DEMOGRAPHY IN THE CONTEXT OF POPULATION SCIENCES: A HISTORICAL REFLECTION

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Abstract

Demography as a science about populations has developed in a close relationship with other natural and social sciences. The tight relationship of demography to social sciences and statistics is now taken for granted, while the relationship to natural sciences remains underappreciated. This paper aims to search for interdisciplinary connections of demography to natural sciences focused on populations. It starts with an excursion to history and contemplates on the motivation for the historical development of demography in a broader scientific and historical context. Individual topics discusses here include the origins of probabilistic mortality tables and historical personalities of Adolphe Quetelet, Leonard Darwin, and Ronald A. Fisher, where an original application of Fisher factorial test is presented. The connection between the history of demography and eugenics in the first half of the 20th century is also recalled. Finally, the paper continues with a discussion of current relationships of demography with (modern) eugenics or population genetics.

Key words: population, history of demography, statistics, demography and biology, population stability

JEL Code: J19, Z13, N33

Introduction

Demography as an interdisciplinary science devoted to the study of human populations has been from its beginnings related to other scientific disciplines. Great historical personalities who contributed to demography were polyhistors, who were able to excel in several fields of science. Typically, they contributed to other population sciences including as eugenics or population health (Li et al., 2012). Also many of very popular statistical methods were developed as tailor made tools for demographic tasks. Some of the personalities of the history of demography were active also in eugenics, while the connection between demography and eugenics from the first half of the 20th century is now only rarely discussed. The current demography is unimaginable without a close relationship with social sciences and statistical methodology, but other connections are not sufficiently discussed in the recent literature; to be specific, there seems an insufficient discussion about the relationship between demography and biology as pointed out by Carey and Roach (2020).

This paper aims to search for interdisciplinary connections of demography to other disciplines. It starts with an excursion to history and recalls selected great scientists, who contributed to demography (Abraham de Moivre, Adolphe Quetelet, Leonard Darwin, Francis Galton, and Ronald Fisher). Our focus is on documenting that population sciences (and demography in particular) developed in a close relationship with other scientific disciplines, e.g. probability theory and statistics. The paper thus contemplates on the motivation for the historical development of demography in a broader scientific and historical context. Further, a discussion of current issues reveals that also some current results in population sciences follow the ideas and philosophical foundations of its great pioneers and explain why modern demography needs a reflection about its history (Sear, 2021) and contact with the subfields of current biology that are focused on populations (Lowe et al., 2017).

1 Eugenics in the first half of the 20th century

Eugenics was founded by the British polyhistor Francis Galton (1822-1911), a half-cousin of Charles Darwin, as a framework ("superscience") encompassing other scientific disciplines (Langkjær-Bain, 2019). In demography, Galton was interested in population stability, i.e. in stability of demographic variables of the British population across time. Nevertheless, all Galton's scientific endeavors stemmed from his eugenic vision. He also introduced new statistical methods useful for his eugenic ideas.

Galton founded eugenics with the aim to improve (enhance) the human population by focusing on its genetic quality. He strived for more intelligent population with an improved human capital. Eugenics can be described as the science of man stemming from the evolution theory formulated by Charles Darwin (1809-1882) in 1859 in the book "On the Origin of Species". Galton applied darwinistic notions to the human population and founded the field of social darwinism. Eugenics was centered around the concept of population, and although it was also called the Science of Man, its emphasis was laid to the whole population rather than to individual humans. For Galton's statistical thinking, an individual human played the role of a single observation from the population. Galton also founded the Eugenics Education Society and became its first president. He is also known as the main personality in science popularization in the era of Queen Victoria, who reigned between 1837 and 1901. An extensive curriculum vitae of Galton was elaborated by his influential follower Karl Pearson (1857-1936). It was Pearson who laid profound mathematical foundations of modern statistics (Delzell and Poliak, 2013).

