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The Emergence and Historical Development of Statistics

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Abstract

This article analyzes the development of statistics from the practice of state record-keeping in ancient times to modern data science. The study is based on historical-comparative analysis, comparison of sources, and chronological systematization. It examines population censuses in ancient and medieval periods; the formation of scientific schools in the seventeenth and eighteenth centuries (state studies, political arithmetic, and probability theory); the introduction of mathematical foundations in the nineteenth and twentieth centuries; and modern trends in the age of computing technology. The contributions of scholars such as Graunt, Galton, Pearson, Fisher, and Kolmogorov are analyzed, together with the emergence of sampling methods, bootstrap and MCMC methods, and the development of statistics in Central Asia and Uzbekistan. The findings show that statistical methods developed in response to practical needs through the integration of probability theory and the practice of mass observation, while data quality and sampling procedures determine the reliability of conclusions.

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Introduction

Statistics is a science and a field of practical activity that studies the quantitative regularities of mass phenomena in society and nature. The term "statistics" derives from the Latin "status," meaning condition or state, and was initially used to describe the condition of the state [1]. The history of statistics consists of the convergence of three main strands: the practice of state record-keeping, the quantitative study of population and economic phenomena, and probability theory. The purpose of this article is to present the historical development of these strands in chronological order.

Today, almost all areas of decision-making (the economy, healthcare, education, sociology, and technology) rely on statistical data and methods. Therefore, understanding how statistics emerged and which historical needs gave rise to its concepts and methods helps us correctly assess the current capabilities and limitations of the discipline [2].

The aim of the study is to provide a systematic account of the main stages in the emergence and development of statistics. To achieve this aim, the following objectives were set: 1. To examine the initial forms of state record-keeping; 2. To analyze the formation of statistical schools in the seventeenth and eighteenth centuries; 3. To identify the introduction of mathematical foundations in the nineteenth and twentieth centuries; 4. To highlight the main trends of the modern period [3], [4].

Methodology

The article employs historical-comparative analysis, comparison of sources, and chronological systematization. Fundamental studies devoted to the history of statistics served as the principal basis.

Results

The roots of statistics can be traced to the needs of public administration. Traditionally, the counting of populations, property, and troops in Ancient Egypt, Babylon, China, and India was used for tax collection and military mobilization. In Ancient Rome, regular population registration served as a means of determining citizens' property status and their eligibility for military service [5].

Such records continued in the Middle Ages. One of the best-known examples is the "Domesday Book," a land and property survey compiled in England in 1086 by order of William I. In the East, tax and land records were maintained through the divan administrative system. In India, the "Ain-i-Akbari," compiled by Abul Fazl during the reign of Akbar, is mentioned as a work containing extensive information about the empire's population, lands, and revenues. However, during this period statistics

was not yet an independent science, but rather an auxiliary instrument of governance [6].

Sources indicate that a census conducted in China during the Han dynasty in 2 CE recorded approximately 57–58 million people; this is considered one of the largest enumerations in the ancient world [7], [8]. Historical sources also indicate that population and property were regularly recorded in Egypt for tax collection and the mobilization of labor for construction projects. Such censuses generally took the form of complete enumeration; the sampling approach was not yet known.

In Rome, a census was conducted every few years; citizens were classified according to the amount of property they owned, which determined the extent of their tax and military obligations. The Roman ruler Augustus included the results of citizen censuses in the record of his achievements. Thus, record-keeping initially arose from the direct practical needs of the state [9].

Eastern scholars also contributed to the development of quantitative methods. Al-Kindi described a method of analyzing the frequency of letter occurrence to decipher encrypted texts, which is considered one of the earliest examples of frequency analysis [10]. In his work "Muqaddimah," Ibn Khaldun emphasized the need to study regularities in social phenomena and drew attention to the relationship between state power, population size, and tax revenues. The results of extensive astronomical observations conducted at the observatory of Mirzo Ulugbek in the fifteenth century were compiled into tables, providing a clear example of the systematic collection of quantitative data. The "Ain-i-Akbari," compiled in India during Akbar's reign, is also regarded as a major example of state record-keeping [11].

