

EDUCATIONAL STANDARDS OF A NEW MASTER'S DEGREE PROGRAM IN BIostatISTICS

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Abstract. *This work presents the educational standards of an interdisciplinary master's degree program in Biostatistics. The education in it is carried out jointly by University of Plovdiv Paisii Hilendarski and Medical University of Plovdiv. The aim is to educate highly qualified specialists in Biostatistics (Biometrics). Students acquire knowledge in modern aspects of the theory of the specialty, as well as practical skills for conducting relevant statistical studies. This pioneering program for the country is designed to meet the growing needs of biostatistics professionals to integrate into teams for modeling and analyzing processes and phenomena in the field of natural sciences for living systems and medicine. In this paper, general characteristics of the specialty, specific knowledge and skills, and possibilities of professional realization by its graduates are described.*

Key words: Biostatistics, Master's degree, University education, Educational standards.

Mathematics Subject Classification: 97B70, 97M10, 97M60

1. Introduction

According to the definition given by the International Biometric Society (IBS): “Biostatistics is mainly concerned with the development, implementation and application of statistical methods in the field of medical research.” (see [1, 2]).

According to leading research: “Unlike the clearly defined steps in a physician's education and professional career, there is no unique way to prepare a biostatistician. Very few universities really offer education in Biostatistics (Biometrics), so most people working as biostatisticians have studied something related, majors like mathematics or statistics, or applied subjects like Medicine, Psychology or Biology.” (see [3]).

The IBS defines Biostatistics (Biometrics) as “the field of develop-

ment of statistical and mathematical methods applicable in the biological sciences” [1]. In the considered specialty we focus on (human) medicine as an application area among the biological sciences.

According to the German Association for Medical Informatics, Biometrics and Epidemiology (GMDS): “Medical Biostatistics develops, implements and uses statistical and mathematical methods to enable the acquisition of knowledge from medical data.”; “Results are available to individual medical disciplines and to the public through statistically valid interpretations and appropriate presentations” and “Biostatisticians work in the areas of: clinical trials; systematic reviews and meta-analysis; observational and complex interventional studies; statistical genetics.” (see [1]).

The Master’s degree program in the specialty “Biostatistics” is part of the area of higher education 4. Natural Sciences, Mathematics and Informatics, professional field 4.5. Mathematics. The duration of the educational process is 4 semesters divided into 2 academic years. The education in the Master’s degree “Biostatistics” is carried out jointly by University of Plovdiv Paisii Hilendarski and Medical University of Plovdiv.

There are some terms that are often used interchangeably with the term “Biostatistics”. In this case, the expression “(Medical) Biostatistics” is used as a synonym for “Medical Biometrics” and “Medical Statistics” ([2]). Therefore, the name of the relevant profession can be “Biostatistician” or “Biometrician” which is the acquired professional qualification of the Masters graduates in this specialty. In the National Classification of Professions and Positions, the profession “Biometrician” can be found with the code 21206004, as well as the profession “Clinical trial monitoring specialist” with the code 21315035.

2. General characteristics of the specialty

The aim of the program is to acquaint students with the modern aspects of Biostatistics and provide in-depth knowledge of biostatistically innovative scientific methods, algorithms and systems, as well as practical skills for conducting Biomedical and Health Research. The program is interdisciplinary and designed to meet the growing needs of Biostatistics professionals to integrate into the field of Medical Research, in organizations that define Public Health Policy, and in the fields of Biotechnology and Bioinformatics. The focus of the program is on current challenges in the analysis of data obtained from medical, biological and other similar

research. Students acquire modern knowledge and skills for using basic mathematical models for real processes, basic statistical software and its application in biological, clinical, epidemiological, population and other statistical studies.

The study content is block structured in semesters based on compulsory, elective and optional disciplines. The training ends with a written state exam or a thesis defense. The compulsory courses provide theoretical education to students with the acquisition of knowledge and competencies in the professional field. The elective courses enrich the preparation of students in the major by allowing them to expand their knowledge and skills through their chosen disciplines. Optional disciplines provide an opportunity to acquire knowledge and skills in various scientific fields related to students' specialty, in accordance with their interests, and the obtained grade carries additional credit and entry in the diploma. For the academic disciplines, there are also hours for extracurricular work, during which students absorb the taught theoretical and practical knowledge, develop skills and acquire competencies for their application and independent problem solving and preparation for exams and ongoing assessment.

In order to receive systematic training as analytical specialists in the field of analysis and modeling of living (biological, ecological, physiological, medical, pharmacological, etc.) systems, students of this Master's program study scientific disciplines that can conditionally be grouped into four groups:

- Mathematical Modeling of Living Systems;
- Statistical Modeling of Living Systems;
- Specialized Software and Programming Languages in Biostatistics;
- Molecular Biology, Genetics and Health Care.

Mathematical Modeling of Living Systems is based on the methods of non-linear dynamics. Living systems are complex systems with many interactions and feedbacks and as such they obey the laws of non-linear dynamics. With the help of Linear Mathematics in the 18th, 19th and 20th centuries, many problems were solved in the sciences of non-living nature (Mechanics, Physics, Engineering Sciences) but it could not help the development of the sciences studying the living world. Hence the erroneous (but very widespread) belief that Mathematics is not necessary for these sciences. This perception is also reflected in the curricula of these

specialties in the Biological and Medical Sciences.

This situation changed at the end of the last century with the powerful development of Chaos Theory methods. Chaos is one of the characteristic states of non-linear dynamical systems in Biology and Medicine. In his monograph “Chaos Theory” [4], Stoycho Panchev defines chaos as organized and determined randomness or order disguised as randomness.