2 The work of Leonard Darwin

Eugenics was intensively popularized by Leonard Darwin (1850-1943), a son of Charles Darwin and president of the Eugenic Society in 1911-1928. The aims and ambitions of eugenics are very clearly revealed in the book "What is Eugenics?" written by Leonard Darwin (Darwin, 1929). The book encapsulated his eugenic views on the British (or in fact global) population. Nowadays, the book is difficult to obtain and is often removed from libraries, because it is penetrated by self-evident racism or embarrassing offences against women. Shortly, we can say that the main topic of Darwin (1929) is human reproduction and natality.

Let us now discuss the main ideas from the original book Darwin (1929), which have often been interpreted in a very biased way in later studies. Darwin criticized overpopulation and its negative consequences, because the size of the human population was increasing at that time. He focused on economic issues in much detail and criticized that poor people typically had more children. Darwin was supporting the idea that rich people with good (beneficial) traits should have more children and argued that eugenicists have the ability to save the humankind from poverty.

Darwin was interested not only in a descriptive study of the population size, which is a topic of current demographers, but rather in its control, management, governing, or population control. He advised everyone to think very carefully before making the decision to enter into marriage. He wanted to suppress the reproduction of so-called feeble-minded individuals, whose proportion in the population was at that time increasing, by adopting means for preventing conception. He expected that physicians recommend every individual whether to get married and to have children. If the individual is ill e.g. with tuberculosis or epilepsy, then a physician should give not only a non-binding recommendation, but should be (according to Darwin's opinion) in charge of making the decision and the individual would be required to accept it. Darwin recommends voluntary sterilizations of mentally ill. For feeble-minded, he required at least their sterilizations (even without their agreement), but would rather prefer their lifelong isolation and segregation.

Darwin deduced that the state should not allow unlimited reproduction and suggested every British patriot to have at least 4 children. He was thinking about scientific implementations of his ideas about selective reproduction (in fact controlled breeding) of humans with better biological properties. He also claimed that the worst crime of criminals was their having children. At the same time, he demanded to regulate also sexual orientation. Further, the ideas of Darwin (1929) include a desire to control the struggle for existence (natural selection), which takes place (according to his opinion) in the human population. He wanted the state to have this under control, which explains the intensive political ambitions of eugenicists for reforming the whole society. He strived for power for "intellectually superior" individuals and perceived eugenics as an alternative to all existing religions. While he proposed political reforms improving the positive support of family in the society, he wanted to eliminate negative influences in the population. Particularly, he wanted to suppress (using Darwin's terminology) criminals, feeble-minded, physically or mentally handicapped, deaf, or blind individuals. In the book, however, there are no statistical arguments in favor of eugenics; Darwin's justification of his ideas is very subjective void of scientific arguments.

3 Ronald A. Fisher and population genetics

Ronald A. Fisher (1890-1962) was a British polyhistor, who greatly influenced eugenics, statistics and biology including population genetics and evolution theory (biological synthesis). Fisher was interested in studying hereditary principles related to marriages, fertility, migration, mortality, or morbidity, which are topics commonly studied by demographers. He also contributed to the coalescent theory focused on tracing the genes back in time; the process nowadays known as the Wright-Fisher model allows to study the demographic history of a population in terms of sizes and numbers of subpopulations or migration rates between subpopulations (de Vries and Caswell, 2019). Fisher was also interested in population stability (just like Galton), i.e. stability of demographic parameters in population models across time. Fisher contributed to the foundations of population genetics with a eugenic motivation. He was applying the concepts of selection, gene dominance, and degeneration to the human population. Population genetics, which historically stems from the eugenic ideology, is devoted to the study of genetic diversity within a given population. Demographic data represent the basic element of population genetics for reconstructing the demographic history of populations.

Fisher as the father of biostatistics served as the president of Royal Statistical Society in 1952-1954; he greatly contributed to the development of multivariate statistics, theory of point estimation, and classification and discrimination (Kalina, 2012). The ideas can be described as the basis of current analysis of data even in the context of molecular genetics and bioinformatics (Kalina, 2018). Fisher also laid foundations of statistical design of experiments; in this field, he admitted to be much influenced by the heredity experiments of Gregor Mendel. In addition, Fisher contributed to statistical tools for evaluating contingency tables; contingency was understood as a phenomenon in evolution theory describing randomness, uncertainty, or unpredictable effects influencing the whole population concurrently. The concept of contingency table then remained in statistics as one of fundamental concepts with a biological name. Fisher much contributed to the theory of hypothesis tests by proposing permutation-based procedures. It is worth noting that hypothesis testing in the current form reflects the eugenic aim to make inference for the whole population: the test makes induction of the information from the observed data to the whole (unknown, unobserved) population.

