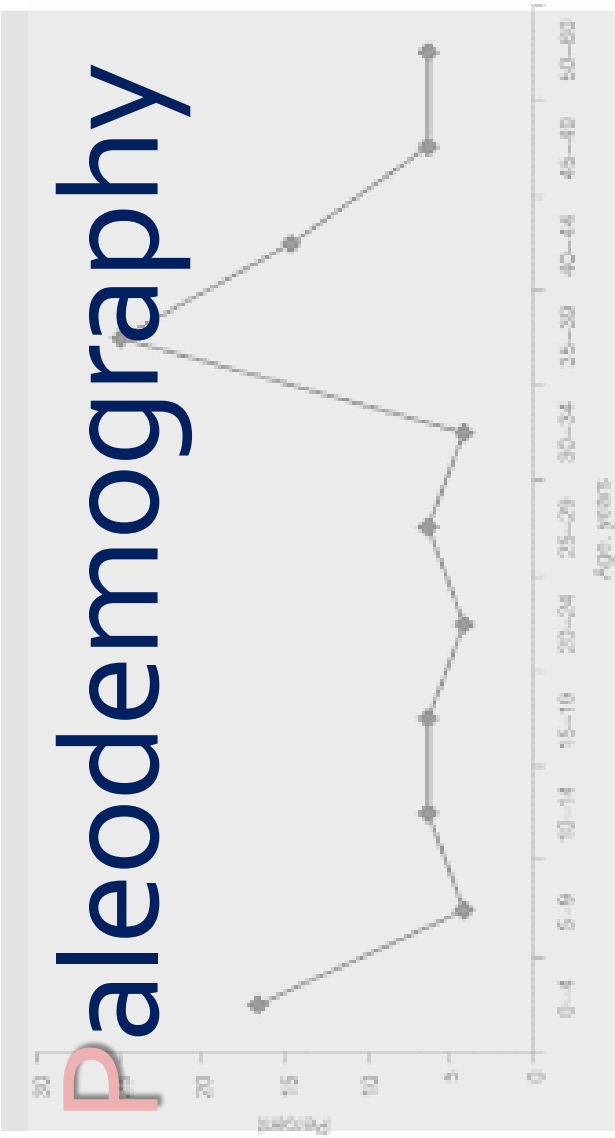
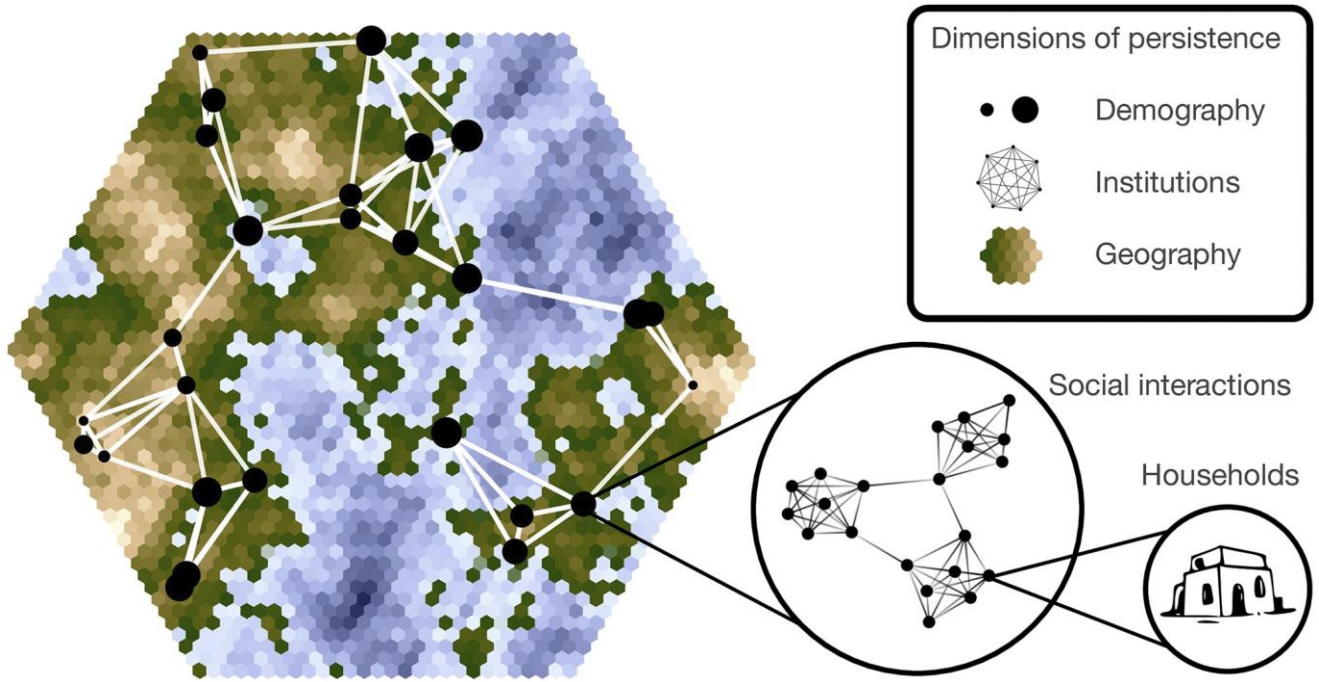
Paleodemography



Dr Arwa KHAROBI

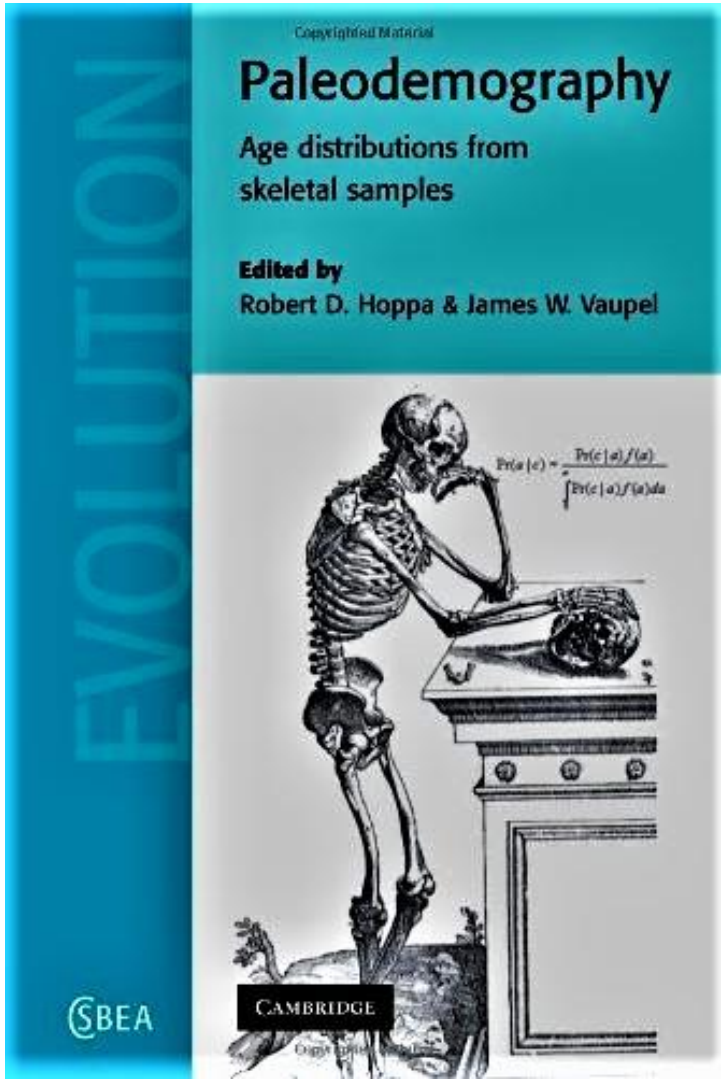
- based on a single source: human bone remains = a precious biological archive
- typically prior to or in the absence of historical records (historical demographics)



Paleodemography

attempts to:

1. identify demographic parameters from past populations
2. make interpretations regarding the health & well-being of those populations

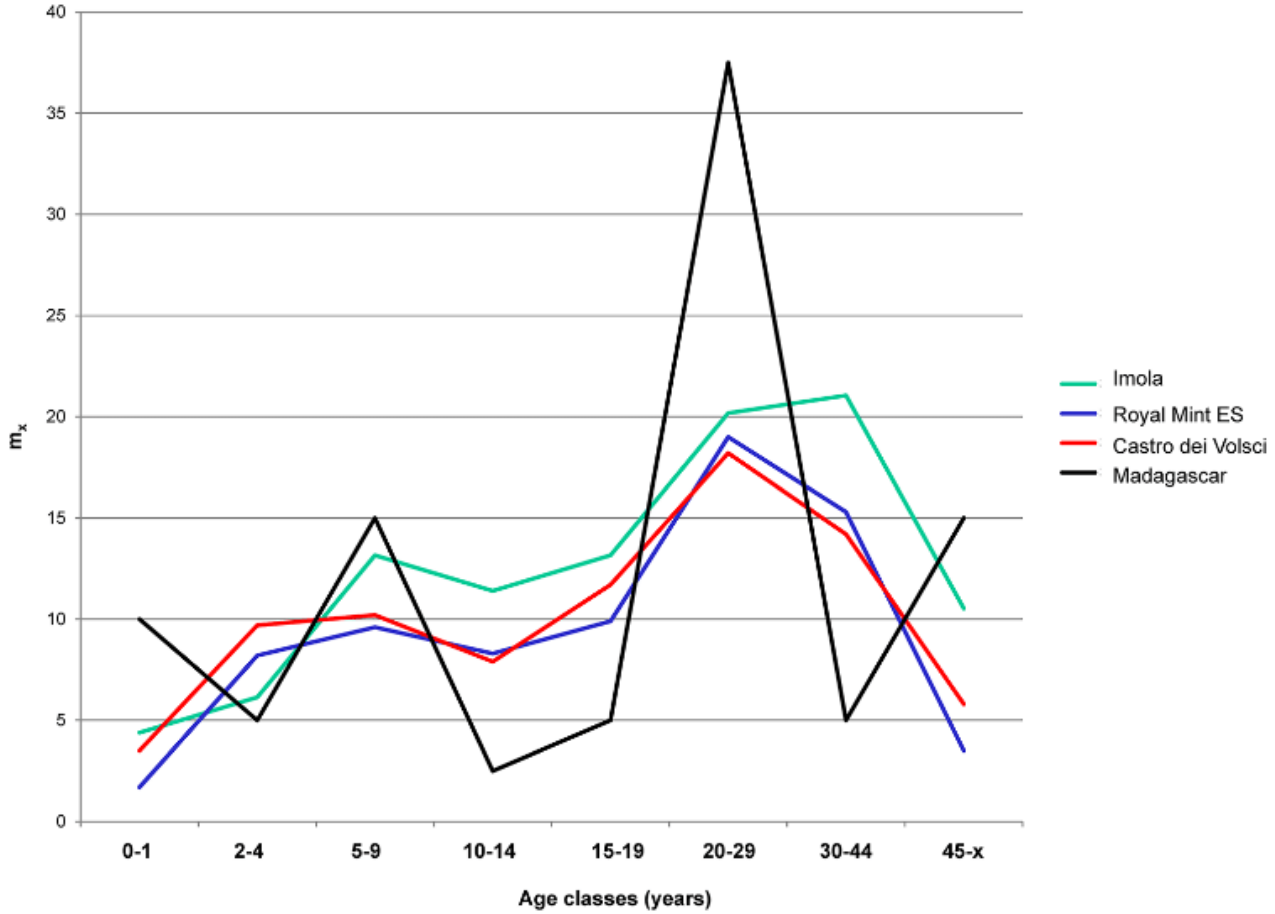


Paleodemography reconstructs parameters such as:

