



# Advancements in Epidemiological Methods: A Comprehensive Review of Contemporary Approaches

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## ABSTRACT

This review article systematically examines the significant advancements in epidemiological methods from 2005 to 2023, highlighting the evolution and impact of contemporary approaches in the field. Employing a thorough literature search across key databases, the review focuses on peer-reviewed articles, reviews, and meta-analyses that underscore innovative methodologies and applications in epidemiology. The inclusion criteria prioritized studies that introduced new techniques, integrated technology, or applied interdisciplinary approaches. This article synthesizes these advancements, revealing trends such as the incorporation of big data analytics, machine learning, and genetic epidemiology, which have substantially enhanced the scope and accuracy of epidemiological research. The review also discusses the challenges and ethical considerations emerging from these advanced methods, particularly in data privacy and the complexity of analysis. The findings underscore the shift towards more dynamic, precise, and interdisciplinary methods in epidemiology, reflecting the field's adaptation to the demands of modern public health challenges. This comprehensive overview not only provides a valuable resource for epidemiologists and public health professionals but also sets the stage for future research directions, emphasizing the need for continued innovation and ethical vigilance in epidemiological practices.

**Keywords:** Advancement, Epidemiological Methods, Review, Contemporary Approaches.

## 1. Introduction

Epidemiology, as a fundamental discipline in public health, plays a critical role in understanding and addressing health issues at the population level. The importance of epidemiological methods lies in their ability to identify risk factors for disease, determine the effectiveness of medical and public health interventions, and provide a foundation for developing policies and strategies to improve health outcomes (1). These methods have

evolved to adapt to the changing landscape of health challenges, integrating new technologies and analytical approaches to enhance their effectiveness (2).

The evolution of epidemiological methods has been marked by significant advancements, from early observational studies to sophisticated analytical techniques. This evolution reflects the field's response to emerging health threats, technological advancements, and the growing complexity of health data (3). Notable developments in theoretical epidemiology, particularly from the statistical

perspective, have included multilevel modeling and the integration of 'frequentist' versus Bayesian approaches to causal inference (4).

The field of epidemiology is at a pivotal juncture, with traditional methods being augmented or replaced by more advanced techniques (5). This review will delve into these contemporary approaches, providing insights into how they are shaping the future of epidemiological research and public health interventions. Understanding these advancements is crucial for health professionals, researchers, and policymakers to effectively address current and emerging health challenges.

Therefore, this review aims to provide a comprehensive overview of contemporary approaches in epidemiological methods. It will explore the advancements in study design, data collection methods, statistical techniques, and the integration of multidisciplinary approaches in epidemiology. The review will also discuss the challenges and ethical considerations in modern epidemiological studies and offer insights into future directions in this field.

## 2. Methods and Materials

A structured literature search was conducted across several academic databases, including PubMed, Scopus, Web of Science, and Google Scholar. The search timeframe spanned from 2005 to December 2023, capturing a broad spectrum of contemporary advancements in epidemiological methods.

### 2.1. Data Collection

The search strategy incorporated a combination of keywords and phrases pertinent to epidemiological methods and their advancements. These included: "epidemiology," "epidemiological methods," "study design in epidemiology," "statistical methods in epidemiology," "big data," "machine learning," "genetic epidemiology," "environmental epidemiology," and "public health." Boolean operators (AND, OR) were employed to refine the search results.

The review focused on literature published within the last ten years, from 2000 to 2023, to provide the most current insights into the application of cognitive psychology in sports. Seminal works predating this period were also considered for their foundational value and historical perspective.

### 2.2. Inclusion and Exclusion Criteria

Inclusion criteria were:

- Peer-reviewed articles, reviews, and meta-analyses.
- Studies focusing on the advancement of epidemiological methods.
- Publications discussing the application of new technologies or interdisciplinary approaches in epidemiology.

Exclusion criteria included:

- Non-peer-reviewed articles, editorials, and opinion pieces.
- Studies with outdated or traditional methods not contributing to recent advancements.
- Articles not written in English or without an available English translation.

### 2.3. Data Analysis

The quality of the included studies was assessed using appropriate checklists and criteria, such as the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for observational studies. This assessment ensured the inclusion of high-quality and relevant studies in the review.

