriorating, labour becoming simply another commodity to be thought of like any other, and so to large sections of the population, those whom the markets judge to be of little value, being forced into the margins of a society rather than to participate fully within it.

What our analyses indicate, however, is that the solutions offered by increased European integration have created a new kind of problem: more mobile populations are harder to count. Paradoxically, it seems likely that the solution to this problem of greater European integration is more European integration. The population records of different European Union member states, it seems, could benefit from becoming increasingly integrated, shared, standardized, and harmonized.

**Action**: look for examples of surveys that are pan European, or examples where national surveys have adopted pan European definitions.

As a specific example of such pan-European collaboration, we modestly suggest that conducting a Census of Europe, counting heads and asking the same questions in as similar a way as possible throughout the region, would be a good idea for a range of reasons; banishing statistical ghosts would be just one of these. For example, this would make it easier to understand differences in health, attitudes, occupation, and work-life balance between and within countries. As the forthcoming Social Atlas of Europe argues it makes increasing sense to consider Europe as if it were a single, very large country than a large number of different countries, with some regions within different countries having more in common with each other than with other regions within the same country. [REF/PLUG to Danny’s new book!]

## Limitations

A possible limitation with the analyses presented here is in the choice of population count error measure used. It could be argued that there is a circularity in the reasoning used to produce these metrics, as of course the ‘actual’ population counts will not be perfect, and the ‘actual’ counts used in one year are then used to estimate the ‘expected’ population count in the following year. However, so long as the errors involved in producing these measures are not expected to vary systematically between the sub-populations considered then they appear a reasonable means of comparing between the sub-populations. The measures also have the benefit of simplicity, and require only population count data in order to calculate.