3.1 Exploiting Fisher factorial test in population genetics

It is possible to consider a formal hypothesis test of the Hardy-Weinberg equilibrium in the form of the (exact) Fisher factorial test. Originally, R.A. Fisher proposed this test to check independence or homogenity in $2x2$ contingency tables. It may also be used for testing the Hardy-Weinberg equilibrium, which can be described as the basic law or principle of population genetics. We say that a particular gene fulfils the Hardy-Weinberg equilibrium (or Hardy-Weinberg law), if its individual forms remain to have stable proportions in the population across generations. Thus, the law describes an equilibrium state in the genetic information across the whole population. Recently, various extensions allowing to combine the Hardy-Weinberg equilibrium with demographic history have been available; an example is the study of Choi and Hey (2011), who proposed a sophisticated method for assigning individuals to populations using both genetic and demographic parameters.

The equilibrium will be now understood as the null hypothesis, which is either rejected or not rejected by means of Fisher factorial test. Let us denote two versions (alleles) of the considered particular gene by A and a. Each individual inherits one allele from the mother and one from the father. Thus, each individual has one of possible genotypes AA, Aa, or aa. The probability of the occurrence of the allele A (i.e. expected probability in the population) will be denoted as p with the requirement $0 < p < 1$. Probability of the allele a is then $1 - p$. The Hardy-Weinberg equilibrium corresponds to the null hypothesis that the alleles are inherited randomly and independently; the independence means that the allele from the father does not depend on the allele from the mother. Under such model, probability of the genotype AA equals p^2, probability of Aa equals $2p(1 - p)$, and probability of aa is thus the remaining quantity $(1 - p)^2$.

Let us consider a random sample of individuals from the considered population. The notation n_{AA} for the number of individuals with the genotype AA will be introduced. In the same spirit, n_{Aa} denotes the number of individuals with Aa, and n_{aa} the number of individuals with aa. Let the counts of individual alles in the population be denoted by n_A and n_a. It holds that $n_A = 2n_{AA} + n_{Aa}$. Let us further denote $n = n_{AA} + n_{Aa} + n_{aa}$. We may consider the two by two contingency table with counts of individuals according to their genotype. This contingency table is shown here in the form of Table 1. It contains the count n_{21} of individuals, who inherit the allele A from the father and the allele a from the mother. This count cannot be distinguished from the count n_{12} of individuals, who inherit a from the father and A from the mother and only the sum of these two counts $n_{Aa} = n_{21} + n_{12}$ is known in practice.

Tab. 1: Contingency table of countes using the notation presented in Section 5.1

		Allele from the father	
		A	a
Allele from the mother	A	n_{AA}	n_{12}
	a	n_{21}	n_{aa}

Source: own considerations

Fisher factorial test is evaluated as the probability (likelihood) of the observed table of counts under the condition that the marginal counts (i.e. the row and column totals) are fixed. Such approach is based on computing the conditional probability for the occurrence of the genotype Aa, given the fixed values of n_A and $n_a = n - n_A$. The observed count n_{Aa} will be now understood as a realization of the random variable N_{Aa} corresponding to the population (expected) count of the genotype Aa. We may express the conditional probability

$$P(N_{aa} = n_{Aa}) = P(N_{12} + N_{21} = n_{Aa}/n_A, n_a) = \sum_j P(N_{12} = j, N_{21} = n_{Aa} - j/n_A, n_a) \tag{1}$$

to obtain the final form

$$P(N_{aa} = n_{Aa}) = \frac{n!}{n_{AA}!n_{Aa}!n_{aa}!} 2^{n_{Aa}} / \binom{2n}{n_A}, \tag{2}$$

which is evaluated conditioning on fixed values of the constants n_A and n_a. The test of the Hardy-Weinberg equilibrium for the given gene rejects the null hypothesis, if the conditional probability $P(N_{Aa} \geq n_{Aa}/n_A, n_a)$ obtained by adding individual probabilities (2) exceeds the chosen level $\alpha = 0.05$.

