Demographic anthropology

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1 INTRODUCTION

Demography is the study of population dynamics. The primary foci of demography are rates and levels of mortality, fertility, and migration and how these all interact to produce population growth (or decline), density, and age- and sex-structures; how these rates or levels vary across time and space and what produces such variation; and what consequences these have on other aspects of human (or nonhuman) existence. These demographic phenomena lie at the very heart of evolution. Natural selection occurs as a result of differential fertility and mortality within a population; gene flow occurs because of migration between populations; and the effects of genetic drift are dependent upon population size, which is an outcome of the interactions among mortality, fertility, and migration (Gage, DeWitte, & Wood, 2012).

These demographic forces also affect, are affected by, and reflect many of the things that anthropologists find most interesting. For example, the age–sex structure of a population influences the population’s ratio of consumers to producers and numbers of potential marriage partners, and thus places limits on such things as subsistence strategies and household structure. The age–sex structure of a population can also significantly influence economic relationships among families and communities, as cultures often have inheritance and habitation rules that depend on the sex and sometimes age of individuals, and thus are inherently influenced strongly by demographic structure. Population growth and density affect socio-political structures and shape disease ecologies, which can, in turn, affect demographic rates and drive biological and cultural adaptations. Sociocultural phenomena also have the potential to powerfully shape demography. For example, warfare can have short- and long-term effects on sex ratios or age structures (as in the case of the post-World War II baby boom). Sex-selective infanticide and abortion, and withholding of resources or medical care from daughters because of cultural preferences for sons affects sex ratios. Economic policies and warfare influence patterns of migration. Ultimately, demography is relevant to all fields of anthropology, whether or not all anthropologists are interested in demography itself and its effects on other aspects of human life. Although, as can be seen in the pages of the American Journal of Physical Anthropology, numerous anthropologists over the last 100 years of the journal’s existence have been explicitly interested in demography, and in demographic anthropology in particular.

In contrast to national demography, which primarily focuses on large datasets (often derived from censuses) from European and other industrialized populations, demographic anthropology typically focuses on relatively small, nonindustrial populations from which data are collected as a part of ethnographic fieldwork. Demographic anthropology also examines the demography of populations in the past, as reconstructed from skeletal remains (paleodemography), historical documents (historical demography), or material culture and other evidence of human activities from archaeological sites (demographic archaeology). Demographic anthropology shares with the rest of anthropology a holistic approach, and seeks to understand demographic phenomena in the context of the specific sociocultural, environmental, economic, and political settings in which they exist. In demographic anthropology, the ultimate goal is not to simply describe the demographic characteristics of a living or past population. Rather, there is an explicit focus on the application of demographic data to address questions of an evolutionary, ecological, or cultural nature.

In the first decades of the American Journal of Physical Anthropology, publications of a demographic nature were mostly limited to a handful of brief reports of demographic data from various populations, such as Hrdlička’s (1927) “Anthropology of the American Negro: Historical Notes," and Field’s (1936) “Arabs of Iraq”. The first truly demographic anthropological studies (defined here by an attempt to address evolutionary, ecological, or cultural questions) published in AJPA did not appear until the 1930s, including Aberle’s (1931) study of fertility among Pueblo Indians. Aberle compared historical data from parish records to contemporary data collected via interviews in order to test assumptions about low fecundity among “primitive people” and the effects of “civilization” on birth rates. However, demographic anthropological publications remained relatively rare in the journal until the
1960s. Assessment of publication trends (using the term "demograph"
 in the AJPA website search function) reveals that most of the hundreds
of papers focusing on the demography of small populations or past
populations that have been published in the journal date to the 1960s
onward. There have been steady increases in the numbers of articles
related to demography every decade since the 1950s except for a
slight decline during the 1990s. This trend in the journal reflects a rise
in interest in demographic data in the field of anthropology in general
that began in the 1960s, and which Baker and Sanders attributed in
1972 to trends emerging at the time in primatology, population genetics,
and human ecology (Baker & Sanders, 1972).