- life expectancy at birth

- age profile of a population

- patterns in the ages of death

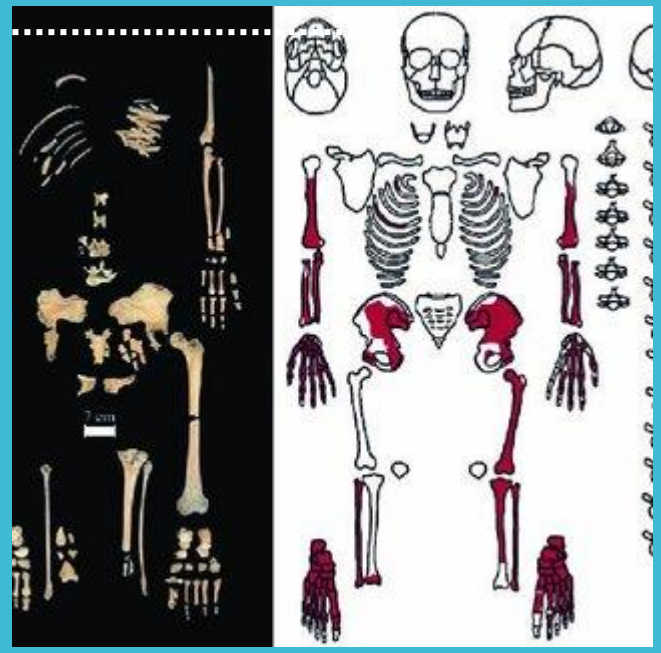


Mortality trends in modern and historic populations exposed to plague

How??

By constructing various sorts of mortality profiles based on the age & sex data of burials.

Mortality profiles show at what age adult males, adult females & children died.



- **<u>Prior to the mid-20th century</u>**: characterizations of the age & sex composition of past populations, regardless of whether data came from skeletons or funerary inscriptions : few & far between

- **<u>Since 1970</u>**: paleodemography has played a central role in studies of archaeological skeletons.

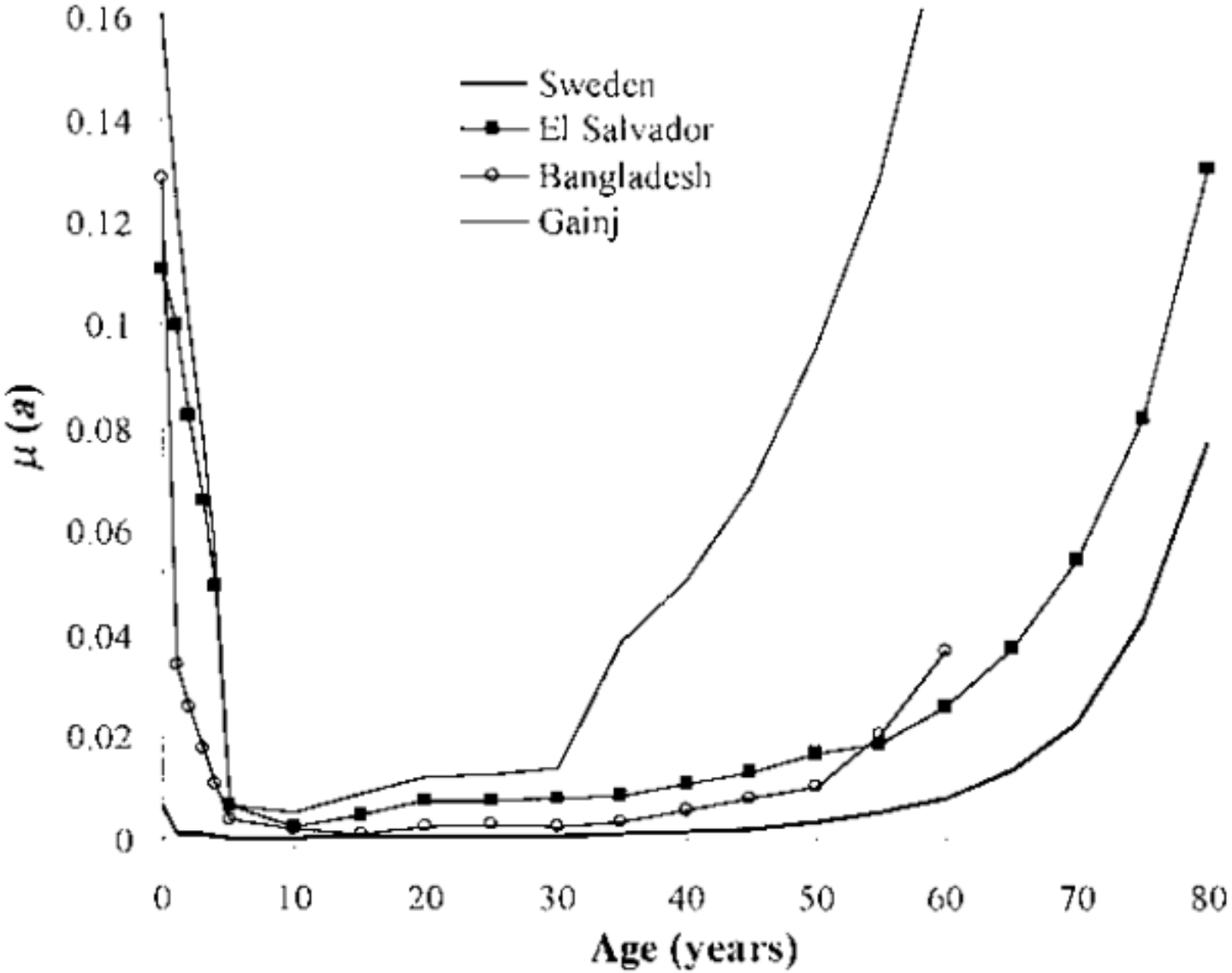
- Paleodemography's origin as a coherent field owes much to the **1960s New Archaeology**.
- Focus on past populations rather than artifacts & architectural remains through skeletons being an important part of that work.

- Mortality patterns are well understood for contemporary & some historical populations, mainly European ones over the past four centuries.
- We typically study small foraging or horticultural societies, representing much of human existence, but there's limited knowledge about their mortality conditions.
- Existing research -> mortality profiles in these societies generally align with a common human pattern, often at the higher end of mortality rates observed in national & historical populations.
- Despite the limited data, it is meaningful to discuss a 'common' age pattern of human mortality.

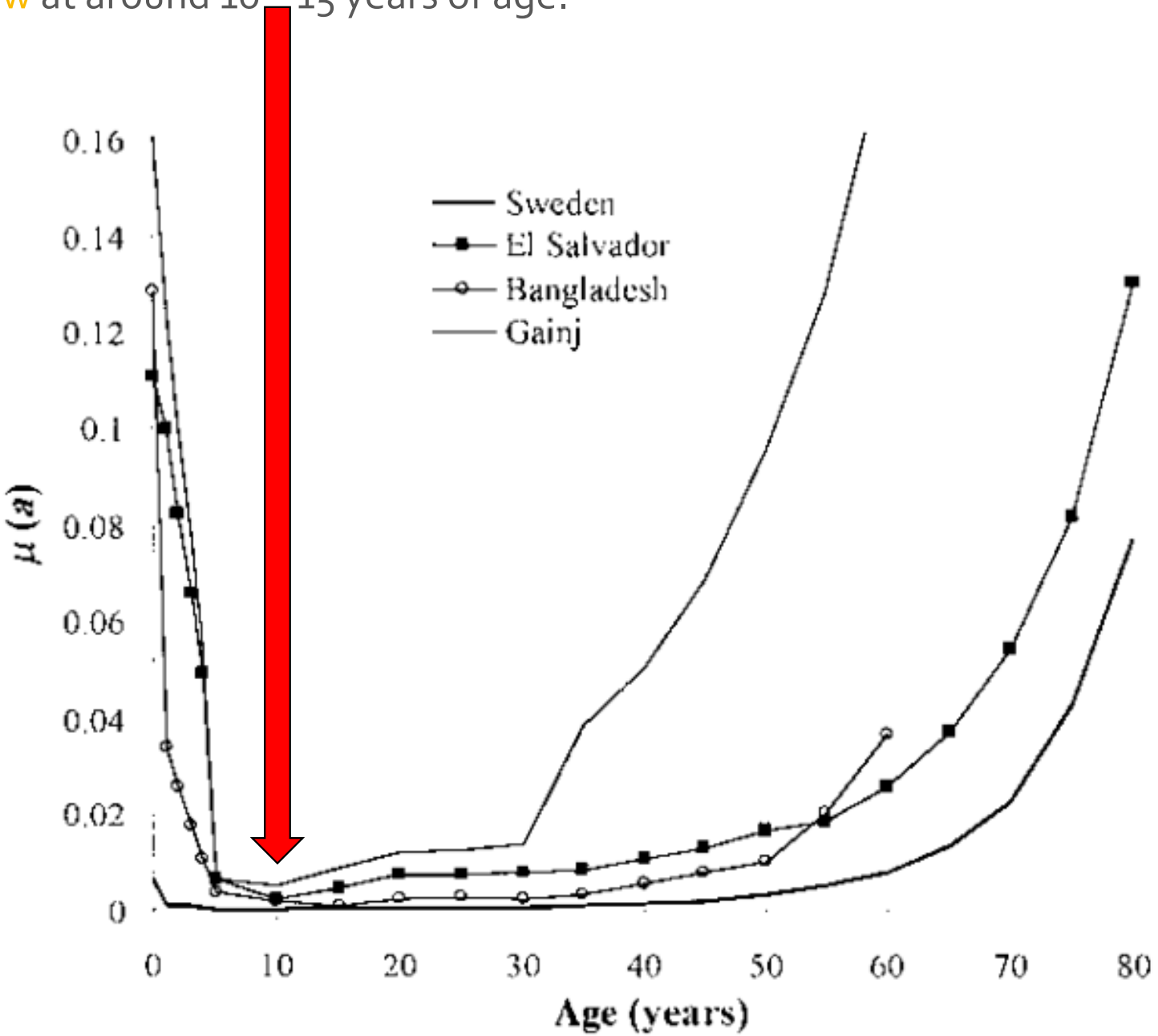

But what does the
human mortality curve
look like?

