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How genetic determinism and essentialism relate to health care

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ABSTRACT

Genetics has become important in various areas of life, especially in healthcare. People can undergo a range of genetic testing to assess their susceptibility to acquiring diseases. Nevertheless, data derived from genetic testing might indicate bias due to genetic determinism and essentialism. This study aimed to provide a comprehensive analysis of the impact of genetic determinism and essentialism on several aspects of healthcare. This study conducted a systematic review approach using the Scopus database and followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) search framework. We initially received 802 publications, then reduced to 49 articles based on inclusion and exclusion criteria, and then content analysis was conducted. Our research showed that determinist bias and genetic essentialism may reduce patient diagnosis, treatment accuracy, and effectiveness. Moreover, biases related to genetic determinism and essentialism may go against healthcare regulations and cause discrimination and other negative clinical outcomes from ethical, social, and legal aspects. To improve this problem, it is essential for laypeople, particularly medical experts, to understand genetic principles related to the development of variances in traits among individuals in a precise and relatable approach.

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1. INTRODUCTION

Recent advances in health care indicate that genetics plays a fundamental role [1], with numerous diagnoses and treatments being conducted based on genetic factors. However, as genetics has progressed, there has also been a rise in the prejudice associated with genetic determinism and essentialism, which poses a real, dangerous, and unavoidable problem [2]. The increasing stigma related to genetic determinism is directly responsible for a significant number of prejudiced beliefs, such as racism or eugenics [3], [4]. Genetic determinism is the concept that genes play the most fundamental role in developing a phenotype. Genes are considered to have a more significant impact on the development of a phenotype than other factors, including epigenetics and environments, particularly for complex traits like behavior and personality [5], [6]. According to Ellison and de Wett, genetic determinism refers to the belief to explain different human social situations using biological factors in a negative way [7]. This concept of genetic determinism came from a conventional perspective on genetics that emphasized the connection between genes, proteins, functions, and traits. Therefore, it indicates most disorders are associated with a single gene [8]. Genetic determinism and genetic essentialism are strongly linked to the explanation of views regarding inequality [9].

Genetic essentialism is the idea that genes are fixed entities that determine the characteristics of an individual and are passed on to the next generation without any change [10]. Genetic essentialism is a reductionist perspective that believes an individual's genetic composition is an unchangeable attribute that defines their character and behavior [9]. Genetic essentialism beliefs can lead individuals to develop negative prejudices. These beliefs assume that people from the same social group, such as race or gender, share the same genes, resulting in physical, cognitive, and behavioral similarity and distinguishing them from other groups [3]. Genetic essentialism substantially impact inequality in multiple domains of life, including the realm of healthcare [11], [12].

Genes are currently receiving massive interest in the health industry for their role in determining individual characteristics. Various media tend to provide coverage of scientific research that establishes a connection between specific genetic variations and various human conditions [13]. One of the phenomenal reports that received much public attention was related to the design of the human genome sequence. The existence of this design then received an extraordinary response from President Clinton, who stated, "Today, we study the language that God used to create life, now it is conceivable that our children will know the term 'cancer' only as a constellation of stars" [14]. Through this response, scientists raised deep concerns regarding bias in interpreting scientific research findings [14], [15]. Geneticists also expressed worry that focusing too much on the role of genes can result in a heightened belief in genetic determinism and essentialism, which, in turn, can contribute to the rise of discriminating attitudes that are more likely to arise [14], [16].

In its evolution, this over-explanation at the gene level has even replaced some of the previous essences, including ideas like yoga and the Chinese notion of *chi*, which are crucial for comprehending personality and health [17]. An increase in requests for genetic testing of individuals to determine their risk of certain diseases has been seen in the public, indicating their interest in the role of this gene [18]–[23]. Societies widely use genetic testing to determine their offspring's potential genetic makeup [24], the likelihood of contracting fatal diseases [18], [25], and possible professions [13]. Other, more unexpected, situations include the belief that genetic heritability plays a significant role in predicting a variety of social phenomena, including divorce [26], [27], religiosity [28], mental health [20], [29], smoking prevalence [30], and even individual behavior [4], [31]. For instance, when diagnosing depression, a doctor may excessively prefer the genetic testing results of a patient who is discovered to have a genetic predisposition to depression, while disregarding environmental factors like stress and sleep patterns. This can lead to ineffective treatment.