Table 1. State Record-Keeping Practices in Ancient and Medieval Periods

Region and period	Object of enumeration	Main purpose	Characteristics
Egypt, Babylon, China, India (ancient period)	Population, property, army	Tax collection, military mobilization	Complete enumeration; sampling approach was not known
Han China (2 CE)	Population	Needs of state administration	Approximately 57–58 million people were recorded
Ancient Rome	Citizens and their property	Determining the extent of tax and military obligations	A census was conducted every few years; classification by property

England (1086)	Land and property	Keeping land records by order of William I	The "Domesday Book" land register
India (reign of Akbar)	Population, land, revenue	Compiling the resources of the empire	Abul Fazl's "Ain-i-Akbari"

In conclusion, statistics existed as a practical activity in ancient and medieval times, but it lacked theoretical foundations aimed at identifying general regularities. This gap began to be filled from the seventeenth century onward [12].

Three branches of statistics took shape in the seventeenth and eighteenth centuries. Hermann Conring, a scholar from Helmstedt, delivered a course describing states and laid the foundations for this field. In 1749, Gottfried Achenwall introduced the term "Statistik" into scholarly usage. This school primarily described the characteristics of a state (population, territory, administration, and economy) in words and relied less on numerical data [13].

In 1662, John Graunt identified patterns in the natural movement of the population based on London's Bills of Mortality, including the stable ratio of male and female births and causes of death [14]. His work is considered the beginning of demographic statistics. William Petty advocated expressing economic phenomena in terms of "number, weight, and measure" and wrote "Political Arithmetick" [15]. In 1693, Edmund Halley compiled a mortality table and laid the foundations for calculating life expectancy. Johann Peter Süssmilch systematically studied regularities in births, marriages, and deaths in his work "The Divine Order" [16]. Probability theory also developed during this period: the correspondence between Pascal and Fermat, and Jacob Bernoulli's work "The Art of Conjecturing," in which an early form of the law of large numbers was proved [17].

State scholars sought to answer the question "How is the state organized?", whereas political arithmeticians sought answers to "How many?" and "In what proportion?" Initially, statistics was mainly concerned with describing the state, and numbers were of secondary importance. From the late eighteenth to the early nineteenth century, the descriptive approach gradually gave way to quantitative analysis: government agencies made the preparation of tables on taxation, trade, and population a routine practice [18], [19]. Süssmilch combined the two approaches, attempting to identify natural order through numbers, and thus paved the way for the convergence of statistics with its probability-based branch [20], [21].

By analyzing London's Bills of Mortality, Graunt found that slightly more boys than girls were born,

showed that deaths in the city were offset by population migration, and compared the proportions of deaths by disease [22], [23]. Halley, in turn, compiled a mortality table based on data from the city of Breslau (modern-day Wrocław) and demonstrated that it could be used to calculate life insurance and annuity prices [24]. These studies practically demonstrated that statistical regularities could be identified through mass observation.

Questions related to gambling led to correspondence between Pascal and Fermat in 1654; Huygens published the first treatise on this subject in 1657, while De Moivre published a result in 1733 on approximating the binomial distribution using the normal curve [25]. These ideas later became tools for quantitatively assessing random variability.

The differences among the three branches that emerged in the seventeenth and eighteenth centuries are presented in Table 2.

Table 2. Formation of Statistical Schools in the Seventeenth and Eighteenth Centuries

Branch	Main representatives	Main idea	Outcome
State studies	H. Conring, G. Achenwall (term introduced in 1749)	Describing the characteristics of the state mainly in words	Numbers were secondary; the term "statistics" entered scholarly usage
Political arithmetic	J. Graunt (1662), W. Petty, E. Halley (1693), J. P. Süssmilch	Expressing population and economic phenomena numerically	Beginning of demographic statistics; mortality table; regularities in births and deaths
Probability theory	B. Pascal and P. Fermat (1654), C. Huygens (1657), J. Bernoulli, A. de Moivre (1733)	Moving from gambling problems to the quantitative assessment of randomness	Early form of the law of large numbers; approximation of the binomial distribution by the normal curve