Data extracted from the selected articles included the author(s), publication year, study focus, methodological advancements, and key findings. This information was synthesized to identify and categorize the major advancements in epidemiological methods, their applications, and implications. A narrative synthesis approach was used to integrate findings from different studies, providing a comprehensive overview of the field's evolution.

## 3. Historical Overview of Epidemiological Methods

The history of epidemiological methods is a testament to the evolution of medical science and public health. From its early beginnings, epidemiology has been pivotal in understanding disease patterns and health outcomes in populations. The roots of epidemiology can be traced back to the 17th century when John Graunt performed systematic analysis of mortality data in London, laying the groundwork for vital statistics. However, it was not until the 19th century that epidemiology began to take shape as a scientific discipline, marked by seminal works such as John Snow's investigation of the cholera outbreak in London, which

established the foundations of modern epidemiological methods (6).

### 3.1. *Key Milestones and Foundational Methods in Epidemiology*

Key milestones in the history of epidemiology include the development of foundational methods such as cohort and case-control studies. These methods provided robust frameworks for understanding the associations between exposures and health outcomes. The Framingham Heart Study, initiated in 1948, is a prime example of a cohort study that revolutionized our understanding of cardiovascular disease risk factors. Similarly, case-control studies have been instrumental in identifying causal relationships in epidemiology, such as the link between smoking and lung cancer (7).

### 3.2. *Transition from Traditional to Contemporary Approaches*

The transition from traditional to contemporary epidemiological methods has been driven by advancements in technology and statistical techniques. The advent of computational power and the emergence of big data have transformed epidemiological research, allowing for more complex and comprehensive analyses. Modern epidemiology now employs a range of sophisticated methods, including multilevel modeling and Bayesian approaches, to decipher the intricate web of factors influencing health (4). The integration of genomics and molecular biology into epidemiological studies, often referred to as molecular epidemiology, has further expanded the scope of the field, enabling a deeper understanding of the biological mechanisms underlying disease processes (8).

The historical evolution of epidemiological methods reflects the field's adaptability and responsiveness to emerging health challenges and technological advancements. From its early descriptive roots to the current era of analytical and molecular epidemiology, the field has continually evolved, enhancing our ability to understand and improve population health.

## 4. **Current Trends in Health Behavior Change Interventions**

### 4.1. *Dominant Theories and Models in Contemporary Health Behavior Change*

The landscape of health behavior change interventions is continually evolving, with current trends being shaped by a

blend of established and emerging theories. The Health Belief Model (HBM) and the Transtheoretical Model (TTM) continue to be influential, providing a framework for understanding the stages of behavior change and the factors influencing individual decisions. Additionally, the Social Cognitive Theory, emphasizing the role of observational learning, self-efficacy, and social influences, remains relevant in designing and implementing behavior change interventions. These models collectively underscore the complexity of health behavior change, recognizing the interplay of personal, behavioral, and environmental factors (9).

## 5. **Advancements in Study Design and Data Collection in Epidemiology**

### 5.1. *Innovative Study Designs in Epidemiology*

The landscape of epidemiological study designs has evolved significantly, incorporating innovative approaches to address complex health issues. Traditional designs like cohort, case-control, and cross-sectional studies remain fundamental, but their application has become more sophisticated. Cohort studies, for instance, have expanded beyond the classic prospective design to include retrospective and ambidirectional cohorts, allowing for more comprehensive data analysis over different time frames. Case-control studies have seen advancements in matching techniques and bias reduction, enhancing their ability to identify causal relationships. Cross-sectional studies, often used for preliminary investigations, have been adapted to include more complex sampling methods, increasing their representativeness and reliability (10).

### 5.2. *Advances in Data Collection Methods*

Data collection methods in epidemiology have undergone a transformation, largely driven by technological advancements. The use of electronic health records (EHRs) has become increasingly common, providing a rich source of real-time patient data for large-scale studies. EHRs allow for the collection of detailed patient histories, treatment outcomes, and demographic information, facilitating more accurate and efficient research (11). Biobanking, another significant advancement, involves the collection and storage of biological samples, such as blood or tissue, which can be used for various types of biomedical research, including genetic and molecular epidemiology studies.