Despite the discovery of a genetic correlation with the origins of different disease forms, additional theories, such as those related to social and environmental factors, are still required to support this genetic explanation [32]. In general, many diseases or characteristics investigated deterministically and existentialistically appear from the expression of multiple genes that interacting. Social situations and environmental factors also play an essential role [33]–[35]. People frequently believe that an illness is formed only due to hereditary causes when determinism bias and genetic essentialism occur, despite a complex network of etiological interactions [36]. Moreover, when people continue maintaining this genetic determinism and essentialism attitude, they will undervalue important aspects like experience and environment while trying to treat a specific condition. They will believe more in the genetic components of the condition [33]. Several studies have revealed that the stigma associated with essentialism and genetic determinism has deterred certain groups of people from having children because they worry that their mental health issues would be inherited by their progeny [37], [38]. The question of how far the diagnosis and treatment of different types of diseases on a genomic basis are explained by views in genetic determinism and essentialism is then brought into focus through the emergence of this issue.

The combination of essentialism and genetic determinism in its evolution also has consequences for rising public health issues, especially social, ethical, and legal problems. It is generally accepted that the strong trust in genetic essentialism and determinism is an unusual concept that substantially impacts the medical field and cannot be altered or compared to other medical theories. This belief in genetic determinism and essentialism claims that even weak genetic explanations can reveal significant truths and serve as the foundation for various judgments related to universal health [25], [29]. However, this deeply held belief has forced decision-makers in every country to deal with scientific dilemmas related to moral, legal, and social healthcare concerns. Significant worries about discrimination are unavoidable when a policy depends on deterministic bias and genetic essentialism, particularly when it comes to vulnerable populations like children [39], unborn children [37], and criminals [34].

Even for sensitive data, the possibility of wide usage of a child's genome test results becomes greater [40]. Long-term usage of a kid's genetic information may result in imbalances, such as identifying or differentiating a child based on behavior or academic capacity, which will affect the child's chances of employment in the future [41]. These ethically doubtful geneticization concerns might also affect babies receiving noninvasive prenatal testing [42]. This testing can impact a mother's and infant's access to health services and their ability to apply to governments for social support when it comes to complicated traits like behavior with a poor genetic foundation and unclear outcomes [36], [43]. Discrimination and stigmatization

of criminals are additional issues that may arise from the misuse of genetic data [31]. People will perceive the criminal behavior of prisoners as inherited, making others who commit similar crimes more likely to conduct them again. In addition, these convicts may face prejudice in every area of life or even be rejected by society. Investigating the moral, legal, and social implications of essentialism and genetic determinism on clinical practice and public health is necessary for avoiding these negative impacts. It is crucial to have a solid understanding of genetic principles to conduct comprehensive research, particularly genetic determinism and essentialism in health care.

Understanding genetics, in general, is crucial to reducing or correcting the bias of essentialism and genetic determinism, especially in healthcare. Genetic concepts may be learned through a variety of methods, however, this knowledge is only a component that can be obtained after some time. Special efforts are needed to achieve credible and accurate knowledge of genetic concepts. Genetic learning is one method that may be used to get a reliable understanding of genetic ideas [1]. According to earlier research, such as [44], [45], genetic learning about gene variations within or across racial groups might seriously counteract the bias of genetic essentialism and determinism that permeates many facets of life, including the medical field. Racial prejudice and the misperception of genetic racial groups can be successfully reduced when people are provided accurate, scientific knowledge about human genetic differences [3], [46]. Focusing on genetic variety and genetic learning may reduce social inequity that stems from solely genetic variables [47]–[49]. Genetic education may also assist people in realizing that social characteristics, including IQ, social behavior, and some illnesses, are determined by social interactions rather than being only a result of genetics [47]. Given the potential of genetics education, further information about how genetics education might increase genetic essentialism and determinism in the medical field requires particular focus.