- The basic pattern of the age-specific force of mortality is similar across a wide range of human populations, whether characterized by high mortality or low.

Age-specific force of mortality in four human populations with widely differing levels of mortality: Sweden 1985, females (Keyfitz and Flieger 1990); El Salvador 1950, males (Keyfitz and Flieger 1968); Bangladesh 1978, both sexes (Chowdhury et al. 1981); Gainj (highland New Guinea) 1970—77, males (Wood 1987b). Note that the Gainj, a small horticultural group, was the only one of the four without regular access to modern medical care at the time of data collection. In addition, the Gainj curve is based on a small sample (150 deaths) and therefore appears somewhat more "jagged" than the other examples.



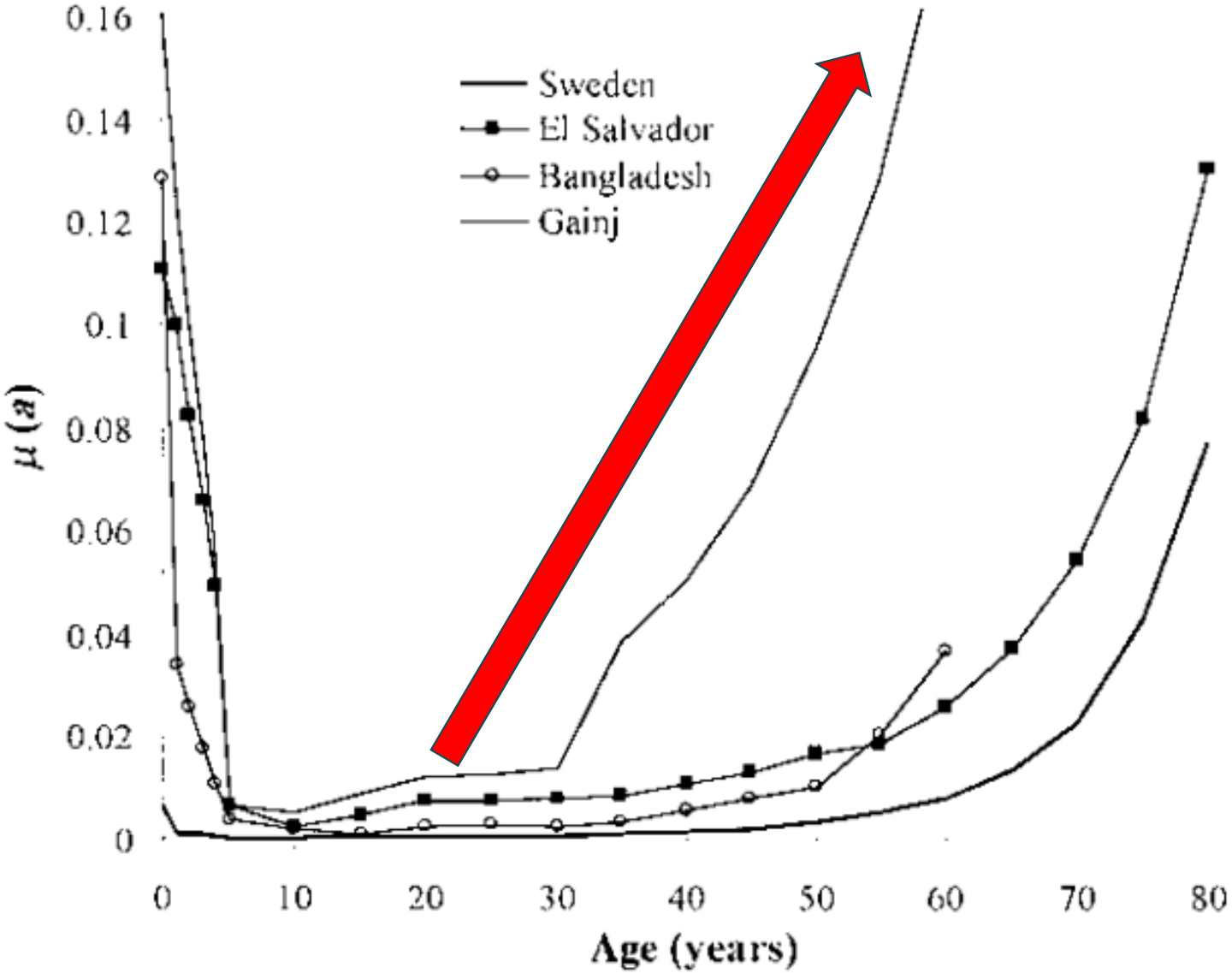
- The general pattern appears to be one of excess mortality at the youngest ages of the lifespan, with a rapid, monotonic decline to a lifetime low at around 10—15 years of age.



Age-specific force of mortality in four human populations with widely differing levels of mortality: Sweden 1985, females (Keyfitz and Flieger 1990); El Salvador 1950, males (Keyfitz and Flieger 1968); Bangladesh 1978, both sexes (Chowdhury et al. 1981); Gainj (highland New Guinea) 1970—77, males (Wood 1987b). Note that the Gainj, a small horticultural group, was the only one of the four without regular access to modern medical care at the time of data collection. In addition, the Gainj curve is based on a small sample (150 deaths) and therefore appears somewhat more "jagged" than the other examples.

- This low point is followed by an accelerating rise in mortality later

Age-specific force of mortality in four human populations with widely differing levels of mortality: Sweden 1985, females (Keyfitz and Flieger 1990); El Salvador 1950, males (Keyfitz and Flieger 1968); Bangladesh 1978, both sexes (Chowdhury et al. 1981); Gainj (highland New Guinea) 1970—77, males (Wood 1987b). Note that the Gainj, a small horticultural group, was the only one of the four without regular access to modern medical care at the time of data collection. In addition, the Gainj curve is based on a small sample (150 deaths) and therefore appears somewhat more "jagged" than the other examples.



After determining age + sex of a set of exhumed individuals, the aim is to obtain from among the various possible combinations the most likely distribution by groups of age at death.

General methodological principles

1. **Use** a reference population whose age structure is close to the standard for pre-industrial populations
2. **Maintain** a probabilistic approach to age at death
3. **Seek** compatibility with demographers' tools

Mortality models for paleodemography

1. Outline of the "probability vector" method

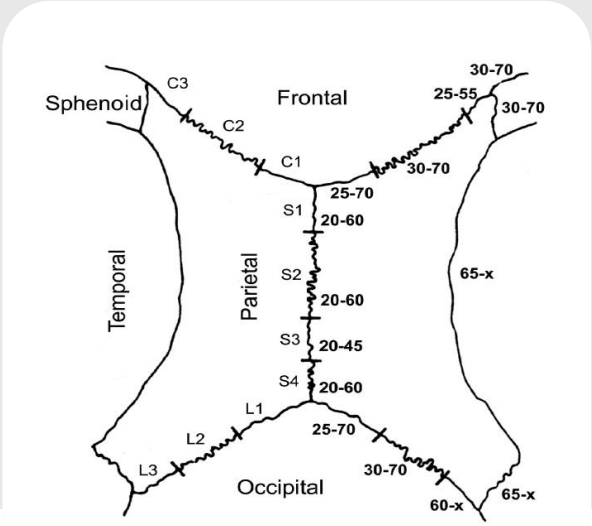
   (Masset, 1973, 1982, 1989)

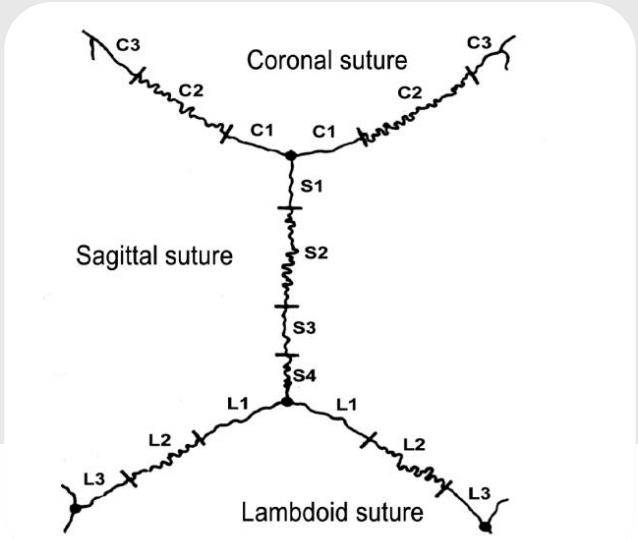
2. Outline of the "estimator" method

   (Bocquet-Appel, Masset, 1977, 1996)

1. Probability vector Method (Masset, 1973, 1982, 1989)

Masset introduced the "probability method" for analyzing buried adult populations based on age groups.