The demographic anthropology papers published in AJPA have been
 crucial in terms of revealing the particulars and evolutionary, cultural,
or human biological significance of the demography of living and past populations. Examples include Burton Jones et al.’s (1992) analysis of
demographic data from and the ecological context of the Hazda in
comparison to the !Kung, Mazess’ (1965) study of neonatal mortality in highland vs. lowland Peru, and Wilson’s (2014) study of the effect of
early life stressors on survivorship in the context of shifts in subsist-
ence strategies and settlement patterns in the pre-Columbian Illinois
River Valley. Rather than providing an exhaustive summary of demo-
graphic anthropological work published in the journal, I focus here on
key papers published in the journal that have tackled the fundamental
problems that plague the collection, analysis, and interpretation of eth-
nographic census and paleodemographic data. I begin with a descrip-
tion of three major problems faced by demographers: small sample
sizes; inaccurate, incomplete, or biased data; and heterogeneity in pop-
ulations (much of which might not be observable, particularly for paleo-
demographers who work with biased samples of the dead). I then
describe several of the most important possible solutions to these
problems, highlighting those solutions (or applications thereof) that
have been published in AJPA and thus how the journal has played a
crucial role in shaping research in ways that we will continue to see
reflected in the field.

2 | PROBLEMS WITH DEMOGRAPHIC DATA

2.1 | Small sample sizes

National demographers have at their disposal datasets from censuses
numbering in the hundreds of thousands or millions of people (though
this incurs the potential cost of having a sample comprised of a hetero-
geogeneous group; see below). However, demographic anthropologists
most often work with samples sizes of just a few hundred individuals.
In their AJPA paper detailing power analysis in biological anthropology,
Hodges and Schell (1988, p. 175) write that the “problem of small sam-
ples is common, even characteristic of hypothesis testing in anthropol-
yogy”. They demonstrate, using published paleopathological data that
the sample sizes typical of demographic anthropological studies are
adequate for detecting large but not small differences between groups.
A similar point that small samples make it difficult to separate signifi-
cant vs. nonsignificant demographic differences was later made by
Whittington (1991). Small sample sizes are problematic because they
make it difficult to accurately estimate the demographic parameters
that interest us. Demographic studies usually require that samples be
divided into age groups, which further exacerbates the problems of
small sample size in general. For example, as detailed in Brainard’s
(1986) study of mortality in Turkana published in AJPA, with small over-
all sample sizes, the number of deaths per age group are insufficient to
allow the estimation of reliable age-specific mortality rates. Small sam-
ples are also much more vulnerable to the effects of bias. If the total
sample is very small, each individual represents a relatively large pro-
portion of the sample and thus has a more substantial effect on infer-
ences about population dynamics and patterns than would be true if
the samples were very large. Small sample sizes in demographic anthro-
pology can be the result of small overall population sizes; if the popula-
tion studied by an anthropologist is only comprised of a few hundred
individuals, sample size is clearly inherently limited. Small samples sizes
are also a consequence of fewer resources available to anthropologists
to obtain demographic data than is true for the production of censuses
that typically yield the data for national demography.

Balancing the problems associated with small samples sizes is the
greater likelihood that the populations conventionally studied by
anthropologists are more homogenous than those studied by national
demographers. For the sake of simplicity, demographers often assume
population homogeneity, but doing so runs the risk of ignoring impor-
tant variation among subgroups (e.g. based on socioeconomic status,
occupation, engagement in risky behaviors, etc.) (Gage et al., 2012).
Importantly, the majority of human populations that have ever existed
were small, so understanding small population demography is crucial
for understanding our shared history and the forces that have shaped
the variation in human biology and culture that we can observe today.

In the case of paleodemography, small skeletal samples are often
the result of excavations that are constrained by limited time and
money, and by existing structures or features that cannot or should not
be destroyed or altered in the pursuit of research. Thus, even if the
number of individuals originally buried in a particular archaeological site
was quite large, it might only be possible to excavate a small proportion
of them. For example, the excavated assemblage from the medieval
East Smithfield cemetery from London, which has been used for vari-
ous studies reported in AJPA (e.g., DeWitte, 2010; Kendall, Montgomery,
Evans, Stantis, & Mueller, 2013; Margerison & Knüsel, 2002; Watts, 2015), represents only about 25% of the original cemetery. In
paleodemography, sample sizes sufficiently large for interpretable anal-
yses are often obtained by pooling data temporally, geographically, or
along some other variable. For example, Brewis, Molloy, and Sutton
(1990) pooled sites in New Zealand dating from 1150 to 1769 AD for
pooled types of religious-status individuals in her analysis of mortality,
status, and gender in medieval York. In fact, for most of the cemeteries
studied by paleodemographers, some pooling of data across time is
inevitable because the burial sites are typically used for multiple gener-
ations, and resolving temporal patterns might not be possible or finan-
cially feasible. However, pooling data across time, space, or some other
variable means that we run the risk of masking interesting differences.
Ultimately, using the sample sizes that are available to us from archaeological sites to reconstruct life in the past usually entails some sort of trade-off between adequate statistical power and assessing potential heterogeneity within or between samples.