In order to address this problem, it is crucial to carry out an extensive study of genetic determinism and essentialism in healthcare. This can be achieved by utilizing data from Scopus, which is widely recognized as a reputable and well-used database. A thorough analysis of the publications in this database is required to obtain valuable insights into the impact of determinism and genetic essentialism on the quality of health services and the potential of genetics education in addressing these biases. A highly recommended approach for examining and analyzing these issues is a systematic literature review (SLR). The SLR is a rigorous and transparent process that involves identifying, synthesizing, and evaluating all relevant data, whether it is quantitative or qualitative, in order to generate precise and reliable responses [50]. SLR offers several benefits to researchers, particularly in giving a brief and thorough overview of the material found in databases related to their study topics [51]. SLR can assist researchers in identifying both methodological research gaps and issues that necessitate additional investigation. It can also aid in developing new research ideas and synthesizing multiple references in a critical and constructive approach [52]. In this study, there are research questions which include the following: i) RQ 1: How do genetic determinism and essentialism explain the genomic diagnosis and treatment of various diseases?; ii) RQ 2: How do genetic determinism and essentialism impact public health and clinical practice from an ethical, legal, and social perspective?; iii) RQ 3: How can genetics education decrease genetic essentialism and determinism levels in the medical field?

2. METHOD

2.1. Research framework

This research is a SLR, which is a process that involves three steps: i) presenting all published evidence related to the research question, ii) synthesizing scientific evidence to answer a specific research question in a transparent and reproducible way, iii) evaluating the quality of the evidence presented [51]. This research uses a SLR methodology supported by narrative analysis. The narrative approach facilitates a comprehensive and complex presentation of findings, providing a credible response to specific review topics, including how genetic determinism and essentialism relate to health care. It can also highlight areas of our understanding that require additional research. It can also convey the robustness of the accessible evidence and the quality of the included studies, indicating the confidence that practitioners, policymakers, and the popular media should place in the results. Research synthesis can also facilitate assessment of the efficacy of a policy, program, technique, or intervention across different user subgroups and provide insight into potential side effects.

2.2. Search term

The search in the Scopus database uses the "AND" operator to combine the keywords determinism and genetic essentialism. This search was conducted in 2024. We obtained a total of 802 articles from the Scopus database. Several papers discovered show publication years ranging from 2006 to 2023. The majority of articles were discovered in 2019. The acquired data is kept in comma separated values (CSV) and RIS formats and synchronized with Mendeley. The search history for articles in Scopus runs as ALL (essentialism+genetic AND determinism) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (SUBJAREA, "MEDI") OR LIMIT-TO (SUBJAREA, "NURS")).

2.3. Selection of papers for inclusion in review

Our research employed the preferred reporting items for PRISMA [51] to establish the inclusion criteria and methods of search. After a search for keywords, researchers examine the titles and abstracts of articles to identify target papers that match the specified criteria: i) publications including research/original articles, ii) articles published in English, iii) only articles that are open-access and indexed by Scopus, iv) the subject area of the article is nursing and medicine and, v) only abstracts and full-text articles are selected that are appropriate to the theme being discussed.

Suppose the abstract of an article needs to provide more information. In that case, we will analyze the important sections of the part, such as the methodology and results, to establish a judgment. In addition, the researchers applied the following exclusion criteria to filter out papers that were not included in this study: i) Publications with the type of conference paper, book chapter, conference review, review, editorial, and book; ii) Non-English published studies; iii) Non-open access articles and not indexed by Scopus; iv) Not relevant to the theme being discussed; and v) Incomplete text. The order of review of inclusion and exclusion that we carried out is presented in Figure 1.