In the nineteenth century, statistics began to develop into a science combining the study of mass data with probability theory. Laplace and Gauss developed the theory of errors and the method of least squares Legendre published this method in 1805 [26], [27]. The Belgian scholar Adolphe Quetelet applied probability theory to social phenomena, introduced the concept of the "average man," and advanced the idea of "social physics" [28]. At his initiative, the first International Statistical Congress was held in Brussels in 1853. Statistical organizations also emerged during this period: for example, the Statistical Society was established in London in 1834, while official statistical services and regular population censuses became institutionalized [29].

Francis Galton developed the ideas of regression and correlation on the basis of biological data. Karl Pearson subsequently developed these ideas mathematically.

In 1886, Galton analyzed the relationship between the heights of parents and their children and identified the phenomenon of "regression toward the mean" [30]. In 1896, Pearson established the modern formula for the correlation coefficient, while Yule developed the concepts of partial correlation and multiple regression in 1897 [31].

In the nineteenth century, regular population censuses began to be conducted in major countries: in the United States, censuses were held every ten years from 1790, and in Great Britain from 1801; in the Russian Empire, a single general census was conducted in 1897, also covering the Turkestan region [32]. The International Statistical Institute was established in 1885 and contributed to the development of unified classifications and methodologies for comparing data.

Population growth made manual data processing increasingly difficult. The 1890 United States census used punched-card tabulating machines developed by Herman Hollerith, significantly reducing processing time [33]. The computing technology industry later developed from this line of innovation.

In his 1786 atlas, William Playfair used line and bar charts and later also proposed the pie chart. During the Crimean War, Florence Nightingale prepared polar-area diagrams showing causes of death and demonstrated the impact of data on practical decision-making. In 1854, John Snow mapped cholera cases in London, helping identify the source of the disease. These examples proved that data visualization is also an integral part of analysis.

At the end of the nineteenth century, the high cost of complete censuses led to the idea of observing only a part of the population. In 1895, Anders Kiaer, head of the Norwegian statistical service, proposed the "representative" method at the International Statistical Institute. In 1906, Arthur Bowley presented the theoretical foundations of random sampling, and in 1934 Neyman strengthened the theory of stratified

sampling and inference based on samples.

The chronology of major organizational and scientific innovations in the nineteenth century is presented in Table 3.

Table 3. Institutional and Mathematical Foundations of Statistics in the Nineteenth Century

Year	Scholar or organization	Contribution	Field
1786	W. Playfair	Used line and bar charts in an atlas	Data visualization
1805	A. Legendre	The method of least squares was published	Mathematical foundations
1834	Statistical Society of London	Emergence of statistical organizations	Organization
1853	At the initiative of A. Quetelet (Brussels)	First International Statistical Congress	Organization
1854	J. Snow	Mapped cholera cases and identified the outbreak source	Data visualization
1885	International Statistical Institute	Contributed to the development of unified classifications and methodologies	Organization
1886	F. Galton	"Regression toward the mean," illustrated by the heights of parents and children	Regression
1890	H. Hollerith	Punched-card tabulating machines were used in the U.S. census	Computing technology
1895	A. Kiaer	The "representative" method was proposed	Sampling method
1896–1897	K. Pearson, G. Yule	Correlation coefficient; partial correlation and multiple regression	Mathematical foundations
1897	Russian Empire	A single general census (including the Turkestan region)	Population census

At the beginning of the twentieth century, statistics became firmly established as a discipline based on the theory of statistical inference:

- In 1900, Pearson proposed the chi-square test; in 1901, the journal "Biometrika" was established.
- In 1908, William Gosset (under the pseudonym "Student") published the t-distribution for small samples.
- Ronald Fisher developed analysis of variance, experimental design, and the maximum likelihood method; in 1925, he published the book "Statistical Methods for Research Workers."
- In 1933, Neyman and E. Pearson developed the theory of statistical hypothesis testing.
- In the same year, A. N. Kolmogorov set out the axiomatic foundations of probability theory and established a rigorous mathematical basis for the theory.

