Analyzing Biostatistics and It's Impact on the Healthcare System

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Abstract: **The paper seeks to analyze Biostatics and its impact on healthcare outcomes as well as how impactful it is on health research result implementation. Biostatistics is a crucial field in public health and biomedical research. It is a branch of statistics that applies statistical methods to a wide range of topics in biology. It encompasses the design of biological experiments, the collection and analysis of data from those experiments and the interpretation of the results. In this review, the research question describes how Biostatistics has impacted the healthcare system. Describing Statistical modeling forms as an important part of numerous modern biological theories. Further the review highlights current trends and the future aspect in terms of shaping health care and improved access for all to healthcare services. Genetics studies, since its beginning, used statistical concepts to understand observed experimental results. Some genetics scientists even contributed statistical advances with the development of methods and tools; however, how were these findings interpreted and implemented? Biostatistics has been used to study the effects of environmental factors on human health, such as air pollution and water contamination. Biostatistics is also used in clinical trials to determine the efficacy of new drugs and treatments. How best can those results help to find solutions for health care challenges in Africa and global populations.**

Keywords: **Artificial Intelligence, Bayesian Statistics, Big Data.**

1. INTRODUCTION

Biostatistics is essential in public health and biomedical research because it helps to draw guardrails around project scopes and methodology, and informs all the logistical choices around new initiatives, such as test subjects, budgets, and ultimately, their potential for scientific influence on the public health field. Biostatisticians collaborate with other biomedical researchers to identify and solve problems that pose threats to health and to quality of life. It is also used to explain and predict some of the health outcomes and the direction of epidemics and pandemics, and it definitely influences decision-makers in public health. Biostatistics data and results are used to guide public health and other healthcare practitioners on how to go about controlling diseases.

THE HISTORICAL DEVELOPMENT OF BIOSTATISTICS AND ITS APPLICATION IN VARIOUS FIELDS

According to Valentine et al (2013) from time in history, Biostatistics has proven to be an important aspect in attending to scientific methods related to solution - based goals. It is truly valuable in emergencies, when connecting the reality of panic and uncertainty with the strength of the scientific method to provide solutions. Biostatistics is also used to design studies, collect and interpret data, and extrapolate results to further interpret them. All research in public health and health sciences is and should be based on scientific methodology and planning.

The fundamental concepts and techniques in biostatistics, such as hypothesis testing, regression analysis, and study design. Some of the techniques used in biostatistics include hypothesis testing, regression analysis, and survival analysis. Hypothesis testing is a statistical method used to determine whether a hypothesis about a population parameter is supported by the sample data (Ott, 2017) Regression analysis is a statistical method used to model the relationship between two or

more variables. It is used to predict the value of one variable based on the value of another variable. Survival analysis is a statistical method used to analyze the time it takes for an event of interest to occur. It is commonly used in medical research to analyze the time it takes for a patient to recover from a disease or the time it takes for a patient to experience a relapse. (Ott ,2017)

For example, researchers have said in a clinical trial, biostatisticians may use hypothesis testing to determine whether a new drug causes improved outcomes in patients. They may also use regression analysis to model the relationship between a patient's age and their blood pressure. Survival analysis may be used to analyze the time it takes for a patient to recover from a disease or the time it takes for a patient to experience a relapse.

Recent advances in biostatistical methods have been made in evidence-based global health research and decision-making. One such example is the use of modern biostatistical methods to improve global health research. This includes the use of data harmonization and analysis, systematic review and statistical meta-analysis, spatial-temporal modeling and disease mapping, and Bayesian statistical modeling.

For instance, studies have shown that modern Biostatistical methods for evidence-based global health research is a book that provides an overview of the emerging topics in statistical theories and methods through their applications to evidence-based global health research and decision-making. The book features the perspectives of world-class subject experts and researchers and provides both real data and computer programming language, so that readers can practice new methods. All these tools have shown the seriousness of this fraternity and give hope for new advances.

CONTEMPORARY STATISTICAL METHODS AND TECHNIQUES USED IN BIOSTATISTICS.

According to Machekano et al (2015) Bayesian statistics in healthcare research-Bayesian statistics is a statistical method that has been gaining popularity in healthcare research. It is used to analyze data and assess the safety and efficacy of drugs. Bayesian statistics is particularly useful in clinical trials, where it can be used to synthesize clinical trial data and improve regulatory decision-making. The Bayesian approach to pharmaceutical decision-making has been gaining momentum in the pharmaceutical industry over the past 20 years. It has been used to speed up drug discovery, development, and approvals.