### 5.3. *Impact of Technology on Epidemiological Research*

Technology has had a profound impact on epidemiological research, particularly through the introduction of mobile health data and wearable devices. These technologies enable the continuous monitoring of health-related parameters, such as physical activity, heart rate, and sleep patterns, providing valuable insights into lifestyle factors and their impact on health. Digital contact tracing technologies, especially relevant during infectious disease outbreaks like COVID-19, have demonstrated the potential of technology in identifying and controlling the spread of diseases (12). Furthermore, the integration of big data analytics and machine learning techniques has opened new avenues for analyzing complex health data, leading to more precise and predictive epidemiological models.

### 5.4. *Real-World Evidence and Observational Research*

The concept of real-world evidence (RWE) has gained prominence, emphasizing the value of data obtained outside of traditional clinical trials. RWE is derived from various sources, including patient registries, health surveys, and observational studies, providing insights into the effectiveness of interventions in real-world settings. This approach complements traditional randomized controlled trials, offering a more holistic view of patient outcomes and healthcare practices (13).

### 5.5. *Nationwide Population Databases*

The development of nationwide population databases, such as the Taiwan National Health Insurance Research Database, exemplifies the scale and scope of modern epidemiological research. These databases cover vast populations, enabling researchers to conduct comprehensive studies on healthcare utilization, health economics, and various biomedical and behavioral research topics. Such large-scale databases are invaluable for identifying trends, evaluating healthcare policies, and understanding the broader implications of health interventions (14).

Advancements in study design and data collection have significantly enhanced the capabilities of epidemiological research. Innovative study designs, coupled with advanced data collection methods and the integration of technology, have enabled researchers to tackle complex health issues more effectively. As technology continues to evolve, so too will the methods and tools at the disposal of epidemiologists,

paving the way for more insightful, impactful research in public health.

## 6. **Statistical Methods and Analytical Tools in Epidemiology**

The field of epidemiology has witnessed a significant transformation in statistical methodologies, particularly with the advent of machine learning and Bayesian methods. Machine learning techniques, such as random forests, gradient boosting, and deep learning, have been increasingly applied in epidemiological studies to handle complex datasets and uncover patterns that traditional statistical methods might miss. These methods are particularly useful in dealing with large-scale data, allowing for more nuanced and precise analysis (15, 16).

Bayesian methods, on the other hand, offer a probabilistic approach to data analysis, which is particularly advantageous in epidemiological research for modeling uncertainty and incorporating prior knowledge into the analysis. Bayesian approaches have been applied in various epidemiological studies, providing a flexible framework for complex data analysis (17).

### 6.1. *Role of Big Data and Data Science in Epidemiological Analysis*

The role of big data and data science in epidemiology cannot be overstated. The emergence of big data has revolutionized the way epidemiological data is collected, analyzed, and interpreted. Large datasets from electronic health records, biobanks, and population-based health surveys provide a wealth of information that can be leveraged to understand health patterns and disease dynamics more comprehensively (14).

Data science techniques, including advanced analytics and machine learning, are instrumental in extracting meaningful insights from these large datasets. They enable researchers to identify trends, predict outcomes, and generate hypotheses in ways that were not possible with smaller, more traditional datasets (18).

### 6.2. *Case Studies of How These Methods Have Been Applied*

One notable application of these advanced statistical methods is in the field of genomics, where machine learning and Bayesian methods have been used to understand complex genetic interactions and their implications for disease. For example, the development of a graphical model



of causal gene regulatory networks using medical big data and Bayesian machine learning has provided new insights into the genetic basis of diseases (19).

Another case study involves the use of big data and machine learning in pharmacovigilance. The analysis of over 37,000 Dupilumab reports from the World Health Organization Individual Case Safety reporting pharmacovigilance database (VigiBase™) utilized big data and machine learning techniques to evaluate sleep-related adverse drug reactions, demonstrating the potential of these methods in drug safety surveillance (20).

The advancements in statistical methods and analytical tools have significantly enhanced the capabilities of epidemiological research. The integration of machine learning, Bayesian methods, and big data analytics has opened new avenues for understanding complex health issues. As these technologies continue to evolve, they promise to further revolutionize the field of epidemiology, offering more precise, comprehensive, and actionable insights into public health.