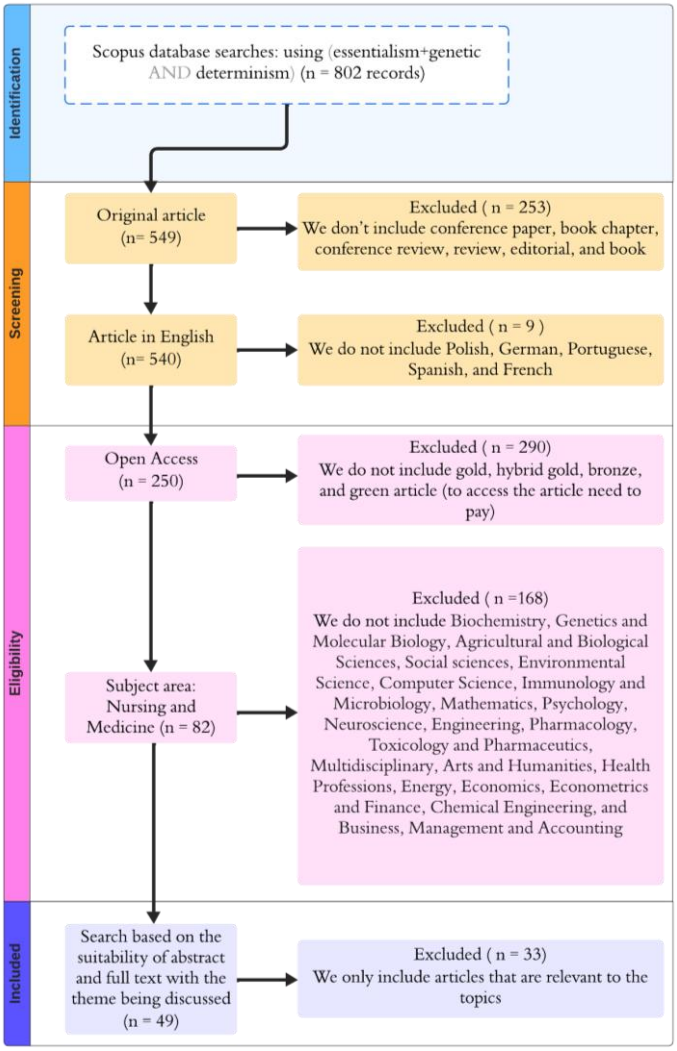

Figure 1. Systematic review flow diagram source: authors' own elaboration

Figure 1 shows that the original search found a total of 802 items. Subsequently, we selectively considered publications that exclusively contained research/original papers, identifying 549 articles, and 253 articles were excluded. Next, we applied the second criterion, specifically selecting only publications that were published in English. Using this criterion, we obtained a total of 540 articles. Consequently, nine articles that use Polish, German, Portuguese, Spanish, and French were removed from the analysis. In

general, authors need more capacity to comprehend these languages. The author intentionally avoids using Google Translate to mitigate the risk of translation inaccuracies and misinterpretations. This approach also saves time compared to hiring professional translation services, which can be pricy. According to Mheissen *et al*., it has been demonstrated that limits do not result in biased effects [53]. For the next step, we exclusively utilized open-access publications. Out of them, 250 articles satisfied the established criteria, whereas 290 articles were excluded. For the next step, we applied the topic area inclusion criteria of "nursing and medicine" and selected 82 papers, excluding 168 publications. We prevent the inclusion of inappropriate subject areas such as biochemistry, genetics and molecular biology, agricultural and biological sciences, social sciences, environmental science, computer science, immunology and microbiology, mathematics, psychology, neuroscience, engineering, pharmacology, toxicology and pharmaceutics, multidisciplinary, arts and humanities, health professions, energy, economics, econometrics and finance, chemical engineering, and business, management and accounting. During the concluding phase of the search, we thoroughly examined the existing articles and verified their relevance to the topic under discussion. Four researchers individually reviewed each article included in this systematic review. To deal with the differing opinions that evolved during the review process, we needed an open discussion method until consensus was achieved. If the discrepancies remain unresolved, a third researcher with deep knowledge of the subject was requested to provide a conclusive evaluation. At the final stage of the search, we found 49 articles that were appropriate or met the criteria, and 33 articles were excluded. Most of the papers in this systematic literature review used quantitative methods (24 articles), followed by qualitative methods (21 articles), while mixed approaches were the least applied (4 articles).

3. RESULTS AND DISCUSSION

The investigation's findings will be provided in this section as a review of the earlier research questions. This review will highlight the key insights gained from the study, emphasizing the relationship between the results and the original hypotheses. The following subsections will provide further details on the findings and discussion of every research study. Additionally, these subsections will discuss the implications of the results in the context of existing research, providing a comprehensive understanding of the study's contributions.

3.1. Explanation of genetic determinism and essentialism in the genomic diagnosis and treatment of various diseases

The bias of genetic determinism and essentialism has significantly influenced the medical field. Both stigmas impact diagnoses and treatment-related aspects of medicine. Further information on the influence of determinism and essentialism on the scope of diagnosis and treatment of various diseases or disorders can be reviewed in Table 1.

