WILLIAM BRASS

William Brass
1921–1999

PROFESSOR WILLIAM BRASS, who died on 11 November 1999, was a demographer, statistician, and mathematician of great distinction. He made important contributions to knowledge in many fields, but is best known for his development of a body of analytical techniques for the estimation of fertility and mortality rates in countries lacking comprehensive systems of birth and death registration, and where data collected in censuses and surveys are liable to be severely biased by response errors. Such was the importance of his contribution to this field that the techniques were often described as 'Brass methods'. They have also been labelled 'indirect', because many of them derive indices from questions and data only obliquely related to the desired measure. A good example, which will be further discussed below, is the estimation of life table probabilities of survival for adults from questions on whether persons' fathers and mothers are still alive, generally called the 'orphanhood' method. This memoir will attempt to outline Bill Brass's principal contributions to this field; the review will be very far from exhaustive and no attempt is made to describe his contributions in other areas of demography and statistics[1]. But the importance of his work is reflected in the fact that the figures, published regularly by the United Nations and other bodies, of the numbers of people living on this planet have been compiled largely with the help of the methods which he devised.

[1] A complete bibliography of his published works may be obtained from the Centre for Population Studies, London School of Hygiene and Tropical Medicine, 49–51 Bedford Square, London WC1B 3DP.

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Early days and East Africa

Bill Brass was born in Edinburgh on 5 September 1921, and educated at the Royal High School, followed by Edinburgh University. His sojourn at the latter was interrupted by the war, when he served as a Scientific Officer in the Royal Navy Scientific Service, working, among other things, on statistical problems of torpedo ballistics. He returned to the university in 1946 where he completed his Master's degree in mathematics and natural philosophy in 1947. The following year he went out to Nairobi as a statistician in the East African Statistical Department, a body which was responsible for the collection and analysis of statistical data in Kenya, Uganda, Tanganyika (as it then was), and Zanzibar. It was here that his interest in Third World demography was kindled. Among other tasks which landed on his plate was the design and analysis of the East African Medical Survey, which included among its objectives the collection of vital statistics in six rural communities, two in Kenya and four in Tanganyika. Furthermore the first census of the East African countries was carried out in the same year as Bill Brass arrived in Nairobi; indeed this was virtually the first proper census of any sub-Saharan African country in the sense of an enumeration conducted by house-to-house visits by trained enumerators equipped with printed schedules. Many pessimists had maintained that such an operation was not feasible, and, as Dr Johnson said of a dog walking on its hind legs, the remarkable thing is that it was done at all.

Fertility estimates from data in broad age groups

One of the major problems of anyone concerned with African demography has been the widespread ignorance of age, more prevalent fifty years ago than now. Rather than confront this difficulty head-on, many investigations sought to allocate the population to broad age groups. Thus women of child-bearing age would all be lumped together into a broad group ranging from, say, fifteen to forty-five. Thus data obtained from questions on the numbers of children ever born or births in the twelve months preceding the survey could not be broken down into the conventional five-year age groups needed for the computation of the usual indices of fertility. Bill Brass's first major contribution to demographic methodology was to tackle this problem (Brass 1953). He developed a formula for estimating the total fertility rate (TFR) from the mean number of children ever born to women still of child-bearing age, adjusted by a factor which incorporated the slope of the age distribution, and the mean and variance of the age-specific fertility distribution. This method was followed by a modification based on the ratio of total to first births, which, he felt, could be more robust to certain types of error (Brass 1954).

In 1948, while he was in Nairobi, he married Betty Topp; they had two daughters, Barbara, born in 1952, and Sheila in 1953.

Aberdeen and Princeton 1955–64

Bill and Betty Brass left Nairobi in 1955 and returned to Scotland where he took up a post of lecturer in statistics at Aberdeen University. Here his research was largely concerned with the use of mathematical and statistical models for the analysis of biometric data, which included demography but also extended to other problems of medical statistics, such as diagnostic procedures, sequential clinical trials and control surveys. That his interest in Third World demography was still alive was evident from the fact that he presented a paper to the 1961 New York conference of the International Union for the Scientific Study of Population on the conversion of the proportions dead among children ever born by adult women tabulated in conventional five-year age groups into life table survivors (Brass 1961). He once described this paper as being of 'historical interest only', as he subsequently radically revised and simplified the procedure. But for me that New York conference was memorable in that it was there that I first met him, though we had already corresponded, since I had followed in his footsteps, joining the East African Statistical Department in 1957.