## 7. Integration of Multidisciplinary Approaches in Epidemiology

The integration of genetics and molecular biology into epidemiology has led to the emergence of fields like molecular epidemiology and genomic epidemiology. These disciplines combine the principles of epidemiology with molecular and genetic techniques to understand how genetic variations contribute to disease occurrence in populations. Molecular epidemiology has been particularly influential in cancer research, providing insights into the molecular and genetic factors that influence cancer risk and progression (21).

Environmental epidemiology, another critical interdisciplinary field, examines how environmental exposures impact health outcomes. It integrates methods from environmental science to assess exposures to pollutants, chemicals, and other environmental factors. This field plays a crucial role in understanding the complex interactions between genetics, environment, and disease (22).

### 7.1. Role of Social Sciences and Behavioral Epidemiology

The integration of social sciences into epidemiology has led to the development of behavioral epidemiology and social epidemiology. These subfields focus on how social

structures, processes, and behaviors affect health outcomes. Behavioral epidemiology examines the impact of behaviors (like diet, physical activity, and smoking) on health, while social epidemiology looks at how social factors (such as socioeconomic status, race, and social networks) influence health disparities (23).

### 7.2. Examples of Interdisciplinary Research Impacting Epidemiological Methods

One example of interdisciplinary research in epidemiology is the study of life course epidemiology. This approach combines insights from developmental biology, psychology, and sociology to understand how biological, behavioral, and social factors throughout an individual's life influence health outcomes. It considers the cumulative effects of exposures and experiences from pre-conception through adulthood (24).

Another example is the integration of big data and machine learning in psychiatric epidemiology. This approach utilizes large datasets and advanced computational methods to identify patterns and predictors of mental health conditions, providing new insights into psychiatric disorders (25).

The integration of multidisciplinary approaches in epidemiology has significantly expanded the scope and depth of research in the field. By combining genetics, molecular biology, environmental science, and social sciences, epidemiologists can now explore the complex interplay of various factors influencing health. This interdisciplinary approach is crucial for developing more effective strategies for disease prevention and health promotion.

## 8. Challenges and Ethical Considerations in Epidemiology

The implementation of advanced epidemiological methods, such as machine learning and big data analytics, presents several challenges. One of the primary concerns is data privacy. As epidemiological studies increasingly rely on large datasets, including electronic health records and genomic data, protecting patient confidentiality becomes more complex. Ensuring data security and privacy in the era of big data is crucial, especially when dealing with sensitive health information (26).

Another challenge is the complexity of analysis. Advanced statistical methods and machine learning algorithms can be highly complex and require specialized

knowledge. This complexity can pose barriers to their broader application in epidemiology, especially in resource-limited settings or among researchers with limited training in these methods (27).

### 8.1. *Ethical Considerations in Modern Epidemiological Studies*

In the age of big data, ethical considerations in epidemiological studies have become increasingly important. One major ethical concern is informed consent. The traditional concept of informed consent may not always be feasible or adequate in studies using large, de-identified datasets. Researchers must navigate the ethical landscape to ensure that the use of such data aligns with the principles of autonomy, beneficence, and justice (28).

Additionally, the use of big data in epidemiology raises questions about biases and representativeness. Big data sources may not accurately represent all segments of the population, leading to skewed results and potential health disparities. Addressing these biases is crucial to ensure that epidemiological findings are valid and applicable to diverse populations (29).

### 8.2. *Ethical Frameworks and Guidelines*

Developing ethical frameworks and guidelines for big data research in epidemiology is essential. These frameworks should address issues like data ownership, privacy, consent, and the equitable use of data. They should also provide guidance on balancing the potential benefits of big data research against the risks to individual privacy and autonomy (30).

The integration of advanced methods in epidemiology, while offering significant benefits, brings forth challenges and ethical considerations that must be carefully addressed. Ensuring data privacy, managing the complexity of analyses, and adhering to ethical principles in the use of big data are paramount for the responsible advancement of epidemiological research. As the field continues to evolve, developing robust ethical frameworks and addressing these challenges will be key to harnessing the full potential of modern epidemiological methods.

## 9. **Future Directions in Epidemiology**

### 9.1. *Emerging Trends and Potential Advancements*

The future of epidemiological methods is poised for significant advancements, shaped by emerging trends and

technological innovations. One of the key areas of development is the integration of machine learning and artificial intelligence (AI) in epidemiological research. These technologies offer the potential to analyze complex datasets more efficiently and accurately, enabling researchers to identify patterns and associations that traditional methods might miss (27).