The Russian school (Chebyshev, Markov, and Lyapunov) made a major contribution to the development of probability theory and mathematical statistics through its work on limit theorems. Sampling methods also became widespread in official statistics.

Working at the Rothamsted Experimental Station, Fisher established the principles of agricultural experimental design (randomization, replication, and blocking) and introduced analysis of variance into practice. In his 1922 work, he clearly defined the main concepts of statistical inference (sufficiency, efficiency, and likelihood), and in 1935 he published the book "The Design of Experiments."

During the 1920s and 1930s, heated debates took place between the schools of Fisher and Neyman and E. Pearson concerning p-values and decision-making approaches. At the same time, the Bayesian approach also developed: Jeffreys published "Theory of Probability" in 1939, while de Finetti and, later, Savage established the idea of subjective probability. As a result, several approaches coexisted within statistics, a situation that continues to this day.

In 1936, the magazine "Literary Digest" incorrectly predicted the outcome of the U.S. presidential election: despite receiving millions of responses, its sample was not representative of the population. Gallup made a more accurate prediction using a much smaller but properly designed sample. This event demonstrated that the sampling procedure, rather than sample size, is crucial.

During the Second World War, Abraham Wald developed the sequential analysis method. In 1950, he published "Statistical Decision Functions," linking statistical inference with the concepts of loss and risk. This approach was widely applied in industrial quality control and the design of medical trials.

In 1933, Kolmogorov proposed a test for comparing empirical and theoretical distributions; later, N. V. Smirnov developed its application to two samples. Thus, the method known as the Kolmogorov–Smirnov test emerged. Alongside theoretical developments, statistics was widely used in census-taking

and planning systems during the Soviet period.

The main results of the first half of the twentieth century are systematized in Table 4.

Table 4. Consolidation of Mathematical Statistics in the First Half of the Twentieth Century

Year	Scholar	Result	Field
1900	K. Pearson	Chi-square test	Goodness-of-fit tests
1906	A. Bowley	Theoretical foundations of random sampling	Sampling method
1908	W. Gosset ("Student")	t-distribution for small samples	Statistical inference
1922–1935	R. Fisher	Sufficiency, efficiency, likelihood; analysis of variance; experimental design	Inference and experimentation
1933	J. Neyman, E. Pearson	Theory of statistical hypothesis testing	Hypothesis testing
1933	A. N. Kolmogorov	Axiomatic foundations of probability theory; test for comparing distributions	Foundations of probability
1934	J. Neyman	Stratified sampling and sample-based inference	Sampling method
1936	Gallup and "Literary Digest"	A large but unrepresentative sample led to an incorrect prediction	Sampling procedure
1939	H. Jeffreys	"Theory of Probability," advancing the Bayesian approach	Bayesian approach
1950	A. Wald	Linking inference with the concepts of loss and risk	Decision theory

From the second half of the twentieth century onward, computers dramatically expanded the possibilities of statistical computation. In 1977, John Tukey formalized the field of exploratory data analysis. The Bayesian approach (whose foundations were laid in Bayes's work in 1763 and further

developed by Laplace) began to be widely used in practice again with the emergence of computational tools. Today, statistics is developing in close connection with machine learning, big data, and artificial intelligence.

From the 1970s onward, computers took analysis beyond the limitations of exact formulas. In 1979, Bradley Efron proposed the bootstrap method, which assesses statistical variability by repeatedly resampling from an existing sample. During this period, generalized linear models, Cox regression, and the EM algorithm also entered practical use.

In 1990, Gelfand and Smith introduced Markov chain Monte Carlo (MCMC) methods widely to the statistical community. These methods made it possible to compute complex Bayesian models in practice and led to a revival of the approach.

Packages such as SAS and SPSS made statistical analysis accessible to a broad audience. The R programming language, created in the 1990s, was distributed as open-source software and began to be widely used in academic practice. As a result, the use of complex methods was no longer limited to specialists.