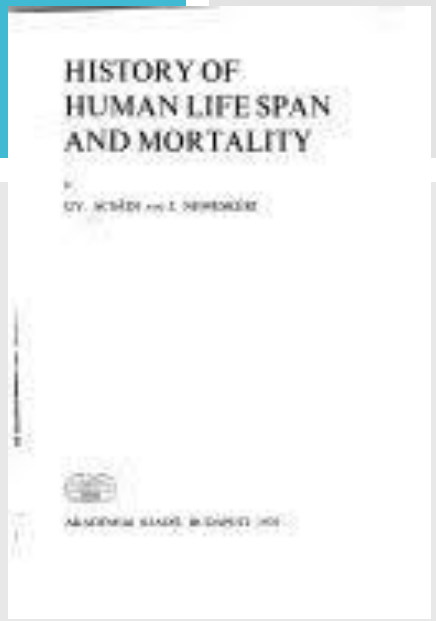


Using a reference collection in which the numbers in each age group had been artificially equalized,

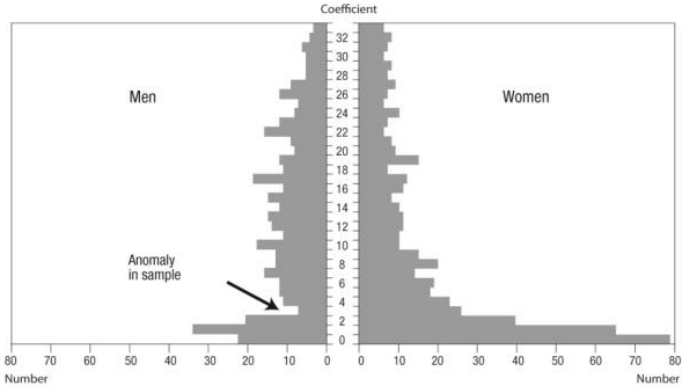
Established frequency matrices to connect a given biological stage (from I to VII) to all the age groups in which that stage is observed.

These matrices include the probability for each skeleton of belonging to one of the 7 age groups chosen, based on its degree of cranial suture closure.

1. Probability Vector Method (Masset, 1973, 1982, 1989)



- The method can be applied to any other age indicator
- Adapted by others, including Bergot, Bocquet-Appel, Langenscheidt & Theureau, on different age indicators and weightings
- Presented by İşcan 1989 & Bintliff/Sbonias 1999
- Applied by many anthropologists in various European site studies



Distribution by coefficient of suture closure and sex in the Masset collection.

2. "Estimator" Method (Bocquet-Appel, Masset, 1977, 1996)

- First response to the problems of individual ages, via a new index providing demographic information on the buried population.
- Noticed that the juvenility index could be obtained from cemetery data, with a slight adaptation to allow for the under-recording of children under 5 in most cemeteries.
- ->They proposed to define the paleodemographic juvenility index as the ratio of children aged 5-14 to "adults" in the sense of all individuals aged over 20 years

2. "Estimator" Method (Bocquet-Appel, Masset, 1977, 1996)

- To address age estimation challenges, Bocquet-Appel & Masset suggested using an age-at-death ratio as a proxy for fertility.

- They introduced the D5–14/D20+ ratio, indicating the proportion of juveniles (5–14 years old) to adults (20+ years old), as a robust estimator of population dynamics.
- Correlations between this ratio and demographic parameters were reported, including:

1. life expectancy,
2. birth rate,
3. mortality rate.

In the past….

Skeletal palaeodemography has **2** main approaches

- estimate mortality & survival rates based on fertility & age-specific mortality.
- Skeletal remains' age-at-death distribution is compared to life tables to assign characteristics.

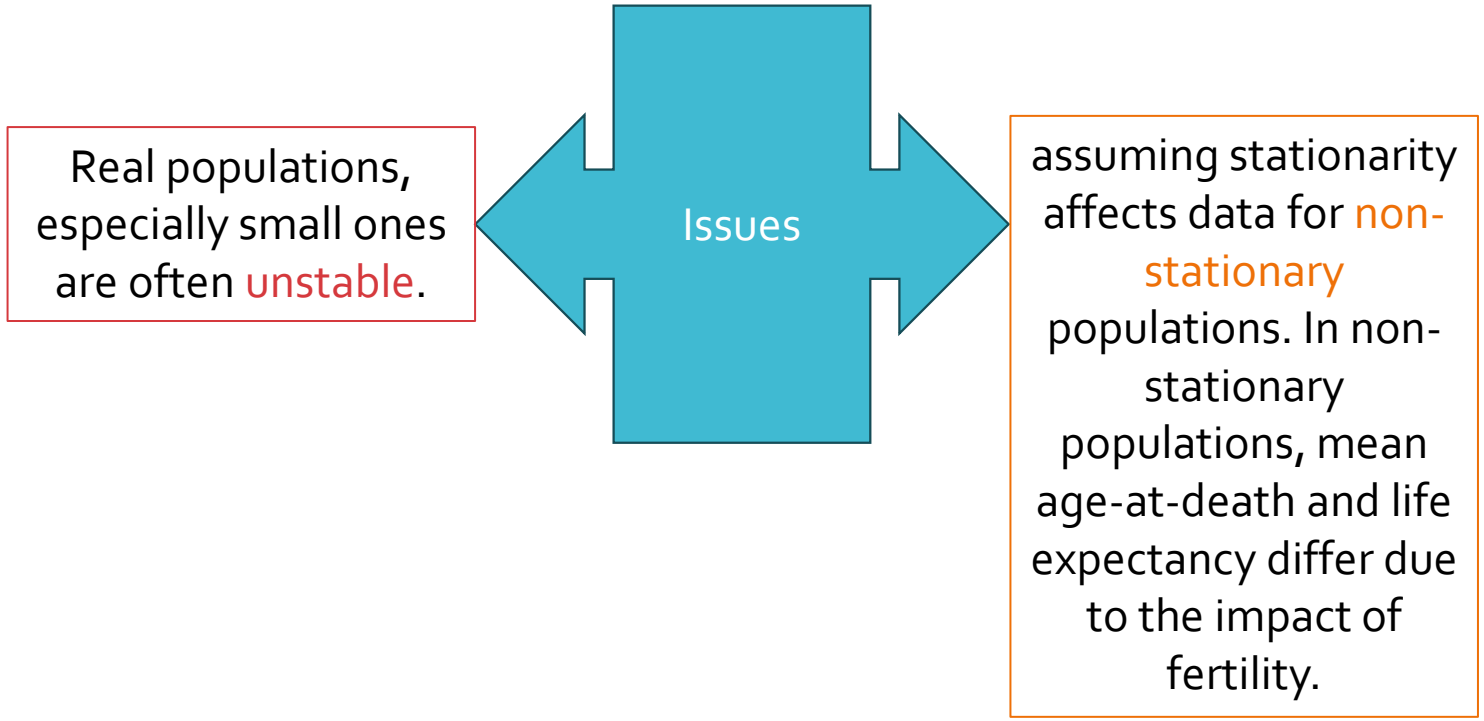
- calculate rates like fertility using proxies from the skeletal population..

Both approaches have benefits, limitations, and discussed issues.

Life table calculations are based on assumptions of stability and stationarity.

Stability implies a closed population with constant age-specific fertility and mortality rates.

Stationarity refers to a stable population with 0% growth.



Life table: limits

Problem I: Johansson & Horowitz highlighted that *assuming stationarity in a growing population could distort demographic history reconstructions.*

Problem II: Scenario testing revealed that *age-at-death estimation techniques with less than 90% accuracy led to unacceptably high error rates in demographic estimates*.

Fact: Adult age estimation remains a persistent challenge in bioarchaeology, with geographical and potentially temporal specificity in degeneration rates and increasing variability with age.

Demographic Proxy Estimators over Life Tables

demographic proxy estimators

life tables

especially in the practical constraints of bioarchaeology.

Ratios Advantages

- Age-at-death ratios offer advantages by minimizing the impact of individual age estimation errors.
- These ratios group individuals into larger age ranges, reducing the sensitivity to estimation errors.
- Bocquet-Appel's 15P5 ratio has been widely applied, showing its practicality in demographic proxy estimation.

Demographic proxy estimators

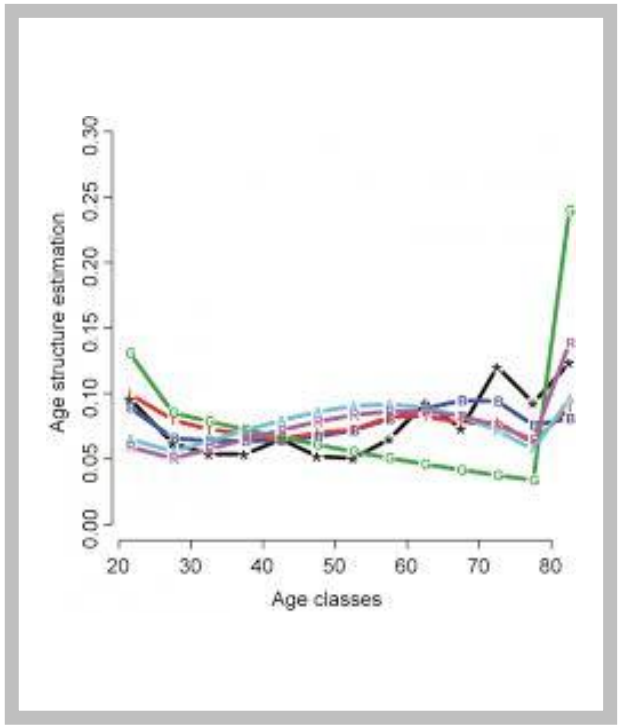
Factors like:

1. soil pH,
2. bone mineral density,
3. burial depth
4. archaeological recovery methods

Underenumeration infants & the elderly in skeletal samples, challenging assumptions about past demographics.

Studies report significant discrepancies between historical records and skeletal remains, suggesting biases in representation.

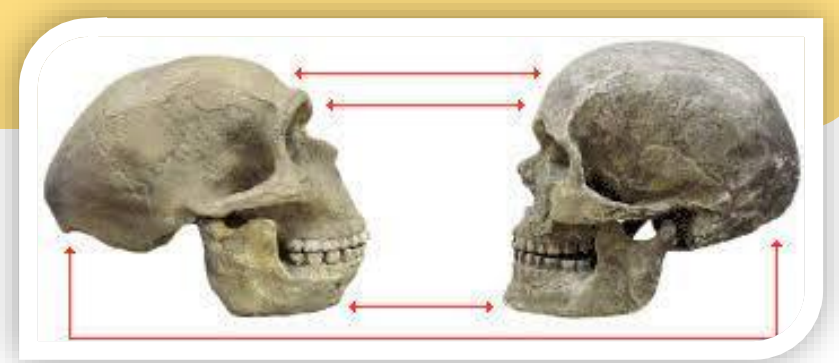
And what about nowadays approach of paleodemography on skeletal remains?