2.2 | Inaccurate, incomplete, or biased data

In addition to working with small samples, demographic anthropologists are faced with data that are often inaccurate, incomplete, or biased. These issues are not unique to anthropology. Indeed, the demographer Petersen (1975, p. 227) wrote that “the demographic data of most of the world, moreover, are full of holes and often quite unreliable”. Our data are imperfect because people are missed by censuses, surveys, or excavations; births or deaths are not recorded; and ages or sex are either misestimated or misreported. These problems are compounded when the associated errors are unequally distributed among segments of the population. For example, in both demographic anthropology and paleodemography, inaccurate age estimates may be more frequent among the very old. Unfortunately, skeletal data on very young individuals is often relatively scarce because of problems with the preservation or recovery of their small, relatively delicate bones (Gordon & Volner, 1988); and the elderly are also underrepresented in some cases, presumably because loss of bone calcium with age makes their bones more vulnerable to disintegration (Walker, Johnson, & Lambert, 1988).

Misreporting of sex in living populations is negligible (Bekele, 2006). Paleodemographic data on sex, however, are potentially problematic for a variety of reasons. Sex is often not determined for pubescent skeletons, and thus many paleodemographic studies are missing these data for (sometimes substantial) portions of their samples (in some cases, where sex is an important component of the overall research design, subadults are totally excluded from sample selection because of the issues with sexing pubescent individuals). Examples of this in AJPA include studies by Alesan, Malgosa, and Simó (1999), Brewis et al. (1990), DeWitte (2009, 2012, 2015), Douglas, Pietrusewsky, and Ikehara-Quebral (1997), Fernández-Crespo and de-la-Rúa (2016), Margerison and Knísel (2002), Nagaoka and Hirata (2007), Owles and Bass (1979), Rathbun (1982), Redfern, DeWitte, Pearce, Hamlin, and Dinwiddy (2015), and Wilson (2014). The estimation of adult sex is most often based on sexually dimorphic features of the skeleton, such as components of the skull and pelvis, and on long bone, dental, or cranial measurements. Adult sex estimation, particularly using subjective, macroscopic traits is not as straightforward as it might seem given the relatively limited number of sex categories. As Weiss (1972) detailed in AJPA, for example, errors in sex estimation result in 12% too many males, on average, in skeletal samples, as there is a tendency to categorize skeletons of intermediate size or rugosity as male rather than female. Also, as reported in AJPA, biased sex estimates might be partly the result of a reliance upon cranial features for sex estimation, as older skulls of both sexes tend to look increasingly masculine (Meindl, Lovejoy, Mensforth, & Carlos, 1985). Ancient DNA analyses of the amelogenin gene to determine sex are highly accurate and applicable to skeletons of all ages (see, for example, the following AJPA publications: Schmidt, Hummel, & Hermann, 2003; Stone, Milner, Pääbo, & Stoneking, 1996). However, these analyses have not yet been widely used, partly because of their cost and destructive nature and the limited number of researchers with the necessary training and equipment to perform them. It should be noted that in addition to the frequently acknowledged problems distinguishing male from female skeletons, bioarchaeological analyses (as can also be true of the demography of living populations) often make the potentially problematic assumption that sex is binary (Geller, 2005, 2017; Wesp, 2017; see Agarwal, 2012 for an exception).

Data on age in living populations are imperfect because some people do not know their exact ages. This can be a consequence of illiteracy, lack of counting systems or calendars, or because knowing exact age is socially irrelevant, and in some populations it is more often a problem with older people (Hadley, Belachew, Lindstrom, & Tesema, 2011; Randall & Coast, 2016). In some cases, people misrepresent their ages because of cultural preferences for or avoidances of certain numbers or a tendency to round age to the nearest 5 or 10 (i.e., age heaping) (Bailey & Makannah, 1996; Pardeshi, 2010).