The New York conference was followed by a year's leave of absence from Aberdeen which was spent at the Office of Population Research at Princeton, working with Ansley Coale and others on various problems of African demography. These included the development of analytical techniques which could be used with the scanty and fragmentary data then available for sub-Saharan Africa, and the derivation of the best estimates which could made for as many of the countries of the region as had published data. The results of this work were eventually published in a book entitled *The Demography of Tropical Africa* (1968), in which Brass made major contributions to the chapter on methods of analysis and estimation, and to that on some Francophone countries where demographic sample surveys had been conducted in the late nineteen-fifties and early sixties (Brass and Coale, 1968; Brass 1968). Of the various techniques which he developed at this time, three were of outstanding importance and should be mentioned here.

Infant and Child Mortality from Proportions of Children Dead by Mother's Age

First he radically simplified the method foreshadowed in his New York paper. Using models of fertility and mortality, he showed that the proportion of children dying among those ever born by mothers aged 20–24 was a close approximation to mortality in the first two years of life; those for mothers aged 25–29 and 30–34 corresponded to mortality up to ages 3 and 5 respectively; thereafter the corresponding ages for the children increased by five years with each quinquennial age group of mothers, (Brass and Coale 1968; Brass 1975). He also showed how these relationships could be refined using indices of the shape of the age-specific fertility distribution. Many modifications and extensions of this method have been evolved by other demographers, notably Trussell (1975) and Feeney (1980), but the pioneer contribution by Brass has been universally acknowledged. It has provided the basis for most of the estimates of infant and child mortality for Third World countries published by the United Nations and UNICEF.

The P/F Ratio

Second, he showed how the ratios, age group by age group, of average parity (obtained from questions on children ever born) to cumulated current fertility (from questions on births in the last twelve months), or 'P/F ratio' as it came to be known, could be used to derive estimates of fertility which were less biased and more up-to-date than would be the case using either data set on their own (Brass and Coale, 1968; Brass 1975). The method hinges on some bold assumptions about the nature and patterns of errors, and subsequent experience has shown that these assumptions do not always hold good. Nevertheless it remains a powerful diagnostic tool which has been extended for use in a variety of situations, and with more complex data sets, than was originally envisaged.

Logit Model Life Tables

Third, he developed a system of model life tables based on the logit transformation of a standard age schedule of life table survivors (l_x), which could be modified by two parameters, one of which would determine the general level of mortality and the other the relationship between child and adult mortality—i.e. the steepness with which mortality increases with age (Brass and Coale 1968; Brass 971). Bill Brass himself once compared model life tables to ready-made suits which could be taken 'off the peg' on the basis of one or two measurements, to be contrasted with 'made-to-measure' life tables calculated from accurate figures of registered deaths and population exposed to risk. Since most mortality data for Third World countries are fragmentary and incomplete, such models have been much in demand. Several different systems of model life tables have been developed, but for simplicity, elegance, flexibility, and the ease with which it can be generated on a computer, Brass's logit system remains unsurpassed. Again, others have taken it further: both Zaba (1979) and Ewbank *et al.* (1983) have developed four-parameter versions which give additional flexibility and can be used in suitable circumstances, but most Third World data still does not warrant the use of more than two parameters with a judiciously selected standard.

London School of Hygiene and Tropical Medicine 1965–88

In 1965 Brass moved from Aberdeen to the London School of Hygiene and Tropical Medicine, where he was appointed first Reader, and then Professor of Medical Demography. Here he established the Centre for Population Studies, and, aided by staff colleagues and research students, achieved his most productive period. Basia Zaba has described how he worked: 'Those of us who were privileged to work with him recall his tremendous openness and intellectual generosity. Bill would have an idea, work out the basic mathematics (always with a stubby 2B pencil) and hand over the work to be finalised and written up by a research student or junior staff member. Often Bill's name would not even appear on the final publication in a learned journal.' (Zaba and Blacker 1999). Once again the methods described here form by no means a comprehensive list of his output, but should at least give the reader an idea of the variety and ingenuity of his methods.