In his popular science book “Quantum Supremacy: How the Quantum Computer Revolution Will Change Everything” [5], eminent quantum physicist and science popularizer Michiu Kaku writes, “Traditionally, most Biology departments have been filled with people who are specialists in one animal or plant... and suddenly breakthroughs (in Genetics) are made and the use of Mathematical Analyses”.

The Nobel laureate, in Physiology and Medicine, Paul Nurse, says that he received all his scientific degrees and titles without a single line of mathematics in his scientific papers, but young scientists now and in the future will have a hard time breaking into reputable scientific journals with articles without mathematical formulas or statistical analyses.

In the series of courses related to Mathematical Modeling of Living Systems in Biology and Medicine (Models of Deterministic Processes; Models of Real Processes; Model Analysis in Biology and Medicine; Population, Evolutionary and Demographic Models and Sufficient Data Analysis) are presented briefly the mathematical foundations of analysis of non-linear dynamic systems. In the mentioned academic disciplines, models related to Organic Chemistry and Biochemistry, Biokinetics, Pharmacology, Genetics, Epidemiology, Populations and Ecology, Immunology are considered.

The study disciplines Models of Random Processes, Applied Mathematical Statistics, Statistical Modeling lay out the fundamentals of statistical data analysis and apply them to the development of Statistical Models in Biology, Medicine and Pharmacy.

The study subjects Databases, SPSS Statistical Software, Cluster Data Analysis, Statistical Forecasting with SPSS, R Programming in Biostatistics, Systematic Review and Meta-Analysis are dedicated to Information Technology and Informatics in Medicine and Biology.

The courses Health Information Systems and Epidemiology and Epidemiological Models relate to fundamentals of the functioning of health care as an important system in society, while in Molecular Biology and

Genetics students are introduced to a methodology for linking mutations to genetic conditions that can support research of treatment of various diseases.

3. Knowledge, skills and competencies acquired

3.1. Area and scope of knowledge

The graduate of the “Biostatistics” specialty has:

- basic knowledge about models of deterministic, random and real processes, as well as nonlinear dynamic living systems;
- basic knowledge about statistical theories and methods, software products for statistical processing and statistical modeling;
- basic knowledge of epidemiology and public health, design and conduct of epidemiological and clinical studies;
- in-depth knowledge of applying statistical modeling;
- in-depth knowledge in the field of Biostatistics with applications in biology, medicine and healthcare.

3.2. Area and scope of skills

The graduate of the “Biostatistics” specialty has the skills for:

- mathematical modeling of real phenomena and processes in the field of natural sciences for living systems and medicine;
- analyzing and improving the built mathematical models, as well as predictions based on them;
- selection and application of appropriate statistical methods for data analysis from the field of biology, medicine and public health;
- use of specialized statistical software for extracting, processing and analyzing data in the field of natural sciences for living systems and medicine;
- designing and conducting experimental medical and epidemiological studies.

3.3. Competencies

The graduate of the “Biostatistics” specialty has the following competencies in the field of natural sciences for living systems and medicine:

- logical thinking and modeling of real phenomena and processes;
- extraction of significant information from statistical data;
- processing and analysis of statistical data;
- interpreting the results of statistical analyses;
- statistical predictions based on data analyses.

4. Possibilities of students' realization

Graduated Masters in “Biostatistics” possess the necessary knowledge, skills and competencies for successful professional realization in the field of Biostatistics and have a wide range of career opportunities, for example as specialists in:

- scientific research organizations;
- university research groups;
- health facilities;
- pharmaceutical companies;
- regional and state organizations in the field of healthcare.

5. Application requirements and admission conditions

The conditions and requirements for admission are regulated on the basis of national legal bases and European directives, the Regulations for the structure and activities of University of Plovdiv Paisii Hilendarski and Medical University of Plovdiv, the Regulations on educational activities at University of Plovdiv Paisii Hilendarski and Medical University of Plovdiv.

Applicants for admission to the specialty must have a diploma of completed higher education with a Bachelor's degree or a Master's degree in one of the fields of higher education 4. Natural Sciences, Mathematics and Informatics, 6. Agricultural Sciences and Veterinary Medicine, 7. Health Care and Sports or another related field of higher education, professional direction and specialty in which they studied academic subjects (according to their higher education diploma) in the field of Mathematics and Informatics with classroom employment of a minimum of 100 academic hours.

Acknowledgments

This research was partially supported by project FP23-FMI-002 of the Scientific Research Fund, University of Plovdiv Paisii Hilendarski.

References

- [1] Homepage of the International Biometric Society, <https://www.biometricsociety.org/about/what-is-biometry>.
- [2] A. Zapf, G. Rauch, M. Kieser, Why do you need a biostatistician?, *BMC Med. Res. Methodol.*, Vol. 20, 2020, 23, doi: 10.1186/s12874-020-0916-4.
- [3] A. Zapf, M. Hübner, G. Rauch, M. Kieser, What makes a biostatistician?, *Stat. Med.*, Vol. 38, No. 4, 2018, 695–701, doi: 10.1002/sim.7998.
- [4] S. Panchev, Chaos Theory, *Academic Publishing House "Prof. Marin Drinov"*, 2001, ISBN: 9544307257, (in Bulgarian).
- [5] M. Kaku, Quantum Supremacy: How the Quantum Computer Revolution Will Change Everything, *Doubleday*, 2023, ISBN: 0385548362.

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