Paleodemographic age estimation is even more fraught with error. Subadult age estimation is based on the growth and development of the skeleton, the timing of which is known from observations (e.g. via radiographs) of living children of known age. Adult age estimation is often based on the degeneration or remodeling of skeletal elements such as the pubic symphysis, iliac auricular surface, sternal rib ends, or teeth. Subadult age estimates are more reliable and accurate than adult age estimates because, though there is some variation in growth and development resulting from diet, disease, genetic variation, stress, or other factors, the range of that variation is relatively narrow. Degeneration of the skeleton in adulthood is more variable than growth and development, and thus considerable attention has been paid to resolving the issues associated with adult age estimation.

The conventional approach to paleodemographic adult age estimation, which has been promoted, criticized, and modified by scholars via AJPA since the earliest years of the journal, is based on visual assessment of the macroscopic appearances of skeletal features and relies on reference samples comprised of people of known ages at death. The reference sample provides data on the joint distribution of age and phases of morphological change in a skeletal age-indicator. This allows for the estimation of age for skeletal samples (frequently referred to as “target” samples, e.g., Konigsberg & Frankenbarg, 1992) for which only the distribution of age-indicator phases is observable. Widely used examples of this approach have been published in AJPA, including methods using the pubic symphysis (Gilbert & McKern, 1973; Katz & Suchey, 1986; Todd, 1920), auricular surface (Buckberry & Chamberlain, 2002; Lovejoy, Meindl, Pryzbeck, & Mensforth, 1985), and cranial sutures (Meindl & Lovejoy, 1985). Conventionally in paleodemography, individual skeletal age estimates are combined to estimate population-level patterns, such as age-at-death distributions or life expectancy.

Conventional methods of adult age estimation are unfortunately limited with respect to estimating ages for older adults; most produce broad terminal age intervals, such as 50+ years. This clearly hampers
examination of health and demographic patterns for the oldest old. Importantly, conventional age estimates are also biased toward the age composition of reference samples (i.e. age mimicry) as described by Bocquet-Appel and Masset (1982) decades ago and initially explicitly brought to the pages of AJPA in 1985 (Jackes, 1985; Mensforth & Lovejoy, 1985). The criticisms of Bocquet-Appel and Masset have been acknowledged or addressed in over 50 publications in AJPA since then. Bocquet-Appel and Masset viewed age-mimicry as a fatal flaw that doomed paleodemography as it was then widely practiced.

These problems with determining age in living and past populations are important because so much of demography is dependent on age data, such as estimating levels of mortality (e.g., life expectancy at birth) or age-patterns of mortality or fertility. Estimation of the age patterns of migration is important for gaining insights about the causes, variation in, and consequences of migration. Accurate information about age is also important for those interested in health in the past, as age-based approaches might allow us to address the fundamental issues of heterogeneous frailty and selective mortality (i.e. the Osteological Paradox) (DeWitte & Stojanowski, 2015; Wood, Milner, Harpending, & Weiss, 1992). Improving age estimation for the oldest old (i.e. moving beyond broad terminal age estimates) opens the door to addressing important questions about late-life experiences in the past (e.g. the antiquity of the male-female health-survival paradox observed in some modern populations). An interest in learning more about these and other demographic phenomena has driven anthropologists to apply methods, either borrowed from other fields or developed specifically by and for anthropologists, that can improve the accuracy of and compensate for the limitations of demographic data.

3 | POTENTIAL SOLUTIONS

3.1 | Demographic models, hazards analysis, and indirect estimator procedures

Population models (of the relationships among, mortality, fertility, migration, and the age structure of a population) allow for the indirect estimation of demographic rates and have been applied in demographic anthropology to deal with the limitations of small samples and incomplete data (Gage et al., 2012). Demographic anthropologists most often use stable and stationary population models. A stable population is closed to migration, and has unchanging age-specific fertility and mortality rates and a stable age distribution (i.e. the proportion of the population at each age remains constant over time) (Coale, 1972; Lotka, 1907, 1922, 1931). A stable population grows or declines at a constant rate \( r \), the intrinsic rate of increase, and each age category grows or declines at a constant rate defined by \( r \). If a population is stable, a census taken at two points in time provides the information needed to estimate a life table (see description below). The application of the stable population model is generally reasonable, because populations naturally tend toward stable age distributions (Coale, 1972; Gage et al., 2012; Lopez, 1961; Wood, Holman, O’connor, & Ferrell, 2002). In the absence of the information needed to estimate \( r \), researchers apply the stationary population model, which includes all the characteristics of a stable population with the added restriction of zero growth (i.e. \( r = 0.0 \)). If a population is assumed to be stationary, a life table can be computed from a cemetery age-at-death distribution or a single ethnographic census (Gage et al., 2012).