As early as 1962, Tukey had argued that data analysis should be regarded as a separate discipline. In 2001, Breiman emphasized the existence of two "cultures" in statistical modeling: an approach that models the mechanism generating the data, and an algorithmic approach focused on prediction. Modern data science seeks to combine these two approaches.

The United Nations Statistical Commission was established in 1947. In 1994, it adopted the Fundamental Principles of Official Statistics, which were endorsed by the United Nations General Assembly in 2014. These principles require objectivity, professional independence, confidentiality, and openness in the production of data.

Changes during the era of computing technology and international principles are shown in Table 5.

Table 5. Development of Statistics in the Era of Computing Technology and International Principles

Year	Scholar or organization	Essence	Field
1947	UN Statistical Commission	An organization was established to coordinate official statistics internationally	Organization
1962, 1977	J. Tukey	Treating data analysis as a separate discipline; exploratory	Data analysis

		data analysis (EDA)	
1979	B. Efron	Bootstrap: assessing variability through resampling	Computational methods
1990	A. Gelfand, A. Smith	MCMC methods made it possible to compute complex Bayesian models	Computational methods
1990s	R language, SAS, SPSS	Complex methods became accessible to a wide audience	Software tools
1994, 2014	United Nations	Principles of official statistics were adopted and endorsed by the General Assembly	Normative framework
2001	L. Breiman	Two approaches in modeling: data-generating mechanism and prediction algorithm	Methodology

In Central Asia, modern-type statistics began to take shape during the period of the Russian Empire: the general census of 1897 also covered the Turkestan region. During the Soviet period, population censuses were conducted in 1926, 1939, 1959, 1970, 1979, and 1989, while the results of the 1937 census were annulled.

From a scholarly perspective, Tashkent played an important role in the development of mathematical statistics. V. I. Romanovsky worked in Tashkent and established a scientific school in probability theory and mathematical statistics; his students included scholars such as T. A. Sarimsoqov and S. Kh. Sirojiddinov.

During the years of independence, official statistics in Uzbekistan have been adapted to international standards, with United Nations principles and international classifications serving as the basis. It would be appropriate to supplement this section with local official publications (annual collections issued by statistical authorities) and studies by Uzbek researchers.

The above findings are summarized by period in Table 6.

Table 6. Main Periods in the Development of Statistics (Summary)

Period	Chronology	Main driving force	Leading methods and

			ideas
Practice of state record-keeping	Ancient and medieval periods	Taxation, military records, land and property records	Complete enumeration and censuses; no theory seeking general regularities
Separation of scientific branches	Seventeenth–eighteenth centuries	Description of the state, study of population dynamics, gambling problems	State studies, political arithmetic, probability theory
Mathematical statistics and the age of computing	From the nineteenth century to the present	Mass censuses, biology, agriculture, industry, medicine, computers	Correlation, sampling, hypotheses, analysis of variance, axiomatic foundations, bootstrap, MCMC

Discussion

The historical analysis reveals several general patterns. First, statistical methods developed in response to practical needs: tax and military records gave rise to demography; life insurance stimulated probability calculations; agricultural experiments led to analysis of variance; and industry and medicine generated sampling and decision theories [34]. Second, every major advance resulted from the convergence of probability theory and the practice of mass observation. Third, progress in computing technology (from Hollerith machines to modern computers) has repeatedly expanded the capabilities of statistics.

At the same time, history also demonstrates the risks of misusing statistical methods: the 1936 election prediction proved that data quality and sampling procedures, rather than data volume, are decisive. In the future, the task of statistics will be to ensure the reliability, transparency, and objectivity of conclusions in the age of big data and artificial intelligence [35], [36].

Conclusion

The history of statistics can be viewed in three stages: the practice of state record-keeping; its division into scientific branches in the seventeenth and eighteenth centuries; and its convergence with probability theory and transformation into mathematical statistics in the nineteenth and twentieth centuries. Today, statistics is one of the principal tools for decision-making in economics, medicine, science, and public administration.

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