Orphanhood

The Princeton book on *The Demography of Tropical Africa* took some time to appear, but a preview of the methods described above was given to a privileged group of demographers (which included the writer) at a workshop convened by the United Nations Economic Commission for Africa in Addis Ababa in 1964 (Brass 1964). At that meeting the French demographer Remy Clairin asked Bill Brass for his views on an idea promulgated earlier by Louis Henry (1960): if, he asked, one could estimate child mortality by questioning mothers about the survival of their children, could we not reverse the procedure and estimate adult mortality by asking children about the survival of their parents? Bill replied that it was a brilliant idea, but one would also need a brilliant analyst to interpret the results; but fortunately, he added, we had in Louis Henry one of the most brilliant analysts the world of demography had ever known. But in the end it was not Henry who took up the challenge, but Bill himself. He developed a simple procedure for converting the proportions of persons with mothers (or fathers) alive, for each five-year age group of respondents, into life table probabilities of survival. The method was widely circulated among interested persons, and the orphanhood questions—'Is your father alive?' and 'Is your mother alive?'—were included in several censuses and surveys in Africa in the late sixties and early seventies. The procedure, illustrated by its application to data from the 1969 census of Uganda, was presented in a paper for the International Population Conference in Liège in 1973 (Brass and Hill 1973). Once again many modifications have been developed, and the idea has been extended to deriving mortality estimates from data on the survival of other relatives, such as siblings and grand-parents.

Growth Balance Method

Although comprehensive systems of vital registration are generally lacking in Third World countries, information on current deaths by sex and age are frequently available from census questions on deaths among household members during the preceding year, or from multi-round surveys in which enumerators make repeated visits to sample households to ascertain what births and deaths have occurred during the intervals between the rounds. Unfortunately deaths recorded in these ways are often seriously under-reported. The Growth Balance Method constitutes a means of testing for the completeness of the recording and, with luck, of correcting for any shortfall (Brass 1975). It is a good example of the simplicity and elegance of Bill Brass's methods and as such it is perhaps worth describing it in rather more detail than is possible here with the other methods.

If a population has a *proportionate* age structure which is roughly constant, and is increasing at an annual rate of growth r, it follows that all sections of the population, such as those aged 15 and over, 20 and over, 25 and over . . . etc., will also be increasing at the rate r. Now, in the absence of migration, the growth rate (r) of a population is the difference between the birth rate (b) and the death rate (d) so that $r = b - d$, and $b = r + d$.

For a population aged y and over, the 'births' are the numbers of persons reaching the age of y every year, which can readily be calculated from the age distribution. (In practice a sufficiently close approximation can be obtained by taking one-tenth of the sum of the two five-year age groups on either side of y.) Thus if $b(y)$ and $d(y)$ are the 'partial' birth and death rates of the population aged y and over, $b(y) = r + d(y)$. Thus, given the age distribution and the recorded deaths by age, the values of $b(y)$ and $d(y)$ may be calculated for various ages. If $b(y)$ is plotted against $d(y)$, and if the data are accurate, the points should lie on a straight line with a slope of 1 and an intercept of r.

Now let us suppose that the deaths are under-reported by a constant proportion at all ages, so that $d(y) = f.d'(y)$: i.e. f is the correction factor which should be applied to the reported death rates $d'(y)$. Our basic equation then becomes: $b(y) = r + f.d'(y)$. If $b(y)$ is now plotted against $d'(y)$, the points should still lie on a straight line with an intercept of r, but the slope now becomes f.

If the basic assumption of the constant under-reporting of deaths does not hold true, then the points will not lie on a straight line. Thus the technique is to some extent self-validating. In practice it can only be used with deaths of adults, since the relative under-reporting of the deaths of infants and children nearly always differs from those of adults. The other assumption that the proportionate age distribution is constant generally holds true in the absence of significant changes in fertility. In cases where fertility has been falling, the method can still be applied to those age cohorts which were not affected by the fertility decline.

Many variations on this theme have been played, using other types of data sets and with modifications which enable some of the basic assumptions to be relaxed. But it was Bill Brass's flash of genius which set the whole field in motion.

The Previous Birth Technique

Since the growth balance method can only be used for estimating adult mortality, alternative means of estimating infant and child mortality from incomplete registration, or some other ongoing system of recording of vital events, were clearly desirable. Brass showed that this could be done if information on the survival of the woman's previous children was obtained at the time of recording her current birth. Working with Sheila Macrae on data from an experimental project of birth notification in the British Solomon Islands, he showed that the proportion who had died among those born immediately before the current birth gave a very close approximation to mortality in the first two years of life (Brass and Macrae 1984). This relationship was remarkably robust even to substantial variations in the length of the birth interval. An important potential use of this method is with data compiled at ante-natal clinics, more especially as in several African countries a remarkably high proportion of pregnant women attend these clinics. In these circumstances the information on the survival of the preceding child would be recorded some months before the delivery of the current birth. Hill and Aguirre (1990) have worked out the necessary modifications.