A life table represents a population’s demographic characteristics including: age, numbers of deaths within each age interval, survivorship, age-specific probabilities of dying, and life expectancy. The interrelatedness of the life table columns means that data from one (e.g. age-at-death) can theoretically be used to calculate all the others. Life tables are ideally constructed using longitudinal data from a single birth cohort, but in practice in demographic anthropology they often are produced from cross-sectional data (ethnographic censuses or cemetery age-at-death distributions) and assuming population stability or stationarity. The accuracy of a life table is dependent upon the quality of data available to construct it. As described above, age data from skeletal samples and ethnographic censuses are far from perfect, and life tables produced for anthropological populations might not accurately reflect reality. For example, a paleodemographic life table based on conventional age estimates with broad terminal age intervals will likely underestimate life expectancy and survivorship.

Some of the potential problems with paleodemographic life tables were articulated in AJPA soon after the emergence of the field by Angel (1969), and the implications of the limitations of anthropological demographic data for life table construction were made clear by Howell (1982) in a response to a report by Lovejoy et al. (1977) for the Libben Site (a Late Woodland archaeological site in Ohio). Lovejoy and colleagues produced a life table for the Libben population using estimated skeletal ages that revealed a life expectancy at birth of 20 years. The authors argue that their multifactorial method for adult age estimation combined with careful excavation (e.g. retrieval of preterm infants) maximized the “census accuracy” for the site (Lovejoy et al., 1977, p. 293). Howell, however, pointed out that if their life table is, in fact, accurate, 83% of the Libben population would have been below the age of 30, and 98% would have been under 45 years of age. This age structure would have created substantial dependency ratios and heavy workloads for adults, and would have meant that those who survived to age 40 would have been widowed and remarried several times, many children would have been orphaned, and few people would have survived to be grandparents. If we take this estimated life table at face value, the implication is that life for the people of Libben was more difficult than was true for any population observed anywhere in the world in the 19th and 20th centuries. Alternatively, Howell argues, we should question the accuracy of estimated paleodemographic life tables and of the age and sex estimation methods used to produce them, as well as the representativeness of excavated skeletal assemblages. Howell’s paper is important, not just for highlighting the potential problems with life tables constructed from paleodemographic or anthropological census data, but also for pushing anthropologists to think carefully about what their demographic reconstructions really imply about life in the associated populations and to critically evaluate whether those implications are truly plausible.

In cases where populations are assumed to be stationary, violations of that assumption can lead to incorrect inferences about the
associated population dynamics. The numbers of people dying at each age are affected by population growth and risk of death, and thus population growth or decline can strongly affect the age-at-death distribution, survivorship, and other components of the life table. For example, in a growing population, there will be an increasing proportion of children over time, which produces a more youthful age structure, and thus decreased average age at death; life table estimates of mortality for this population, assuming stationarity, will therefore tend to be overestimated (Johansson & Horowitz, 1986). As demonstrated by Satenspiel and Harpending (1983), a change in fertility more dramatically affects mean age-at-death than a change in mortality of the same magnitude, and thus mean age-at-death is more reflective of fertility than mortality. This finding has motivated the use of skeletal age-at-death patterns to assess trends in fertility and critiques of such approaches (e.g., Buikstra, Konigsberg, & Bullington, 1986; Horowitz, Armelagos, & Wachter, 1988).

As an alternative (or, in some cases, complementary) approach to constructing life tables directly from skeletal data or ethnographic censuses, some demographic anthropologists use model life tables (Brass, 1971; Coale & Demeny, 1983; Ewbank, Leon & Stoto, 1983; Ledermann, 1969; Weiss, 1973). Model life tables are potentially useful when demographic data from an extant anthropological population or skeletal sample are incomplete or defective, as they provide a basis for estimating mortality indirectly, smooth incomplete data, and allow for estimation of fertility from age distributions (Ewbank et al., 1983; Howell, 1986). Model life tables can also be used as the basis of comparison for untransformed skeletal or anthropological data, for example to determine if a skeletal sample reasonably represents the mortality experience of the associated population (e.g., see Margerison & Knüsel, 2002; Milner, Humpf, & Harpending, 1989; Tayles, 1996). Empirical model life tables (e.g. Coale-Demeny’s regional model life tables, Weiss’ anthropological life tables, and Ledermann’s model life tables) are produced using data from living or historical populations. If one can identify a life table with an age distribution or survivorship function that matches that observed in a skeletal sample or extant population, the model life table can then provide other demographic patterns of interest.