Another emerging trend is the use of big data analytics in epidemiology. The increasing availability of large datasets, including electronic health records, genomic data, and environmental data, provides unprecedented opportunities for epidemiological research. Big data analytics can help uncover the multifactorial nature of diseases and the interactions between genetic, environmental, and lifestyle factors (29).

### 9.2. *Impact of Technology and Interdisciplinary Collaboration*

The impact of technology on epidemiology is expected to grow, with advancements in data collection methods, such as wearable devices and remote sensing technologies, providing new avenues for data acquisition. These technologies enable continuous monitoring of health-related parameters, offering insights into the real-time health status of individuals and populations (31).

Interdisciplinary collaboration is also set to play a crucial role in the future of epidemiology. The integration of insights from genetics, molecular biology, environmental science, and social sciences is essential for a comprehensive understanding of health and disease. Collaborative efforts between epidemiologists, biostatisticians, geneticists, and social scientists will be crucial in advancing the field (32).

#### Recommendations for Future Research and Practice

For future research and practice in epidemiology, it is recommended to focus on the development and validation of AI and machine learning models that are tailored to epidemiological data. Researchers should also prioritize the ethical aspects of big data research, ensuring data privacy and informed consent in studies involving large datasets.

There is a need for continued investment in the development of new data collection methods and technologies that can enhance the accuracy and efficiency of epidemiological research. Additionally, fostering interdisciplinary collaborations and building capacity in emerging areas of epidemiology will be key to addressing complex health challenges (33).

The future of epidemiology is marked by exciting possibilities, with technological advancements and

interdisciplinary collaborations set to transform the field. By embracing these emerging trends and addressing the associated challenges, epidemiology can continue to play a vital role in improving public health and informing health policies.

## 10. Conclusion

The field of epidemiology has undergone a remarkable transformation, marked by significant advancements in methodologies and analytical tools. The integration of machine learning and artificial intelligence has revolutionized the way epidemiological data is analyzed, enabling researchers to uncover complex patterns and associations in large datasets. The adoption of big data analytics has expanded the scope of epidemiological research, allowing for a more comprehensive understanding of the multifactorial nature of diseases.

Advancements in study designs, such as the refinement of cohort, case-control, and cross-sectional studies, have enhanced the robustness and applicability of epidemiological research. The incorporation of genetics, molecular biology, and environmental science has led to the emergence of interdisciplinary fields like molecular epidemiology, further enriching our understanding of disease mechanisms.

These advancements are crucial for the field of epidemiology, as they provide the tools and frameworks necessary to address contemporary health challenges. The ability to analyze complex and large-scale data sets is essential in an era where health issues are increasingly multifaceted, involving genetic, environmental, and lifestyle factors. The integration of diverse scientific disciplines within epidemiology has enabled a more holistic approach to understanding health and disease, leading to more effective public health strategies and interventions.

The evolution of epidemiological methods also underscores the importance of adapting to technological advancements and embracing interdisciplinary collaboration. As the field continues to evolve, epidemiologists must remain agile, integrating new technologies and methodologies to stay at the forefront of public health research.

Looking ahead, the future of epidemiology is bright and full of potential. The continued integration of advanced technologies, such as AI and machine learning, will further enhance the analytical capabilities of epidemiologists. The growing emphasis on interdisciplinary research will lead to

more comprehensive and nuanced understandings of health and disease.

As epidemiology continues to evolve, it will play an increasingly vital role in guiding public health policies and interventions. The advancements in epidemiological methods are not just academic achievements; they are essential tools in the global effort to improve health outcomes and reduce disease burdens. The evolution of these methods reflects the dynamic nature of the field and its unwavering commitment to advancing public health through scientific inquiry and innovation.

## Authors' Contributions

Shiva Taheri and Behzad Taheri made equal contributions to this review article. They both participated in the conception, design, and execution of the systematic literature review, including the identification of relevant articles, data extraction, and synthesis of findings. Shiva Taheri and Behzad Taheri jointly analyzed the collected data and contributed to the interpretation of trends and advancements in epidemiological methods. They collaborated in drafting and revising the manuscript, including sections related to the introduction, methodology, results, and discussion. Both authors critically reviewed and edited the final version of the article prior to submission, ensuring the accuracy and coherence of the content.

## Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

## Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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## Declaration of Interest

The authors report no conflict of interest.

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# Ethics Considerations

Given that this review synthesizes published literature and does not involve primary data collection, ethical

approval was not required. However, the ethical standards and research integrity of the included studies were considered during the selection process.

# References

1. Singh A. 868 Harnessing new approaches and contemporary methods for better evidence on housing and health. *International Journal of Epidemiology*. 2021;50(Supplement\_1):dyab168. 615. [DOI]
2. Hansen GT. Continuous evolution: perspective on the epidemiology of carbapenemase resistance among Enterobacterales and other Gram-negative bacteria. *Infectious diseases and therapy*. 2021;10:75-92. [PMID: 33492641] [PMCID: PMC7954928] [DOI]
3. Canali S. What is new about the exposome? Exploring scientific change in contemporary epidemiology. *International Journal of Environmental Research and Public Health*. 2020;17(8):2879. [PMID: 32331256] [PMCID: PMC7215638] [DOI]
4. Nurminen M. Evolution Of Epidemiologic Methodology From The Statistical Perspective. *Internet Journal of Epidemiology*. 2002;1(1). [DOI]
5. F  rez JA, Cuevas-Ferrando E, Ayala-San Nicol  s M, Sim  n Andreu PJ, L  pez R, Truchado P, et al. Wastewater-Based Epidemiology to Describe the Evolution of SARS-CoV-2 in the South-East of Spain, and Application of Phylogenetic Analysis and a Machine Learning Approach. *Viruses*. 2023;15(7):1499. [PMID: 37515186] [PMCID: PMC10386001] [DOI]
6. Levterova B. APPLIED EPIDEMIOLOGY - HISTORY AND FUTURE. *Knowledge International Journal*. 2018;28:1179-82. [DOI]
7. Meza R, Jeon J. Invited Commentary: Mechanistic and Biologically Based Models in Epidemiology-A Powerful Underutilized Tool. *Am J Epidemiol*. 2022;191(10):1776-80. [PMID: 35650016] [DOI]
8. Giovanetti M, Pinotti F, Zanluca C, Fonseca V, Nakase T, Koishi AC, et al. Genomic epidemiology unveils the dynamics and spatial corridor behind the Yellow Fever virus outbreak in Southern Brazil. *Science Advances*. 2023;9(35):eadg9204.
9. Knowlden AP. Models and theories of behavior change relevant to sleep health. *Sleep and health: Elsevier*; 2019. p. 171-86. [DOI]
10. Lee JH. Addressing the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement in Archives of Plastic Surgery Reports. *Arch Plast Surg*. 2014;41(1):1-2. [PMID: 24511487] [PMCID: PMC3915148] [DOI]
11. Marshall AN, Lam KC. Research at the point of care: using electronic medical record systems to generate clinically meaningful evidence. *Journal of Athletic Training*. 2020;55(2):205-12. [PMID: 31935140] [PMCID: PMC7017890] [DOI]
12. Group CPH, Anglemeyer A, Moore TH, Parker L, Chambers T, Grady A, et al. Digital contact tracing technologies in epidemics: a rapid review. *Cochrane Database of Systematic Reviews*. 1996;2020(8). [PMID: 33502000] [PMCID: PMC8241885] [DOI]
13. Dang A. Real-World Evidence: A Primer. *Pharmaceutical Medicine*. 2023;37(1):25-36. [PMID: 36604368] [PMCID: PMC9815890] [DOI]
14. Hsing AW, Ioannidis JP. Nationwide population science: lessons from the Taiwan national health insurance research database. *JAMA internal medicine*. 2015;175(9):1527-9. [PMID: 26192815] [DOI]
15. Shrivastav LK, Kumar R. Gradient Boosting Machine and Deep Learning Approach in Big Data Analysis: A Case Study of the Stock Market. *Journal of Information Technology Research (JITR)*. 2022;15(1):1-20. [DOI]
16. Hu L, Li L. Using Tree-Based Machine Learning for Health Studies: Literature Review and Case Series. *International Journal of Environmental Research and Public Health*. 2022;19(23):16080. [PMID: 36498153] [PMCID: PMC9736500] [DOI]
17. Sambasivan R, Das S, Sahu SK. A Bayesian perspective of statistical machine learning for big data. *Computational Statistics*. 2020;35:893-930. [DOI]
18. Morgenstern JD, Rosella LC, Costa AP, de Souza RJ, Anderson LN. Perspective: Big data and machine learning could help advance nutritional epidemiology. *Advances in Nutrition*. 2021;12(3):621-31. [PMID: 33606879] [PMCID: PMC8166570] [DOI]
19. Park SB, Yoo C. Development of a graphical model of causal gene regulatory networks using medical big data and Bayesian machine learning. *Journal of the Korean Medical Association/Taehan Uisa Hyophoe Chi*. 2022;65(3). [DOI]
20. Alroobaea R, Rubaiee S, Hanbazazah AS, Jahrami H, Garbarino S, Damiani G, et al. IL-4/13 Blockade and sleep-related adverse drug reactions in over 37,000 Dupilumab reports from the World Health Organization Individual Case Safety reporting pharmacovigilance database (VigiBase  ): a big data and machine learning analysis. *European Review for Medical & Pharmacological Sciences*. 2022;26(11). [DOI]
21. Ogino S, Lochhead P, Chan AT, Nishihara R, Cho E, Wolpin BM, et al. Molecular pathological epidemiology of epigenetics: emerging integrative science to analyze environment, host, and disease. *Modern Pathology*. 2013;26(4):465-84. [PMID: 23307060] [PMCID: PMC3637979] [DOI]
22. Nishi A, Milner Jr DA, Giovannucci EL, Nishihara R, Tan AS, Kawachi I, Ogino S. Integration of molecular pathology, epidemiology and social science for global precision medicine. *Expert review of molecular diagnostics*. 2016;16(1):11-23. [PMID: 26636627] [PMCID: PMC4713314] [DOI]
23. Bosworth HB. Expanding the Boundries of Health and Social Science: Case Studies in Interdisciplinary Innovation: Physicians Postgraduate Press, Inc.; 2005. [DOI]
24. Cullati S, Carmeli C, Burton-Jeangros C, Chiolerio A. How the life course perspective transforms epidemiology. *Revue Medicale Suisse*. 2021;17(730):529-33. [PMID: 33755362] [DOI]
25. Weissman M. Translating epidemiology in psychiatry: the future is here. *Epidemiology and psychiatric sciences*. 2012;21(2):167-9. [PMID: 22789165] [PMCID: PMC3536441] [DOI]
26. Blandi L, Amorosi A, Leoni O, Clemens T, Brand H, Odone A. The potential of digital health records for public health research, policy, and practice: the case of the Lombardy Region Data Warehouse. *Acta Biomed*. 2023;94(S3):e2023121.