Current skeletal-based palaeodemographic methods

- Moved away from using historical or model life table data.
- To rely on high-quality & easily accessible modern data from the United Nations statistical database.
- ->This allows for a thorough evaluation of the connections between different population dynamics.
- E.g., we can assess how migration impacts the rate of natural population increase.

- Assumption of this approach "the relationship between certain age-at-death distribution features & population dynamics has remained consistent throughout the history of modern Homo sapiens".



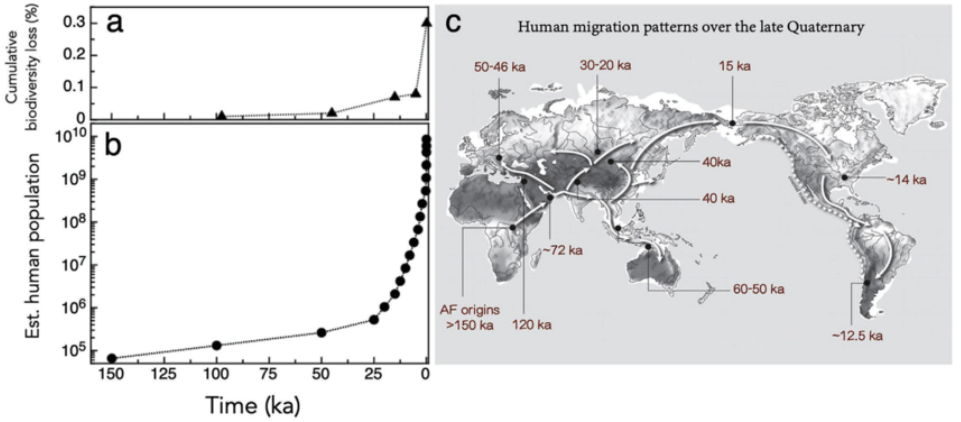
In the present.

Bioarchaeology relies on the idea that human skeletal & dental systems respond consistently to internal & external factors, despite some variability between populations.

This uniformity -> to apply methodologies & knowledge from modern data to understand concepts like:

biological relatedness → distance → skeletal biology → palaeopathology

bones have predictable responses to stimuli, so do human populations across different time periods.



In the present.

the use of juvenile mortality rates as a proxy for understanding the fertility & natural increase of ancient populations

A growing & fertile living population should have a higher proportion of juveniles, and this structure should be reflected in the deceased population.

Various methods have been employed to calculate juvenile-to-adult ratios, with a focus on minimizing age-estimation errors **BUT** challenges in:

still common!

1. age estimation for adults
2. exclusion of individuals aged 0–4 due to preservation & recovery biases

In the present.

Recent methods by McFadden & Oxenham focus on the proportion of the population dying as juveniles (0–14 years), minimizing error to the 14 years cut-off.

Their study evaluates the impact of age estimation errors and under enumeration of infants and the elderly on demographic estimators.

RESEARCH ARTICLE

The D0-14/D ratio: A new paleodemographic index and equation for estimating total fertility rates

Clare McFadden, Marc F. Oxenham

The paleodemographic measure of maternal mortality and a multifaceted approach to maternal health

Clare McFadden, Marc F. Oxenham*

*Corresponding author for this work

Archaeology

Australian National University

Research output: Contribution to journal › Article › peer-review

In the present.

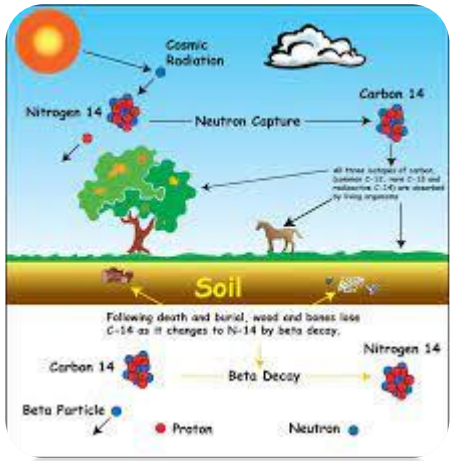
Combined under enumeration has negligible impact, but significant underrepresentation of either group may affect accuracy.

Though evaluating underrepresentation provides a scope for using estimators, determining the degree of underrepresentation remains challenging.

Small proportions of infant deaths might indicate population decline. Including infants, where possible, is crucial for accurate estimations due to their sensitivity to changes in fertility and growth.

dates as data techniques, known as demographic temporal frequency analyses (dTFA), offer an alternative method to study past populations.

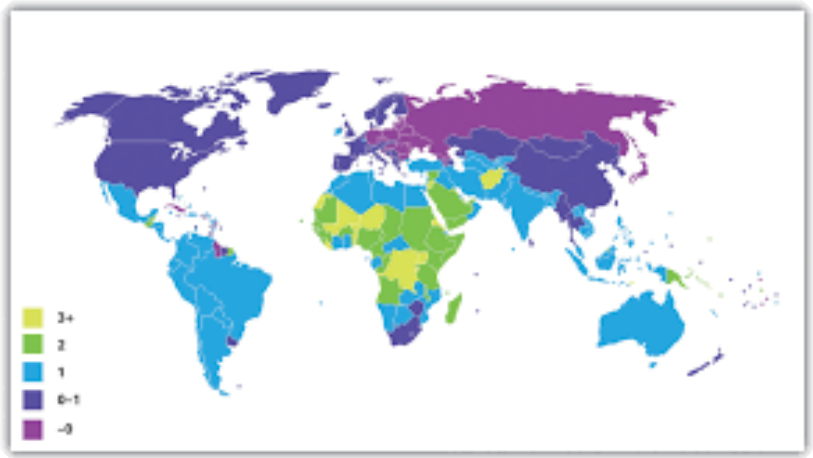
instead of relying on skeletal evidence, dTFA use radiocarbon dates from archaeological sites.



by analyzing the frequency fluctuations of these dates over time, we can quantify changes in the number of sites in a region.

trends in these frequencies serve as a proxy for population growth or decline,

reflecting increases or decreases in population sizes.



Over the last two decades, dTFA methods have gained popularity globally, providing insights into various factors (agriculture & responses to climate change).

Methodological improvements, addressing biases, have been made. However, a limitation is the need for a significant number of precisely dated sites, often restricting application to regional, large-scale palaeodemographic studies.

The availability of funding & resources for radiocarbon dating can also limit the temporal scale of research in certain geographical regions.

Frida Kahlo, “Le rêve, le lit”, 1940 / source image : wahooart.com

In the field!

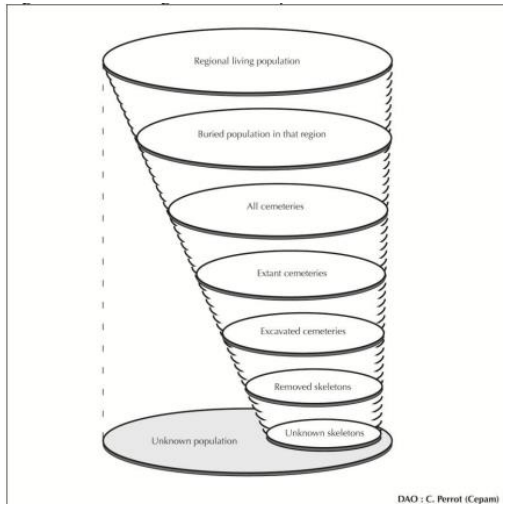
Paleodemography depends on the excavation of burial sites that may be:

- very different in size & nature,
- studied in the context of research excavations or rescue archaeology

Representativeness + limits to the validity of the conclusions proposed.

3 preconditions necessary for any demographic study based on osteological remains:

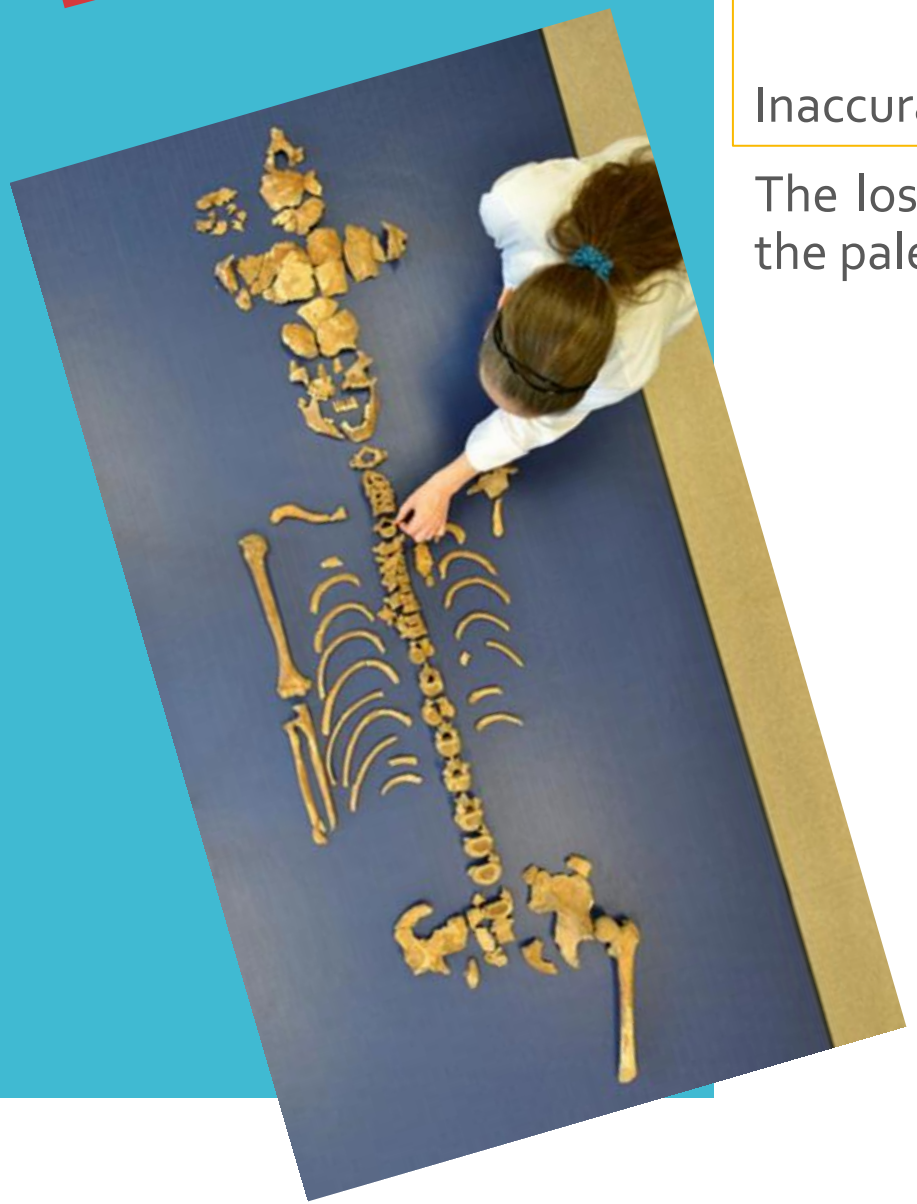
1. the cemetery should be exhaustively excavated and an accurate topo-chronology established,
2. the exhumed skeletons should be well conserved,
3. there should be biological or social links between the individuals.