There are issues with the representativeness of empirical model life tables as they are derived from a limited number of living populations; there are, for example, few non-European countries represented in the Coale-Demeny regional model life tables. Furthermore, often more than one model life table provides a reasonable match to the target sample patterns, and it is not always clear which is most appropriate to use (Gage & Dyke, 1986; Johansson & Horowitz, 1986; Meindl, Mensforth, & Lovejoy, 2008). The use of these model life tables thus risks imposing potentially incorrect demographic patterns on the population of interest (Gage, 1988; Pennington, 1996).

An alternative to empirical life tables are relational life tables, such as the Brass logit life table system (Brass, 1971). The Brass system is based on the assumption that the relationship between the logit transformations of two survivorship functions is approximately linear and that differences between the logit of an observed (e.g. skeletal) survivorship function and that of a standard can be captured by two parameters (Ewbank et al., 1983; Gage & Dyke, 1988; Murray et al., 2003). Relational life tables are also used to generate life tables from a standard by altering the values of those two parameters. Given that the underlying assumption of linearity is not necessarily realistic, the original Brass model has been modified with the addition of parameters; these more complex models can, however, be more difficult to estimate (Ewbank et al., 1983).

There are many examples in AJPA of the application of stable and stationary population theory, particularly to construct life tables from ethnographic censuses and paleodemographic data, and of the use of model life tables. For example, the stable (or stationary) population assumption was explicitly made by Bennett (1973), Mensforth (1990), and Owsley and Bass (1979) in order to construct life tables from skeletal data. Examples of the paleodemographic use of model life tables (Brass, Ledermann, Weiss, or Coale-Demeny model life tables either alone or in combination) include Alesan et al.’s (1999) study of mortality patterns in Iron Age populations of the Western Mediterranean, Lewis’ (2002) assessment of the impact of industrialization in medieval and postmedieval England, and Margerison and Knüsel’s (2002) investigation of whether catastrophic mortality events leave diagnostic paleodemographic signatures (other paleodemographic examples include Bocquet-Appel & Bacro, 1997; Brewis et al., 1990; Douglas et al., 1997; Fernández-Crespo & de-la-Rúa, 2016; Galeta, Sládek, Sosna, & Bruzek, 2011; Martin, Magennis, & Rose, 1987; McGrath, 1988; Milner et al., 1989; Nagaoka & Hirata, 2007; Nagaoka, Hirata, Yokota, & Matsumura, 2006; Paine & Harpending, 1996; Pennington, 1996; Rathbun, 1982; Soltyšak, 2013; Storey, 2007; Tayles, 1996). Neel and Weiss (1975) apply the Weiss model life tables to assess the demographics of contemporary Yanomamo, and Blurton Jones, Smith, O’Connell, Hawkes, and Kamuzora (1992) use the Coale-Demeny life tables in their study of the demography of the Hadza (other examples of the use of these and other model life tables to investigate living populations include Brainard, 1986; Harpending, 1994; Ray & Roth, 1984).

In addition to these applications, several evaluations of the more general suitability and utility of these approaches to demographic anthropology have been published in AJPA. For example, Johansson and Horowitz (1986) assess the paleodemographic use of stable and stationary population theory, highlighting the effects of growth rate on mean-age-at-death (as a measure of mortality) and the invalidity of the stationarity assumption for most paleodemographic samples. Paine (2000) combines Leslie matrix population projection and a Brass standard model life table to model the long-term effects of mortality crises on stable age-at-death distributions and finds that distributions differ significantly from stable baselines 25–50 years (depending on sample size) after perturbations as severe as the medieval Black Death. Paine (1989) has also demonstrated the paleodemographic utility of Coale and Demeny model life tables.

Given the problems of infant under-enumeration and the inaccuracies or imprecision of conventional methods of adult ages estimation, some researchers have promoted the use of other “estimators” rather than relying (entirely or at all) on potentially biased and inaccurate paleodemographic life tables. These include the juvenile index (or juvenile/adult ratio), the ratio between those who died between the ages of
5–14 and those who died at ages 20 and above), which can be used to estimate life expectancy at birth and probability of death at ages 1 and 5, and mean childhood mortality (mean mortality for 5–10, 10–15, and 15–20 age intervals) (Bocquet-Appel & Masset, 1982, 1996; Douglas et al., 1997; Jackes, 1992; Nagaoka et al., 2006; Pietrusewsky, Douglas, & Ikehara-Quebral, 1997).