One example of the use of Bayesian statistics in healthcare research is in the field of pharmaceutical decision-making. The United States Food and Drug Administration (FDA) has embraced Bayesian statistics as a method for supporting clinical trials in medical devices, in adaptive clinical designs, and in rare diseases. Bayesian statistics has also been used to develop personalized treatments, real-time monitoring of patients, and real-time monitoring and decision-making for epidemics.

MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN DISEASE PREDICTION AND

Diagnosis Machine learning and artificial intelligence (AI) have been increasingly used in healthcare research to predict, diagnose, and treat diseases. For instance, machine learning models can be trained to find patterns in patient data to aid in sepsis care, design safer chemotherapy regimens, and predict a patient's risk of having breast cancer or dying in the intensive care units. AI techniques ranging from machine learning to deep learning are prevalent in healthcare for disease diagnosis, drug discovery, and patient risk identification.

One example of the use of machine learning and AI in healthcare research is in the field of disease diagnosis. A systematic literature review conducted by Kumar et at (2023) found that artificial intelligence techniques are used to diagnose numerous diseases such as Alzheimer's, cancer, diabetes, chronic heart disease, Tuberculosis, Stroke and Cerebrovascular, Hypertension, skin, and liver disease. The review also found that numerous medical data sources are required to perfectly diagnose diseases using artificial intelligence techniques, such as ultrasound, magnetic resonance imaging, mammography, genomics, computed tomography scan, etc.

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CAUSAL INFERENCE IN OBSERVATIONAL STUDIES

Causal inference is a statistical method used to determine the causal relationship between two variables. Ruberg et al (2019) said it is used to infer the effect of an intervention on an outcome, based on observational data. Causal inference from observational data is gaining momentum due to the large amount of complex and richer data and advanced techniques from statistics and machine learning.

Miguel Hernan, a professor at Harvard Teaching Hospital Chan School of Public Health, has done extensive research on causal inference from observational data. He has written a book that describes the methods and conditions under which they can be used, which means that investigators need to be subject-matter experts to evaluate whether those conditions are met.

In a statistical model using observational data, one can only compare the risk of the outcome in those exposed, to the risk of the outcome in those unexposed. However, inferring causation implies a comparison of the risk of the outcome if all individuals were exposed and if all were unexposed.

SPATIAL STATISTICS IN EPIDEMIOLOGY

Spatial statistics is a branch of statistics that deals with the analysis of spatial data. In epidemiology, spatial statistics are used to study the occurrence of health-disease events or deaths in a region of interest (Button, 2019)

Spatial epidemiology is the description and analysis of geographically indexed health data with respect to demographic, environmental, behavioral, socioeconomic, genetic, and infectious risk factors There are several types of spatial analysis in epidemiology, including disease mapping, geographical correlation, risk assessment in relation to point or line resources, and cluster detection and disease clustering.

META-ANALYSIS AND SYSTEMATIC REVIEWS IN PUBLIC HEALTH

Hangerly and Butt (2019) stated that systematic reviews provide summaries of evidence contained in a number of individual studies on a specific topic. Evidence synthesis is the general term used to describe a systematic review. Meta-analysis is a statistical technique for combining the results of a number of individual studies to produce a summary result. A systematic review may or may not deploy a meta-analysis. The logic of systematically reviewing literature is applied today in a wide variety of ways leading to a plethora of published reviews on a topic.

Tugwell (2022) described that among other evidence synthesis types, there are meta-synthesis, scoping reviews, rapid reviews, living systematic reviews, umbrella reviews, guidelines, etc. Current healthcare practice and policy increasingly rely on clear and comprehensive summaries of information collated through systematic literature reviews. It is necessary for public health professionals to use reviews for underpinning their practice guidelines. Research that is relevant to public health practice is scattered all over the literature and in multiple languages. Evidence synthesized through a systematic review article, aided by meta-analysis if appropriate, can offer a quick overview of a wide range of information on a particular topic. Such reviews are also frequently cited by others, particularly in the background and discussion section of their papers.

SOME EXAMPLES AND CASE STUDIES THAT SHOWCASE THE PRACTICAL APPLICATION OF THESE METHODS

Systematic reviews and meta-analyses are widely used in public health research to provide a comprehensive summary of the available evidence on a particular topic. Here are some examples of how these methods have been applied in systematic reviews:

Coleman (2020) outlines the 5 examples as follows:-

1. A systematic review and meta-analysis of randomized controlled trials was conducted to evaluate the effectiveness of interventions for reducing sedentary behavior in adults 1. The authors found that interventions that included behavioral counseling, environmental changes, and/or technology-based approaches were effective in reducing sedentary behavior.