According to the data and information shown in Table 1, it can be determined that genetic determinism and genetic essentialism are the primary variables that cause inaccurate diagnosis and the emergence of a fatalistic belief that a disorder or disease is unchangeable [4]. Biases resulting from genetic determinism and essentialism will additionally guide the interpretation towards the possible significance of genes as causal factors in specific situations, behaviors, and diseases [23], [24], [54]. The belief in genetic determinism and essentialism bias is seen to be the main factor influencing decision-making in challenging medical situations, such as deciding whether to terminate a pregnancy or move a patient's care to palliative care [55]. Generally, there needs to be more awareness among the public regarding the bias of genetic determinism and essentialism in interpreting genetic test results [13]. Despite this, genetic testing remains the preferred method for assessing the health status of individuals [13], [25], [43], [56]. Increased market demand has led to a quick growth in support from companies providing genetic testing services, accompanied by a notable decrease in the cost of genotype testing [43]. Various genetic tests, including direct-to-consumer (DTC) [13], [56], PGS tests [32], and WES [57], have been conducted for a range of objectives, from diagnosis to informing decisions about a medical condition.

Although there has been some progress, it is still necessary to adequately address the problems of determinism bias and genetic essentialism. Furthermore, ensuring accuracy in the diagnostic process remains a complex topic that requires particular attention. Additional risks related to protecting the patient's identity, such as a decreased willingness to share information and undergo future genetic testing, should be investigated [24], [25], [54], [58]. Moreover, if determinism bias and genetic essentialism mistakes during the diagnosis process are not immediately fixed, there is a strong likelihood of inaccuracies emerging in later medical procedures.

When genetic determinism and essentialism bias continue throughout the diagnosis and treatment process, the challenges will escalate and become increasingly intricate. Patients who have experienced the negative perception of determinism and essentialism will have an inflated belief in the role of genes in

determining a disease [20]. In addition, patients may lose or have a diminished level of motivation to undergo treatment due to their perception of the limited impact of their environment, personal experiences, and lifestyle on the healing process of their specific condition [2], [33], [55]. In contrast, a robust genetic explanation is only associated with a monogenic etiology of a condition, such as in cases like Huntington's disease when the disease-causing gene has a well-defined connection [2]. Nevertheless, patients will continue to hold on to these monogenic ideas and generalize them to different characteristics or even social phenomena such as divorce [26], [27], [59], religion [28], mental health [20], and smoking [30], as well as the behavior of individuals [4], [20], [31], [60], [61].

Table 1. Implications of genetic determinism and essentialism in the diagnosis and treatment of various types of diseases or disorders

No	Aspect	Information	Reference
1	Diagnosis	• The concepts of determinism and genetic essentialism biases can easily arise during genetic testing, which is used to make decisions regarding various medical procedures. These procedures include terminating a pregnancy, transitioning patient care to palliative care, which focuses on improving quality of life rather than curing the condition, providing recommendations to patients for future health preparation, diagnosing conditions like polycystic ovary syndrome (PCOS), diagnosing congenital diseases such as Alpha-1 Antitrypsin Deficiency, and determining an individual's risk of developing chronic diseases.	[55], [62]–[65]
		• One example of a genetic test that is vulnerable to determinism and genetic essentialism bias is the direct-to-consumer (DTC) genetic origin test. The DTC test can have a significant impact on various aspects, including: a. An individual's self-identity. b. Their inclination to share genetic information with family members and medical professionals. c. Their willingness to do additional genetic testing. Genetic testing bias can lead to negative consequences for patients, including reduced motivation to maintain their overall wellness.	[25], [54]
		• Active participation from genetic counsellors, doctors, and the public is necessary for safely using genetic scoring tests (polygenic scores/PGS). This involvement is crucial in understanding the advantages and disadvantages of PGS tests and ensuring their equitable application in accordance with patient-centred healthcare principles. Supporting the equitable and inclusive implementation of health programs that include PGS tests requires the participation of multiple stakeholders. It is crucial to prevent any biases related to genetic determinism and essentialism while also aligning the programs with the community's specific needs.	[32], [62]
		• To prevent the influence of genetic determinism and genetic essentialism in diagnosing a disorder solely based on genetic test results, it is necessary to conduct thorough research on the intricate interplay of different types of genes and the impact of environmental factors that can contribute to the development of a specific disorder or disease.	[33], [46]
		• Whole exome sequencing (WES) is an essential tool used to diagnose and prevent many kinds of genetic abnormalities in individuals. To ensure accurate outcomes, engaging in efficient and compassionate communication regarding the consequences of this novel approach and establishing a definitive strategy for presenting test results to prevent any influence from genetic determinism and essentialism biases is essential.	[57]
2	Treatment	• Believing in determinism bias and genetic essentialism can amplify the negative stigma around patients by attributing an excessive influence of genes in the development of specific diseases or disorders. Individuals with a firm conviction in determinism and genetic essentialism tend to underestimate the influence of the environment and lifestyle on the recovery process of disorders or diseases such as Alzheimer's, dementia, schizophrenia, depression, alcohol addiction, smoking habits, or weight loss.	[20], [30], [65]–[74]
		• Disseminating information to treat specific disorders or diseases in patients with determinism bias and genetic essentialism can be facilitated by broadcasting through electronic and non-electronic mass media. Nevertheless, it must receive support from a range of additional intervention activities.	[30]
		• Genetic determinism and essentialism bias in genetic test results can lead patients to fixate on the symptoms of particular diseases or disorders excessively.	[75]
		• Providing education on determinism bias and genetic essentialism, specifically about the impact of genes on conditions like obesity, has the potential to be a valuable element in the effort to treat both adults and children successfully.	[39], [76]
		• Belief in determinism or genetic essentialism among family members at high risk of inheriting a congenital disease, such as cancer, may increase their willingness to take preventive measures, such as adopting a healthy lifestyle. Additional research is required to comprehend the variations in response, particularly among persons who have obtained positive test outcomes.	[61], [77]