27. Yadav KK, Gaurav A. Application and Challenges of Machine Learning in Healthcare. *International Journal for Research in Applied Science & Engineering Technology*. 2023;11(9).
28. Samuel G, Buchanan E. Guest editorial: Ethical issues in social media research: SAGE Publications Sage CA: Los Angeles, CA; 2020.
29. Akindote OJ, Adegbite AO, Dawodu SO, Omotosho A, Anyanwu A, Maduka CP. Comparative review of big data analytics and GIS in healthcare decision-making. 2023.
30. Ewuoso C. An African relational approach to healthcare and big data challenges. *Science and Engineering Ethics*. 2021;27(3):34. [PMID: 34047844] [PMCID: PMC8160550] [DOI]
31. Bayomi N, Fernandez JE. Eyes in the Sky: Drones Applications in the Built Environment under Climate Change Challenges. *Drones*. 2023;7(10):637. [DOI]
32. Tamburis O, Benis A, Health SEftIYSTSOfO. Leveraging Data and Technology to Enhance Interdisciplinary Collaboration and Health Outcomes. *Yearbook of Medical Informatics*. 2023;32(01):084-8. [PMID: 38147852] [PMCID: PMC10751125] [DOI]
33. Vignali V, Hines PA, Cruz AG, Ziętek B, Herold R. Health horizons: Future trends and technologies from the European Medicines Agency's horizon scanning collaborations. *Frontiers in medicine*. 2022;9:1064003. [PMID: 36569125] [PMCID: PMC9772004] [DOI]