2. A systematic review and meta-analysis of observational studies was conducted to investigate the association between dietary patterns and the risk of type 2 diabetes. The authors found that a healthy dietary pattern, characterized by high intake of fruits, vegetables, whole grains, and lean protein, was associated with a lower risk of type 2 diabetes.

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3. A systematic review and meta-analysis of randomized controlled trials was conducted to evaluate the effectiveness of interventions for preventing falls in older adults 3. The authors found that exercise-based interventions, such as balance and strength training, were effective in reducing the risk of falls.

4. A systematic review and meta-analysis of randomized controlled trials was conducted to evaluate the effectiveness of interventions for improving adherence to antiretroviral therapy among people living with HIV.

5. The authors found that interventions that included education, counseling, and/or reminders were effective in improving adherence to antiretroviral therapy.

BIG DATA AND BIOSTATISTICS

Lux et al (2017) stated that data has become increasingly important in biostatistics research. It refers to the large and complex datasets that are generated in various fields, including healthcare, genomics, and environmental science. Biostatisticians use big data to identify patterns, trends, and associations that can help improve public health outcomes .

One of the main challenges of working with big data is the need for specialized tools and techniques to manage, process, and analyze the data. Biostatisticians use a variety of statistical methods and machine learning algorithms to extract meaningful insights from big data.

For example, big data can be used to identify risk factors for diseases, predict disease outbreaks, and evaluate the effectiveness of interventions. In addition, big data can be used to develop personalized treatment plans for patients based on their unique characteristics.

Researchers have explored and discovered that there are several programs and courses available that focus on biostatistics and big data. For instance, the University of Michigan School of Public Health offers a Big Data Summer Institute that introduces undergraduate students to the intersection of big data and human health. The University of Texas Medical Branch also offers a course on biostatistics for big data applications.

HOW ADVANCED DATA ANALYTICS AND MACHINE LEARNING ARE BEING USED TO ANALYZE LARGE-SCALE HEALTH DATASETS.

Advanced data analytics and machine learning are being used to analyze large-scale health datasets in a variety of ways. Tuguwell (2017) For example, these techniques can be used to identify patterns in genetic data that would be difficult or impossible to detect using traditional statistical methods. They can also be used to develop predictive models that can help healthcare providers identify patients who are at risk of developing certain conditions, allowing for earlier intervention and treatment.

Shea and Tugwell (2017) added that machine learning algorithms can be used to analyze electronic health records (EHRs) to identify patterns and trends in patient data. This can help healthcare providers identify areas where they can improve patient care and outcomes.

However, in other studies noted that there were also concerns about the use of machine learning in healthcare. For example, studies have shown that there are concerns about the potential for these algorithms to be biased against certain groups of patients. There are also concerns about the privacy and security of patient data, as large-scale health datasets can contain sensitive information that must be protected.

Bayertii (2017) indicated that overall, advanced data analytics and machine learning have the potential to revolutionize healthcare by enabling more accurate diagnoses, earlier intervention, and more personalized treatment plans. However, other studies have disputed that it is important to ensure that these techniques are used in an ethical and responsible manner, with appropriate safeguards in place to protect patient privacy and prevent bias.

On highlighting the challenges and opportunities associated with big data in Biostatistics, Murad and Sultan (2016) on the other hand said that big data also presents several challenges. One of the biggest challenges is data privacy. As the amount of health data being collected continues to grow, ensuring the privacy and security of that data is becoming increasingly important. Biostatisticians are developing new methods for protecting sensitive health data, such as differential privacy and federated learning . According to Tugwell (2015) Another challenge is data quality. Big data is often messy and incomplete, which can make it difficult to draw meaningful conclusions from the data. Further, there is a need for new statistical methods

to analyze big data. Traditional statistical methods may not be well-suited to analyzing large, complex datasets, and new methods are needed to ensure that researchers can draw accurate conclusions from the data.

Overall, big data presents both challenges and opportunities for biostatistics. By developing new methods for protecting sensitive health data, ensuring data quality, and developing new statistical methods, biostatisticians are helping to ensure that big data can be used to improve public health and advance biomedical research.

BIOSTATISTICS IN PUBLIC HEALTH

Biostatisticians use statistical methods to design studies, analyze data, and draw conclusions about the health of populations. They work closely with epidemiologists, public health professionals, and other researchers to identify patterns and trends in health data, and to develop strategies for improving public health outcomes (Shemilt,2015)

For example, biostatistics is used to study the effectiveness of new treatments and interventions, to identify risk factors for diseases, and to evaluate the impact of public health policies and programs.