In reality:
- excavation of funeral sites is more often partial than exhaustive
- the preservation of the skeletons varies in quality

Defined by Acsádi & Nemeskéri as early as 1957

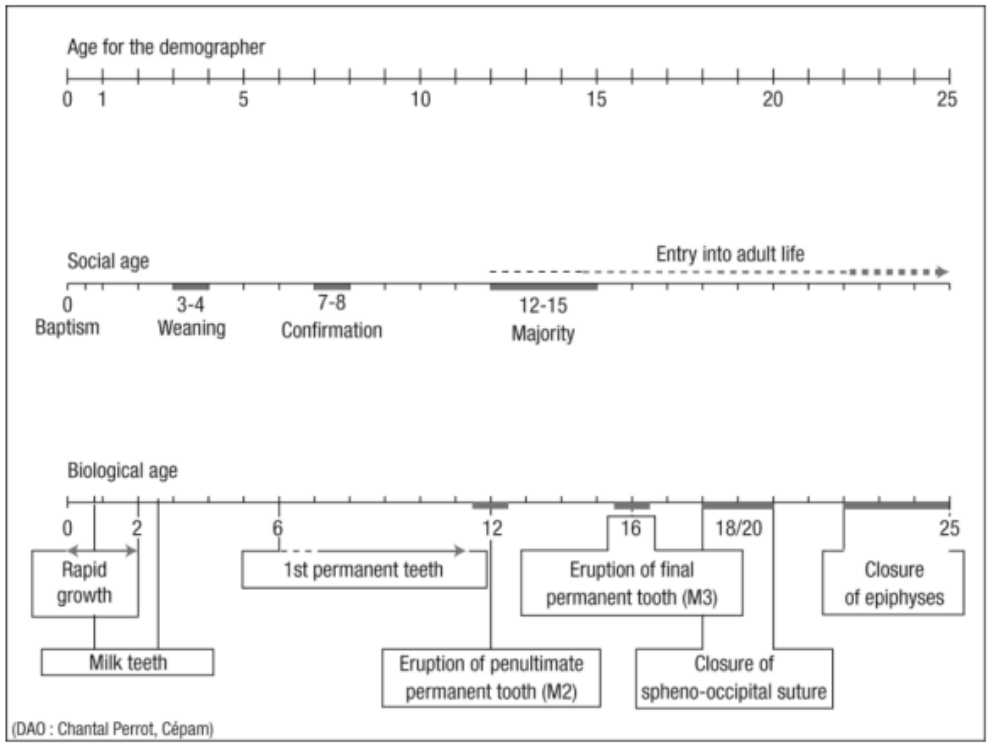
In the lab!



Inaccuracy of methods (sex & age) -> uncertainties & margins of error

The loss of information is considerable between the buried population & the paleodemographic sample

This loss must be identified and, if possible, quantified



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A test of Suchey–Brooks (pubic symphysis) and Buckberry–Chamberlain (auricular surface) methods on an identified Spanish sample: paleodemographic implications

Marta San Millán, Carme Rissech*, Daniel Turbón

Unitat d'Antropologia, Dept. Biologia Animal, Facultat de Biologia, Universitat de Barcelona, Av. Diagonal 643, 08028 Barcelona, Spain

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ABSTRACT

Forensic Anthropology and Bioarchaeology studies depend critically on the accuracy and reliability of age-estimation techniques. In this study we have evaluated two age-estimation methods for adults based on the pubic symphysis (Suchey–Brooks) and the auricular surface (Buckberry–Chamberlain) in a current sample of 139 individuals (67 women and 72 men) from Madrid in order to verify the accuracy of both methods applied to a sample of innominate bones from the central Iberian Peninsula. Based on the overall results of this study, the Buckberry–Chamberlain method seems to be the method that provides better estimates in terms of accuracy (percentage of hits) and absolute difference to the chronological age taking into account the total sample. The percentage of hits and mean absolute difference of the Buckberry–Chamberlain and Suchey–Brooks methods are 97.1% and 11.24 years, and 85.7% and 14.38 years, respectively. However, this apparently greater applicability of the Buckberry–Chamberlain method is mainly due to the broad age ranges provided. Results indicated that Suchey–Brooks method is more appropriate for populations with a majority of young individuals, whereas Buckberry–Chamberlain method is recommended for populations with a higher percentage of individuals in the range 60–70 years. These different age estimation methodologies significantly influence the resulting demographic profile, consequently affecting the biological characteristics reconstruction of the samples in which they are applied.

1. Introduction

The main objective when studying any archaeological sample is to reconstruct the life of the population studied as far as possible. Paleodemographic studies have the potential to provide important information regarding past population dynamics (Hoppa and Vaupel, 2002). Although a diagnosis of the age and sex are vital in this respect, paleodemographic analysis of osteological remains suffers from a number of limitations, especially when we consider it at a population level (Bocquet-Appel and Masset, 1982, 1985; Hoppa and Vaupel, 2002; Konigsberg and Frankenberg, 1992; Milner and Boldsen, 2012; Milner et al., 2008; Wood et al., 1992). One of the most important of those limitations is the validity of age estimation techniques, which has been largely questioned (Bocquel-Appel and Masset, 1982, 1985; Hoppa and Vaupel, 2002; Konigsberg and Frankenberg, 1992). Thus, despite the fact that determination of the age of sub-adult individuals has been fairly well resolved (Cox, 2001), this is one of the complex steps for adult individuals. Variations in the rate of age-related morphological changes in the various adult age markers on which the various methods are based depend on a complex interaction between three factors (genes, culture and environment) that affect the entire life history of the individual concerned. As a result, errors in this preliminary step consequently affect the subsequent biological and cultural interpretation (Schmitt, 2004). Furthermore, the variability observed in the age markers increases with age and continues to increase throughout a person's life, which is a well known characteristic of the ageing process called Trajectory Effect (Nawrocki, 2010), and it is the reason why the age-estimation error is lower in sub-adult individuals than in adults. The key to the success of any particular method of age estimation lies in an understanding of whether the method is accurate (correct), precise (refined) and repeatable from an intra- and inter-observer stand point when applied to unknown individuals outside of the original reference sample. However, the reference collections used to develop the majority of methods for estimating the age of adult skeletal remains

* Corresponding author. Tel.: +34 934021460x213; fax: +34 934035740.
E-mail address: carme.rissech@ub.edu (C. Rissech).

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4 decades later, their challenges, still drive efforts to estimate age from skeletal remains, create age-at-death distributions & extract insights about past life.

Initial excitement for paleodemography's potential was tempered by challenges in handling skeletal data & their analysis.

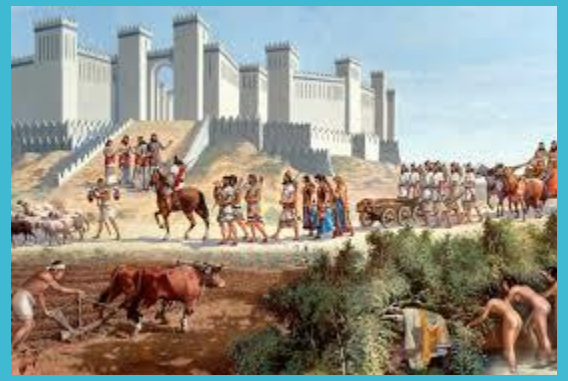
Some issues have been addressed; others persist.

Despite premature predictions of the field's demise in Bocquet-Appel & Masset's (1982) "Farewell to Paleodemography," the research faced setbacks.

Contributions

- Life in past communities
- Life histories
- Disease experience
- Migration
- Evolution & the life course
- Demographic & socioeconomic transitions

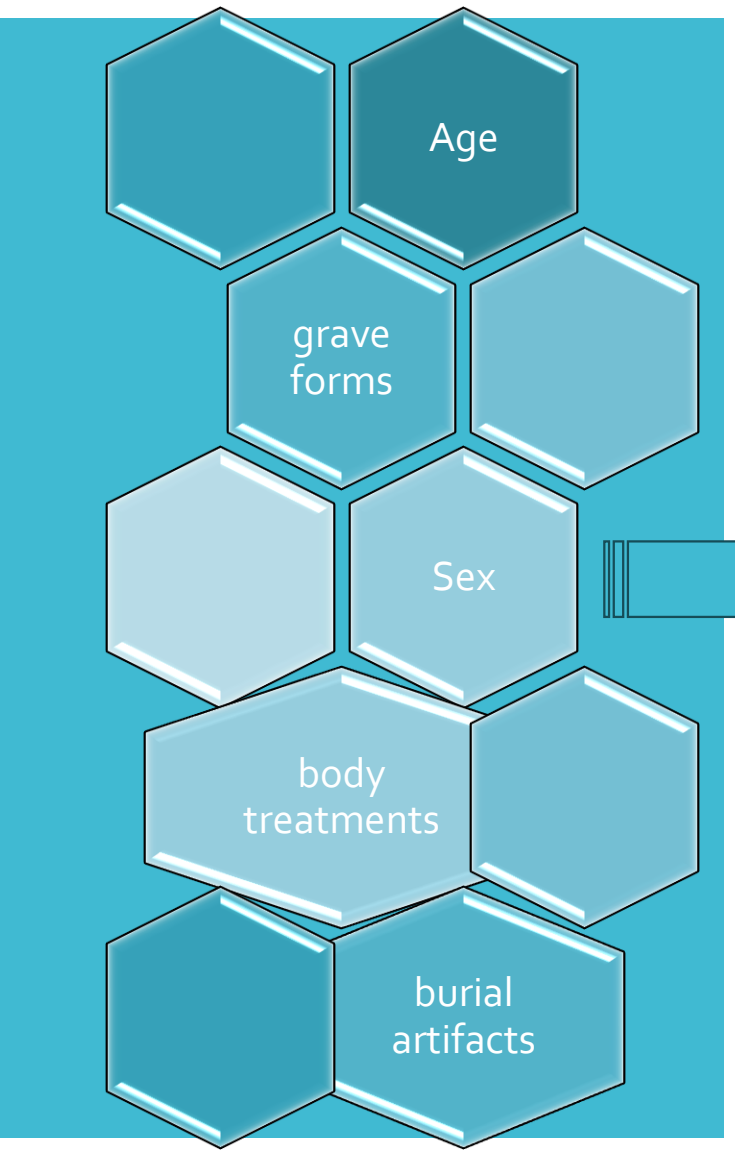
1. Life in past communities



- Absence of biological data compromises the understanding of the experiences of groups & communities.
- Without such data, it becomes challenging to grasp & measure factors such as:

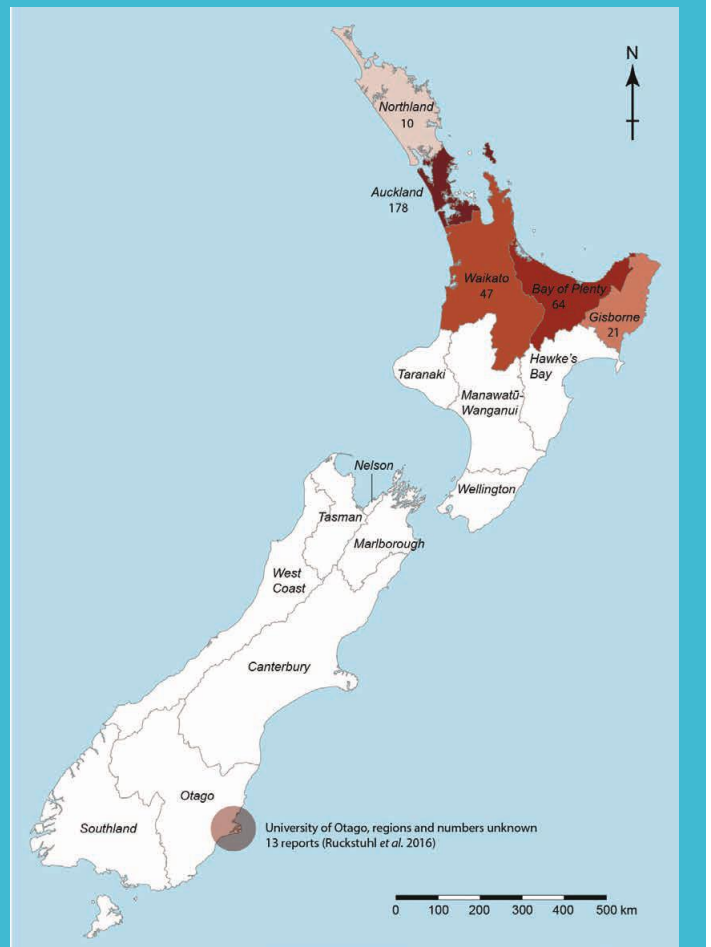
1. distribution of labor
2. challenges related to dependents and producers
3. allocation of resources for survival tasks

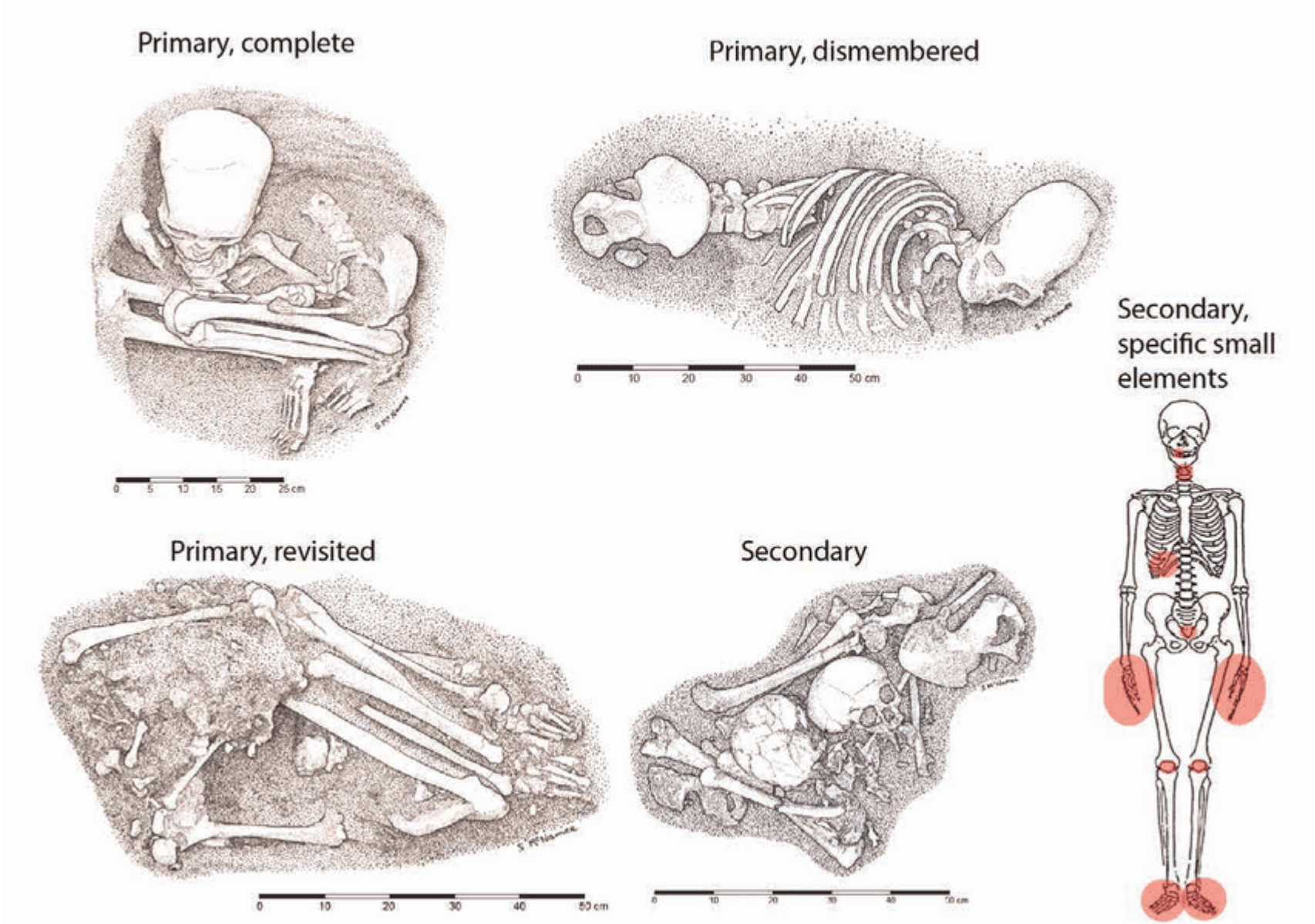
- *Archaeological findings showcase past achievements, they do not provide insight into the toll these endeavors took on past communities or specific segments within them.*



- One of the best means to define the organizational structure of past societies is through a combination of skeletal & archaeological data

perspectives on how general categories of people were regarded in their communities.





Variation and process: the history, current practice and future potential of mortuary archaeology in Aotearoa New Zealand, Hudson 2020

1. Life in past communities

- Recently, bioarchaeologists increasingly focused on group & individual identities, as reconstructed from skeletal remains & contextual information to understand how people experienced their lives

This work owes much to

- Goodenough 1965 explained how individuals have various identities, and only certain ones become relevant in specific situations (e.g. during funerary events). These situationally determined "social personas" are shaped by factors such as age & gender, influencing social relationships.

1. Life in past communities:
sex & gender

- Biological sex can be estimated from adult skeletons only
- An attribution of sex = the observed morphological characteristics conform to a greater or lesser degree to those expected of M or F = inherently probabilistic statement
- The biological & social components of gender are receiving increasing attention in anthropology.

1. Life in past communities:
sex & gender

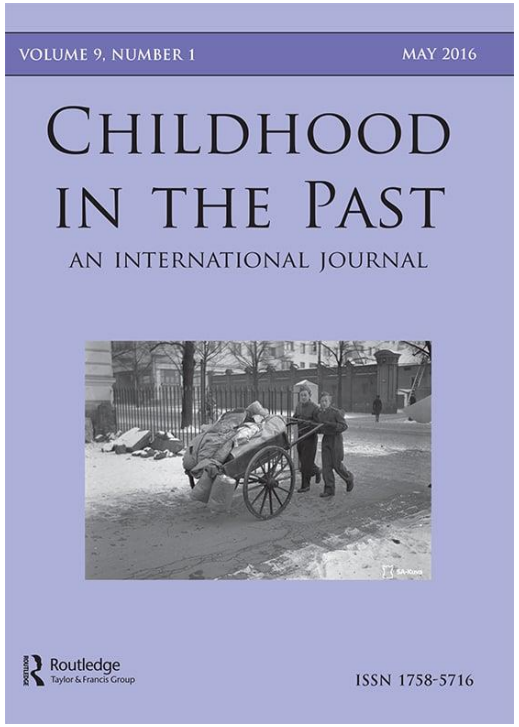
- It requires examining both bones + other data (grave form, burial accompaniments, garments).
- That work is necessarily undertaken on a case-by-case basis, so however much it tells us about life in the past these individual-oriented analyses are not susceptible to quantitative analyses of numerous individuals, the basis of paleodemographic investigations.

1. Life in past communities:
The social significance of age

- The social significance of age is more amenable to paleodemographic studies.
- The familiar distinction between biological and chronological age is augmented by evidence for the roles that people adopted, as well as how they were perceived and treated by others
- Social age analysis requires both skeletal and contextual data.
- Paleodemography uses quantitative analyses on large skeletal samples for studying social age.
- Neolithic Europe shows identifiable subadult stages, such as "middle childhood" based on individual traits (Bickle & Fibiger, 2014).