In a 1988 AJPA paper, Gage pioneered the application of hazards analysis in demographic anthropology as an alternative to life tables, and though this approach has been primarily used in studies of mortality, it has been applied to examine aspects of fertility in living populations. Hazard models specify the time until a certain event occurs, such as conception or death (Wood, Holman, Weiss, Buchanan, & LeFor, 1992). In studies of mortality, hazards analysis often involves fitting a parametric mortality function, survivorship function, or age-at-death distribution (all of which are related) to skeletal or ethnographic census data (Gage, 1988). Models that are frequently used by demographic anthropologists, such as the Gompertz, Gompertz-Makeham, Siler, and Weibull models (Gage, 1989), have only a few parameters and can thus be applied to small samples. They accommodate missing data and smooth the random variation in demographic data that is an artifact of small samples without imposing any particular age pattern. In addition to using fully parametric models, anthropologists have also applied semi-parametric proportional hazards models, which allows for the estimation of the effects of variables on risk of death (or other event), but does not require the specification of a baseline hazard.

AJPA papers applying hazards analysis (most of them focusing on reconstructing mortality patterns in past populations) include Eshed, Gopher, Gage, and Hershkovitz’s (2004) evaluation of the demographic effects of the transition to agriculture in the Levant, Nagaoka et al.’s (2006) paleodemography of medieval Japan and assessment of secular trends in life expectancy over two millennia, and Hughes-Morey’s (2016) investigation of socioeconomic status and health in industrial-era London (for other examples, see DeWitte, Boulware, & Redfern, 2013; Nagaoka & Hirata, 2007; Redfern et al., 2013; Sasaki & Kondo, 2016; Ségy, Causinus, Courgeau, & Buchet, 2013; Temple, 2014; Watts, 2015; Whittington, 1991; Wilson, 2014; Yaussy, DeWitte, & Redfern, 2016). Hazards analysis has also been used in the context of living populations to investigate, for example, waiting time to conception among the Dogon of Mali (Strassmann & Warner, 1998), neonatal size and infant mortality in the Himalaya (Wiley, 1994), and postpartum amenorrhea in rural Bangladesh (Holman, Grimes, Achterberg, Brindle, & O’Connor, 2006).

3.2 Improved paleodemographic sex and age estimation methods

Over 100 articles detailing approaches for skeletal sex determination (for both subadult and adult skeletal remains) or testing their accuracy or reliability have been published in AJPA. These include approaches based on visual evaluation of features of the pelvis (e.g., Bruzek, 2002; Phenicie, 1969; Schutkowski, 1993), and skull (e.g., Loth & Henneberg, 1996; Walker, 2008); andmetric methods for bones (e.g., Holman & Bennett, 1991; Safont, Malgosa, & Subirà, 2000; Steele, 1976) and teeth (e.g., Black, 1978; Kondo, Townsend, & Yamada, 2005). Several approaches have leveraged technological and analytical advances, such as geometric morphometric analysis of three-dimensional laser scan data (Garvin & Ruff, 2012; Wilson, Ives, & Humphrey, 2017) and the DNA-based analyses mentioned above.

Similarly, many studies (over 150) attempting to identify skeletal elements and analysis thereof that accurately and reliably indicate age at death have been published in AJPA. Several of the most widely used age estimation methods, which are based on visual assessment of macroscopic features, have been first described in the journal (see above). However, though these have revealed traits that are strongly correlated with age in reference samples, relatively few satisfactorily resolve the issues of age mimicry and poor older age estimates, i.e. the problems with age estimation that were deemed so severe as to doom the field of paleodemography as typically practiced (Bocquet-Appel & Masset, 1982).

One proposed solution to the problems of age mimicry and poor estimates for the oldest old is a Bayesian approach described by Hoppa and Vaupel (2002) and tested by Müller, Love, and Hoppa (2002). This approach uses maximum likelihood estimation and Bayes’ Theorem to avoid age-mimicry. The Bayesian approach deviates from conventional approaches by beginning, not with individual age estimation, but with estimation of the age-at-death distribution in the target sample using age-indicator data, only after which individual ages at death can be estimated.