In addition, studies have shown that biostatistics plays a key role in the development of evidence-based guidelines and recommendations for public health practice. By synthesizing data from multiple studies, biostatisticians can provide a comprehensive summary of the available evidence on a particular topic, which can help guide public health decisions.

Overall, biostatistics is an essential tool for public health research and policy development. It provides a rigorous and systematic approach to analyzing health data, which is critical for improving public health outcomes and reducing health disparities (Naturheilkunde, 2012.)

The use of biostatistical methods in tracking disease outbreaks, evaluating healthcare interventions, and improving population health. Biostatistics plays a crucial role in public health research and policy development. Biostatisticians use statistical methods to design studies, analyze data, and draw conclusions about the health of populations. They work closely with epidemiologists, public health professionals, and other researchers to identify patterns and trends in health data, and to develop strategies for improving public health outcomes.

Higgins and Thomas (2017) outlined that one of the key applications of biostatistics is in tracking disease outbreaks. Biostatisticians use statistical models to analyze data on the spread of infectious diseases, and to predict the future course of an outbreak. This information could be used to develop strategies for controlling the spread of the disease, such as vaccination campaigns or quarantine measures.

Researchers said that Biostatistics is also used in evaluating healthcare interventions. Biostatisticians design and analyze clinical trials to determine the effectiveness of new treatments and interventions. They use statistical methods to control for confounding variables and to ensure that the results are statistically significant.

In addition, biostatistics plays a key role in improving population health. Biostatisticians use statistical methods to identify risk factors for diseases, to evaluate the impact of public health policies and programs, and to develop evidence-based guidelines and recommendations for public health practice. By synthesizing data from multiple studies, biostatisticians can provide a comprehensive summary of the available evidence on a particular topic, which can help guide public health decisions. Overall, biostatistics is an essential tool for public health research and policy development. It provides a rigorous and systematic approach to analyzing health data, which is critical for improving public health outcomes and reducing health disparities.

Biostatistical Challenges of implementation and Ethical Considerations Machekano et al (2015) emphasized the challenges of ethical considerations in biostatistics research, such as issues related to data privacy, transparency, and reproducibility. To address challenges like data privacy, transparency, and reproducibility, researchers in biostatistics have developed a range of tools and techniques. For example, differential privacy is a technique that can be used to protect the privacy of individuals in large datasets. Federated learning is another technique that allows data to be analyzed without being transferred to a central location, thereby reducing the risk of data breaches.

In addition, researchers in biostatistics have developed guidelines and best practices for ensuring the transparency and reproducibility of research. Berkman (2015) gives an example, the US National Institutes of Health (NIH) requires that research proposals explicitly describe scientific rigor, which includes approaches to ensuring the fidelity of data, minimizing bias, and maximizing new knowledge. Other funders have also signaled a long-term commitment to better practices in science.

Overall, Biostatistics plays a critical role in addressing challenges related to data privacy, transparency, and reproducibility in scientific research. Cumpston and Lasserson (2018) highlighted that biostatistics is a rapidly evolving field, and as with any field, there are several emerging ethical issues that need to be addressed. One of the most significant ethical dilemmas in biostatistics is data privacy. As the amount of health data being collected continues to grow, ensuring the privacy and security of that data is becoming increasingly important. Biostatisticians are developing new methods for protecting sensitive health data, such as differential privacy and federated learning.

Another ethical issue in biostatistics is reproducibility and transparency. There is growing concern about the reproducibility and transparency of scientific research. Biostatisticians are developing new guidelines and best practices for ensuring that research is conducted in a rigorous and transparent manner.

In addition, there are several emerging trends in biostatistics that raise ethical concerns. For example, artificial intelligence (AI) is becoming increasingly important in biostatistics, as it can help researchers analyze large datasets more efficiently and accurately. However, there are concerns about the potential for AI to be used in ways that are discriminatory or biased

Another emerging trend is precision medicine, which takes into account individual differences in genes, environment, and lifestyle when developing treatment plans. While precision medicine has the potential to improve patient outcomes, there are concerns about the potential for it to exacerbate existing health disparities.

Overall, biostatisticians are working to address these ethical dilemmas and emerging trends by developing new tools and techniques, as well as guidelines and best practices for ensuring that research is conducted in a rigorous and transparent manner. By doing so, they are helping to ensure that biostatistics continues to be a field that is dedicated to improving public health while upholding the highest ethical standards.