1. Life in past communities: The social significance of age

- In a late prehistoric American midcontinent village, late teens assumed adult roles (Milner et al., 1991).



1. Life in past communities
The social significance of age

- People were ambushed like older individuals, possibly during tasks exposing them to danger.
- The transition to adulthood is inferred from a higher risk of death by enemies, similar to the concept of legal age in modern investigations.
- While social age enhances community studies, its exploration requires archaeological details beyond bones alone.

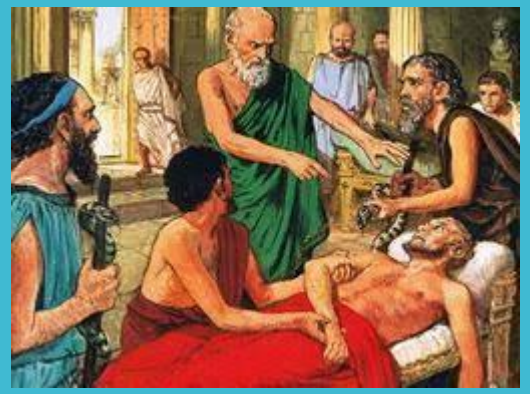
2. Life histories

- Understanding the probabilities of death in past populations, derived from archaeological samples, is crucial for grasping historical changes in human lives.

- This data helps analyze:

1. age-specific mortality,
2. gender differences,
3. human longevity compared to nonhuman primates.

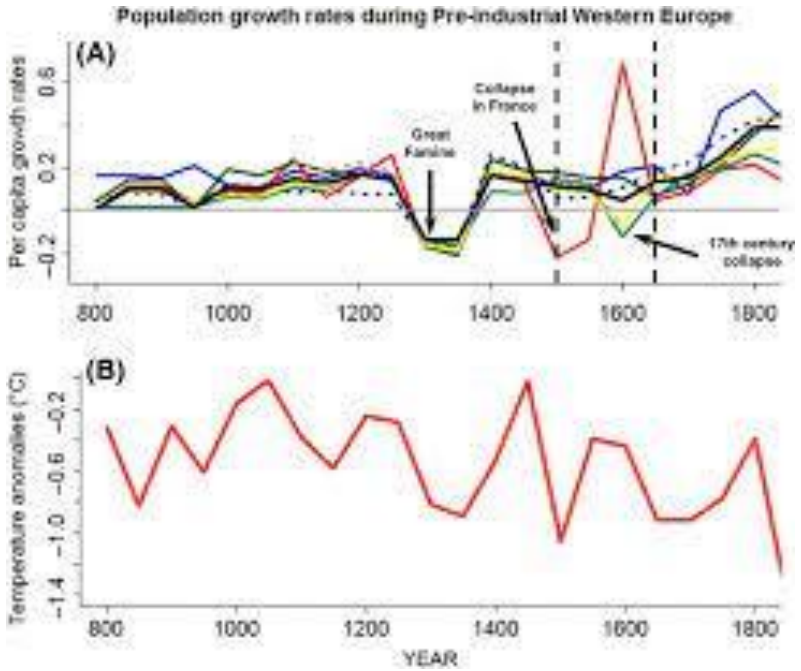
2. Life histories

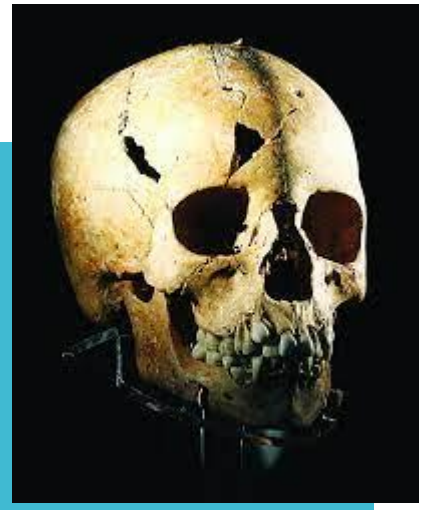


- Improved public health & medicine have contributed to longer life expectancies, and genetics play a role, with about a quarter of lifespan variance explained by genetics.
- Skeletal age estimates from archaeological samples are vital for studying past lifespans.

2. Life histories

- Unfortunately, we lack a clear picture of historical lifespans, and determining trends like a deceleration in the risk of dying among the elderly in preindustrial populations requires more extensive data.





3. Disease experience

- Understanding a community's past involves considering trauma & disease, combining evidence like skeletal remains.
- Age and sex details are crucial for estimating the impact of adverse conditions on communities.
- Paleoepidemiology goes beyond counting bones, quantitatively analyzing risk indicators, including skeletal or dental lesions, sex, stature, and age at death.

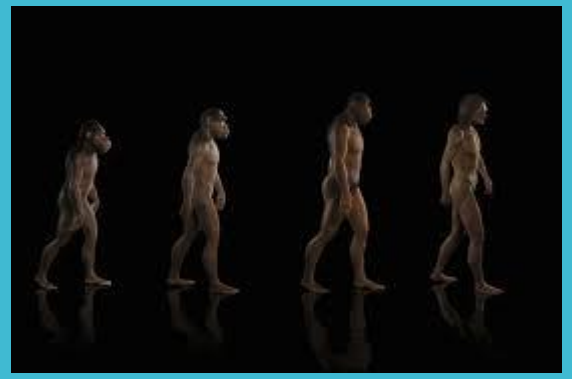
4. Migration

- Population movement in archaeology has a complex history, once seen as a key factor but later dismissed by New Archaeology.
- Recently, there's a renewed interest in understanding the role of population mobility in societal changes.
- Archaeological studies now focus on identifying migrants using biochemical analysis.

4. Migration

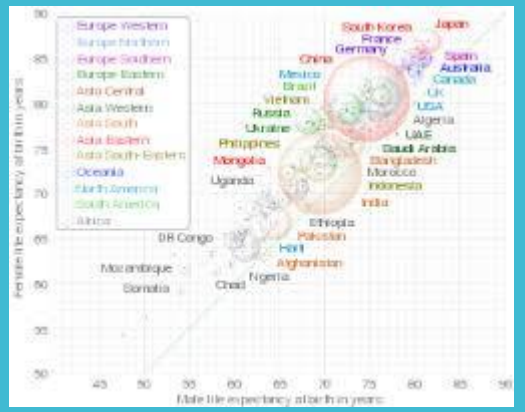
- Analyzing individual life histories with these methods, along with accurate skeletal age estimates, helps estimate migration frequencies on a societal level.
- Modeling the effects of migration on populations is challenging, especially in understanding its impact on both recipient and donor communities.
- The difficulty lies in identifying and quantifying the effects of significant arrivals or departures of people, often dominated by young adults, which remains an unrealized dimension in paleodemographic research.

5. Evolution & the life course

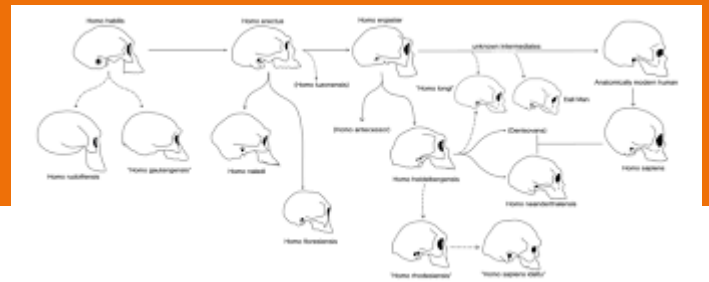


- Understanding human evolution involves examining genetic consequences influenced by demographic processes like fertility, survival, population structure, growth, movement, and interaction.
- Paleodemography, particularly focused on mortality patterns, provides insights into our distant ancestors' lifespans and life-history stages.
- While much research centers on anatomically modern humans from the mid-Holocene onward, studies of Holocene skeletons contribute to knowledge about forces shaping human evolution.

5. Evolution & the life course

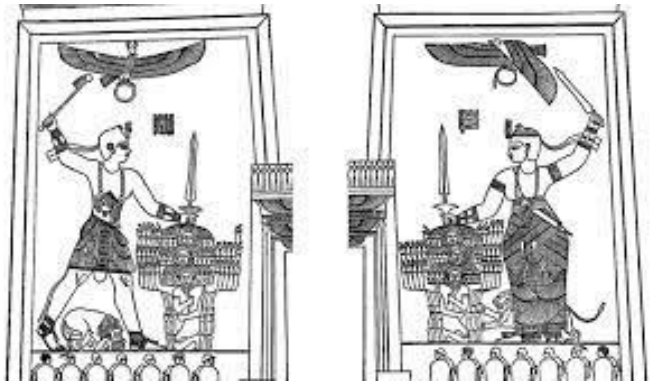


- For instance, the Grandmother Hypothesis suggests that older individuals, particularly women, contributed to the well-being and survival of younger family members.
- However, the reliability of age estimation methods in determining past lifespans remains a challenge in paleodemographic research.



6. Demographic & socioeconomic transitions

- Understanding how we reached our current population involves studying Holocene population growth, especially during shifts to agricultural and complex societal lifestyles.
- Archaeological evidence, including site compilations and radiocarbon dates, is crucial for tracking population changes.
- Skeletal studies play a role in paleodemographic research, offering insights into transitions like the shift to an agricultural way of life.



6. Demographic & socioeconomic transitions

- In regions where food production systems developed independently, a skeletal measure suggests a rapid increase in Neolithic fertility.
- The challenge is to correlate this skeletal indicator with changes in morbidity and mortality through paleodemographic and paleoepidemiological studies.
- The idea of stepwise changes aligns with Wood's model of population growth and production strategy intensification in the preindustrial world.

In the Future

- ✓Application of recently developed methods will hopefully provide insights into the complex relationship between internal and external stimuli and population responses in prehistory.
- ✓One of the greatest challenges for palaeodemography is the inherent lack of verifiability when working with archaeological material.
- ✓As there is no single source of truth, a multifaceted approach to palaeodemography integrating a variety of sources of evidence and relevant theories may improve the precision and accuracy of inferences.
- ✓Such improvements would be mutually beneficial for theory and practice, with improved analyses helping to enhance our understanding of demographic theory in action, and greater theoretical discussion informing inferences derived from holistic practice.