The Relational Gompertz Fertility Model

Models of age-specific fertility are useful tools for demographers concerned with Third World countries for the same reason as model life tables. For females, fertility rates begin from zero at about age 15, rise rapidly with age, and reach a modal value about age 25; they then decline monotonically to reach zero again at about 50. But within the constraints imposed be female fecundity, the shape of this simple uni-modal curve varies greatly from population to population, being influenced by such factors as age at marriage and contraceptive use. For his earlier work on fertility and child mortality, Bill Brass had used a third-degree polynomial $f(x) = c(x - s)(s + 33 - s)^2$, where $f(x)$ is the fertility rate at age x, c is a parameter which determines the level of fertility, and s is the youngest age at which fertility starts (Brass *et al.* 1968; Brass 1975). The curve could be moved bodily up and down the age scale by changing s, but its variance remained fixed. The relational Gompertz model, developed in the nineteen-seventies, gave greater flexibility (Brass 1981). The principle was similar to that of the logit life table system: a standard schedule of age-specific rates could be bent mathematically to fit the data in hand using three parameters, of which the first moved the curve up and down the age scale, the second controlled its width or variance, and the third, the total fertility rate, determined the overall level of fertility. But in place of the logits of the model life tables, Bill used the Gompertz transformation, or double negative exponential, for his fertility model. In its development and applications he was ably assisted by Heather Booth (1979 and 1984), who constructed the standard, Basia Zaba (1981) who devised ways of fitting it to data on children ever born and births in the last twelve months, and Hoda Rashad (Brass and Rashad 1992) who used it for the correction of faulty birth histories (of which more below).

Birth History Analysis

In the nineteen-fifties and sixties demographers working on data from Africa and Asia were concerned primarily with estimating the level of fertility. The prospects of a long-term decline in the birth rate then appeared remote, and the analytical techniques which were used, such as the P/F ratio, were often based on the assumption that it had remained more or less constant for an indefinite period before the census or survey. But in the nineteen-seventies and eighties increasing numbers of Third World countries began to embark on their fertility transition, and birth rates started to fall, sometimes with a rapidity which would have been unthinkable ten or twenty years earlier. In these circumstances the analysis of fertility *trends* assumed much greater importance. At the same time the World Fertility Survey (WFS) was launched, which included among its objectives the elucidation of the determinants of the fertility decline. An important part of the WFS core questionnaire was a detailed birth history for every woman interviewed, wherein were recorded the date of each of her births, the sex of the child, whether or not it was still alive and, if dead, the date of death. Such data should clearly permit the analysis of fertility trends over the last two decades; but they were, inevitably, fraught with errors. In particular the dates of birth tended to be misstated, such that the most recent births were pushed back in time, inflating the numbers reported for the period between five and fifteen years before the survey, depleting those in the most recent quinquennium, and thus simulating a spurious decline in fertility. Bill Brass played a major role in developing techniques for detecting and correcting such errors. His P/F ratio was adapted to be used on a five-yearly cohort-period basis; the birth histories were back-dated in such a way as to reconstruct the parity distributions of the women at points of time in the past when they could be compared with the results of previous surveys; the births were re-distributed in time by fitting Gompertz models to the fertility rates by time period for each cohort of women.

The WFS ran from 1972 to 1984 and was superseded by the Demographic and Health Survey (DHS) which has likewise incorporated birth histories in its core questionnaire. Some countries have conducted as many as three national surveys under the DHS umbrella. In many cases, but by no means all, data quality has improved. But the DHS has also concentrated more on data collection with the rapid production of summary reports in a standardised format and less on critical in-depth analysis than was the case with the WFS. As a result there has been an increasing tendency to accept the results uncritically at their face value. Perhaps also it is because the influence of the towering figure of Bill Brass, urging that the data should be assumed to be guilty until proved innocent, is no longer felt. There is still much work to be done along the lines which he started.