SECTION 6: FUTURE DIRECTIONS IN BIOSTATISTICS

Hartling et al (2019) highlighted new technologies, changing healthcare landscapes, and evolving research paradigms are also having a significant impact on the field of biostatistics. For example, digital transformation in healthcare delivery is changing the way that healthcare is delivered and research is conducted. Innovations such as artificial intelligence and robotics are completely changing the landscape, ushering in a new future for healthcare. Biostatisticians are working to develop new research methodologies and funding models that can keep pace with these changes and ensure that research is conducted in a rigorous and transparent manner.

Overall, biostatistics is a field that is constantly evolving and adapting to new challenges and opportunities. By staying at the forefront of emerging trends and technologies, biostatisticians are helping to ensure that the field continues to make important contributions to public health and scientific research.

HIGHLIGHT ONGOING OR PLANNED RESEARCH PROJECTS THAT AIM TO ADVANCE STATISTICAL METHODOLOGIES

According to Robinson and Chou (2019), artificial intelligence (AI): is becoming increasingly important in biostatistics, as it can help researchers analyze large datasets more efficiently and accurately. For example, it can be used to identify patterns in genetic data that would be difficult or impossible to detect using traditional statistical methods like these below:-

1. Precision medicine: Precision medicine is an approach to healthcare that takes into account individual differences in genes, environment, and lifestyle when developing treatment plans. Biostatistics plays a crucial role in precision medicine, as it can help researchers identify subgroups of patients who are more likely to benefit from a particular treatment.

2. Data privacy and security: As the amount of health data being collected continues to grow, ensuring the privacy and security of that data is becoming increasingly important. Biostatisticians are developing new methods for protecting sensitive health data, such as differential privacy and federated learning.

3. Reproducibility and transparency: There is growing concern about the reproducibility and transparency of scientific research. Biostatisticians are developing new guidelines and best practices for ensuring that research is conducted in a rigorous and transparent manner.

4. Environmental health: Environmental factors such as air pollution, water quality, and climate change can have a significant impact on human health. Biostatisticians are developing new methods for analyzing environmental health data and identifying the most effective interventions to improve public health research.

2. SUMMARY

Biostatistics is a field that uses statistical methods to analyze and interpret biological data. It plays a crucial role in ensuring that scientific research is conducted in a rigorous and reproducible manner. Biostatistics is applied statistics in biological and medical sciences for public health practice. Based on the data and models they provide, epidemiology the study of the causation, spread and control of disease across time and space gives us information about health status, morbidity and mortality in human populations. Biostatisticians play a unique role in safeguarding public health and improving lives through quantitative research. By combining across quantitative disciplines, biostatisticians are able to collaborate with other biomedical researchers to identify and solve problems that pose threats to health and to quality of life.

Advanced data analytics and machine learning are being used to analyze large-scale health datasets in a variety of ways. For example, these techniques can be used to identify patterns in genetic data that would be difficult or impossible to detect using traditional statistical methods. They can also be used to develop predictive models that can help healthcare providers identify patients who are at risk of developing certain conditions, allowing for earlier intervention and treatment.

Overall, biostatistics is a field that is constantly evolving and adapting to new challenges and opportunities. By staying at the forefront of emerging trends and technologies, biostatisticians are helping to ensure that the field continues to make important contributions to public health and scientific research.

3. CONCLUSION

Biostatistics plays a unique role in safeguarding public health and improving lives through quantitative research. By combining across quantitative disciplines, biostatisticians are able to collaborate with other biomedical researchers to identify and solve problems that pose threats to health and to quality of life. Biostatistics is applied statistics in biological and medical sciences for public health practice. Based on the data and models they provide, epidemiology the study of the causation, spread and control of disease across time and space gives us information about health status, morbidity and mortality in human populations.

Biostatisticians are working to address challenges related to data privacy, transparency, and reproducibility in scientific research. They are also developing new methods for analyzing environmental health data and identifying the most effective interventions to improve public health. Advanced data analytics and machine learning are being used to analyze large-scale health datasets in a variety of ways, such as identifying patterns in genetic data that would be difficult or impossible to detect using traditional statistical methods. Biostatisticians are also working to develop new research methodologies and funding models that can keep pace with changes in healthcare delivery and research paradigms Overall, biostatistics is a field that is constantly evolving and adapting to new challenges and opportunities. By staying at the forefront of emerging trends and technologies, biostatisticians are helping to ensure that the field continues to make important contributions to public health and scientific research.

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