The particular Bayesian approach described by Hoppa and Vaupel and Müller and colleagues requires large sample sizes to provide good estimates of the target sample age-at-death distribution. An alternative approach, which is applicable to samples as small as a single skeleton, is transition analysis (Boldsen, Milner, Konigsberg, & Wood, 2002; Milner & Boldsen, 2012). Instead of requiring the estimation of the target sample age-at-death distribution, in transition analysis, a prior distribution (either a uniform or an informative prior such as one estimated from historical data) is used in Bayes’ Theorem. Boldsen, Milner, and colleagues have developed and made freely available software (the ADBOU program) to facilitate the use of transition analysis (e.g., Ousley, 2016). This approach formalizes the simultaneous use of multipurpose features of the skeleton to produce an age estimate, in line with other proposed multifactorial approaches for age estimation that have been described in AJPA (Anderson, Anderson, & Wescott, 2010; Bedford et al., 1993; Lovejoy, Meindl, Mensforth, & Barton, 1985; Mensforth & Lovejoy, 1985). The general method of transition analysis can be applied to any skeletal features that exhibit regular patterns of change with age and is not dependent on the ADBOU software (e.g., see Godde & Hens, 2012, 2015; Konigsberg, Hermann, Wescott, & Kimmerle, 2008). Several applications or evaluations of the performance of transition analysis and other Bayesian approaches to age or mortality profile estimation have been published in AJPA (e.g., Boldsen, 2005; Bullock, Márquez, Hernández, & Ruiz, 2013; DeWitte, 2015; DiGangi, Bethard, Kimmerle, & Konigsberg, 2009; Godde & Hens, 2012, 2015; Hughes-Morey, 2016; Konigsberg & Frankenberger, 2013; Lottering, MacGregor, Meredith, Alston, & Gregory, 2013; Milner & Boldsen, 2012; Steadman, Adams, & Konigsberg, 2006; Stojanowski & Duncan,
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As mentioned above, many proposed and widely used adult age-estimation methods rely on visual assessment of macroscopic features and qualitative scoring protocols. However, as have been described in AJPA, there are quantitative alternatives based on osteon remodeling (Chan, Crowder, & Rogers, 2007; Ericksen, 1991; Kerley, 1965; Kerley & Ubelaker, 1978; Stout & Paine, 1992; Turner-Walker & Mays, 2008), root dentin translucency (Drusini, Callari, & Volpe, 1991), reduction of the coronal pulp cavity because of the formation of secondary dentin (Drusini, Tos, & Ranzato, 1997; Fabbri et al., 2015), and tooth-cementum annulations (cementochronology) (Charles, Condon, Cheverud, & Buikstra, 1986; Condon, Charles, Cheverud, & Buikstra, 1986; Naylor, Miller, Stokes, & Stott, 1985; Wittwer-Backofen, Gampe, & Vaupel, 2004). Osteon remodeling approaches, for example, based on the number of intact and fragmentary oseons and other parameters visible in thin sections of bone can be applied to fragmentary remains for which macroscopic features cannot be evaluated. However, because remodeling is affected by genetics, race, activity patterns, diet, and other variables (Turner-Walker & Mays, 2008), the accuracy of these approaches is dependent upon the availability of formulae derived from reference samples that match the target samples as closely as possible with respect to these factors. The tooth cementum annulation approach is based on counting annual layers of cementum from thin sections of tooth roots; it can yield highly accurate and precise age estimates (Couoh, 2017; Wittwer-Backofen et al., 2004), and is not subject to age-mimicry (Naji et al., 2014), though its application can be impeded by diagenic effects (Roksandic, Vlak, Schillaci, & Voicu, 2009). Given their destructive nature and the need for specialized equipment to process the samples for analysis, these approaches are not yet widely used.

4 | SUMMARY

Much of the influential and pioneering demographic anthropological research and relevant methodological innovations have been first reported, assessed, or criticized in AJPA. In the interests of space, this article has not exhaustively reviewed all of the methodologies relevant to the field nor their specific applications to the demography of living and skeletal populations, and I have excluded discussion of historical demographic research published in the journal and elsewhere (e.g., Sawchuk, Tripp, Damouras, & Debono, 2013; Sparks, Wood, & Johnson, 2013). Nonetheless, what is clear from an overview of papers published in AJPA is that not all of the issues affecting demographic anthropological research have yet been fully resolved. However, what is equally clear is that there is an encouraging tradition of innovation in data collection and analysis and of critical evaluation of the field. The history of publications in the AJPA reveals the important steps that have been and are being taken to deal with the limitations of our data and demonstrates the dedication anthropologists have to improving the inferences we can make about life in the present and past through the lens of demography.