Projected Parity Progression Ratios

Changes in fertility can result from a variety of causes: rising age at marriage, increased use of contraception, changes in pathological sterility or in the duration of breast-feeding can all influence the overall trends. Thus any analysis needs to look, not just at changes in the crude birth rate or total fertility rate, but at more refined indices; as Brass put it, 'any incisive examination' will require a study of births by order. For this purpose the 'parity progression ratio' (PPR), or the proportion of women with n children who go on to have $n + 1$, provides a powerful analytical tool. But completed PPRs can only be calculated for cohorts of women who have reached the end of their childbearing years—i.e. the age of 50. Such women were doing most of their childbearing some fifteen to twenty years before the census or survey, so that their PPRs do not represent the current trends. Bill Brass developed methods for projecting the PPRs of women who were still of childbearing age up to age fifty, using information on recent births tabulated by mother's age and birth order. Trends could then be seen by comparing the PPRs across the cohorts. He evolved two such methods: one for use with census-type data from questions of children ever born and births in the last twelve months (Brass 1985); the other using birth histories and the parity changes they revealed for the last five years (Brass and Juarez, 1983).

The results of these procedures can best be assessed when they have been applied to a series of censuses or surveys and are plotted on the same graph by birth cohort of women, as suggested by Feeney (1988): the consistency of the PPR's for the same cohorts can then readily be seen.

The applications to data from Kenya, for example, have revealed an impressive consistency (Macrae, Bauni, and Blacker, 2001). They also solved a conundrum which had been puzzling demographers. The censuses and surveys carried out in the nineteen-sixties and seventies had shown increases in the numbers of children reported as having been born by each age group of mothers; was this due to a genuine rise in fertility or was it just the result of improved reporting? The plots of the PPRs showed unquestionably that fertility had indeed been rising during this period, and at the last meeting at which he spoke in public,[2] Bill Brass offered a general apology to all such women for having cast aspersions on the veracity of their responses.

During his time at the London School of Hygiene and Tropical Medicine, Bill Brass was immensely active in many fields besides the invention of new analytical methods. He was an inspiring teacher, and took a major share of the lecturing for the Master's degree in Medical Demography. He was head of the Department of Medical Statistics and Epidemiology from 1977 to 1981 and Chairman of Division from 1981 to 1985. He travelled extensively, giving lectures and seminars in places as widely spaced as the East-West Centre in Hawaii, the UN Latin American Demographic Centre in Santiago, Chile, and the Cairo Demographic Centre. He was a member of the Social Science Research Council and was Chairman of its Statistics Committee from 1975 to 1979, and of its Research Grants Board from 1976 to 1980. He was President of the British Society for Population Studies, 1975–7, and of the International Union for the Scientific Study of Population 1985–9. He was a member of the Committee on Population and Demography of the US National Academy of Sciences, and in 1984 was elected a Foreign Associate—the highest honour the Academy can bestow on a foreigner. He was a specialist adviser to the investigation of the population of the United Kingdom by the Select Committee on Science and Technology of the House of Commons. He was elected a Fellow of the British Academy in 1979 and was a member of the Council from 1985–8. In 1978 he received the Mindel Sheps Award of the Population Association of America for distinguished contributions to mathematical and applied demography, and was made a CBE in 1981.

[2] Held at the London School of Economics in 1996 to mark the publication of the fiftieth volume of *Population Studies*.

Retirement 1988–1999

After he retired from the School in 1988, Bill received many invitations to spend time at other academic institutions around the world, and spent several months at the Institute for Advanced Studies in the Netherlands and at the Australian National University in Canberra. He continued to be associated with the Committee on Population and Demography of the US National Academy of Sciences, and when, in 1989, they set up a panel on the population dynamics of sub-Saharan Africa, he was invited both to be a member of the panel and chairman of the working group on Kenya. In this capacity he made a detailed analysis of the 1989 Kenya Demographic and Health Survey, which was the first national survey to show that fertility in that country had at last begun to fall. He made a major contribution to the resulting monograph on *The Population Dynamics of Kenya*, which he also edited in conjunction with Carole Jolly (Brass and Jolly, eds., 1993).

Right up to the end his contributions continued to be innovative and incisive. In 1995 I asked him to take a look at a short paper I had written on the estimation of infant mortality from the proportions dying among those born during the twenty-four months before a census or survey. He promptly came back with an elegant and flexible mathematical model (which I had never seen before and which he had never published) for portraying the age pattern of infant and child mortality. It took the form: $l(x) = (1 + \alpha x)^{-\beta}$ where $l(x)$ is the proportion of life table survivors at age x (expressed in either years or months), and α and β are parameters which can be determined given any two observed values of $l(x)$. I tested it by fitting it to a wide variety of data, and then incorporated it in the paper which was thereby greatly improved (Brass and Blacker 1999).

In January 1997 Bill Brass was tragically hit by a massive stroke which left him speechless and half paralysed until he died three years later. His loss has been keenly felt by all his former students and colleagues, whose respect and affection he had gained in full measure.

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