4 Current demography in relationship with biological population sciences

4.1 Demography and eugenics

To discuss the relationship between current demography and eugenic ideas, it is necessary to start by admitting that the development of demography was heavily influenced by eugenics of the first half of the 20th century. However, this historical influence of eugenics on the development of demography is now very underappreciated and basically neglected in current demographic literature (Sear, 2021). Demography as a science was rebuilt after 1945 as free of the historical links to eugenics.

The new eugenics of the 21st century, which claims to be independent of the historical unscientific eugenics, is focused on ethically controversial issues (not only) on the intersection with demography; these include overpopulation and population control movement, aiming at influencing (mainly reducing) the size of the population by individual countries. Other topics include improving the genetic health of the population e.g. by detection of Down syndrome in fetuses. A particular example of research related to modern eugenics is the study of Ronda et al. (2022), who investigated the genotypes of children with disadvantages in terms of childhood environment, parental human capital, family stability, or parental mental health. The paper claimed that human capital formation heavily depends on genetic influences (pre-disposition). In other words, members of the youngest generation require healthy genes in order to have a higher human capital. We can describe such stance as an echo of Galton's vision of eugenics.

Recently, we can experience a new resurgence of eugenic movement supported by an insignificant part of demographers. Sear (2021) claimed that eugenicists in the second half of the 20th century misused demography by their stimulations to intensive collecting demographic data and to research related to family planning. The solution to prevent from such misuse is to strive for quality of demographic research, for example by using reliable statistical methodology for analyzing demographic models.

4.2 Demography and population genetics

Current population genetics is interested also in demographic variables such as population size, population density, population connectivity, or finding explanations for historical processes that led to the formation of the current population. Unlike demography, population genetics approaches these topics from the genetic point of view. Li et al. (2012) overviewed the contribution of demography and evolutionary biology to the population genetic parameters and particularly focused on the interaction between demography and evolution of gene variants (gene selection). More recently, Lowe et al. (2017) described the trend in population genetics to enrich the study of the population genome also by the influence of the environment (interactions within the community, ecological processes). Recent applications showed that population genetics models (e.g. based on game theory, dynamic systems, or evolutionary programming) may be successfully applied also to economic applications, e.g. to investment strategies (Orr, 2018).

While it has been acknowledged that current research in genetics often fails to consider the context of demographic processes (Lowe et al., 2017), it is the field of population genetics, where the formation of the human genome is investigated on the level of population processes. Thus, we can characterize population genetics as a framework for integrating genetic and demographic information. Recent results in molecular genetics were able to reshape the field of population genetics to a great extent; such new research trends exploit the results of the first mapping of the human genome (in 2003) and especially of the complete sequencing of the human genome, which was finally finished in 2022.

Conclusion

The aim of this paper was to find interesting connections relating the historical development of demography to other scientific disciplines. Demography heavily relies on statistical methods and this paper recalls that statistics overtakes some important demographic (or in fact originally eugenic) concepts. Still, the connections of demography to other disciplines require a revival (Sear, 2021). We understand the population to be the main concept of demographics; however, in the first half of the 20th century, population was the main concept of eugenics. Also population genetics is discussed in this paper as one of population sciences focused on the (genetic) study of populations.

The historical excursion of this paper reveals that demographers and statisticians of the past were not primarily interested in probabilistic models and numbers as such. Instead, their primary interest was the humankind and the human population. We consider the aims of eugenicists from the first half of the 20th century unacceptable and it is not possible to separate their positive efforts from the negative purposes. Eugenics was also misused for justifying the Nazi terror in the second world war. As the discussions of this paper deserve to be much broader and deeper, it remains for future (philosophical, economic, scientific, and moral) discussions whether and how (using morally acceptable tools) to strive for better genetic health of the population with the aim to improve its aggregate human capital.

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