Previous case studies have consistently shown that psychiatric illnesses, such as depression, are often associated with a monogenic gene interaction. When individuals with depression are informed about their genetic predisposition to depression, they tend to report increased levels of depressed symptoms during

the prior two weeks [67]. Under different circumstances, people who are aware of their genetic predisposition to alcoholism recognize that their capacity to regulate alcohol consumption decreases compared to those who are unaware of this risk [33], [69] What is even more surprising is that when depressive disorders or alcoholism are frequently associated with genetic and other biological characteristics, individuals tend to have a less optimistic perspective on their chances of recovering in the future [67]. Despite receiving an intervention video from the mass media that clarified the non-deterministic nature of genes in causing depression or alcohol addiction, the deterministic effect kept going in these individuals. This condition was observed even though nearly all participants comprehended the video's main message [67], [69]. Failure to succeed in recovery can also be attributed to genetic determinism and essentialism bias. This bias views problems in the brain or specific genes as inherent symptoms that are unchangeable [9].

Genetic determinism and essentialism pose a persistent problem in the context of obesity. Certain obese persons in the United States who attribute their weight to biological factors such as genetics have raised the idea that weight is an immutable and unchanging characteristic [18], [39], [65]. Additionally, it was discovered that hereditary variables in individuals with obesity were inversely associated with the belief that body weight could be managed [73]. Furthermore, research has demonstrated that this genetic explanation during the development process might decrease one's belief in their ability to achieve goals and their motivation to engage in physical activity [76] while increasing their desire to consume unhealthy foods [65]. This predisposition towards genetic determinism and essentialism can also manifest in family members who have a heightened susceptibility to inherited conditions, such as cancer. As scientific knowledge improves, family members may exhibit positive behavior by becoming more motivated to engage in preventive measures, such as adopting a healthy lifestyle [57]. Nevertheless, additional investigation is required to comprehend these discrepancies in reaction, particularly among persons who have obtained positive test outcomes.

Based on the study, genetic determinism and essentialism biases can lead to diagnostic inaccuracies and impact treatment decisions, particularly in complex cases where genetic factors are overemphasized at the expense of environmental or lifestyle considerations. This can result in a healthcare environment where patients feel resigned to their genetic fate, reducing their engagement with treatment and preventive measures. As genetic testing becomes more common, healthcare providers must be vigilant in communicating the limitations and context of genetic information to prevent these biases from leading to a sense of inevitability in patients. Addressing these biases is essential for ensuring that genetic insights contribute positively to patient care, fostering a healthcare system that promotes holistic and individualized treatment strategies rather than one constrained by deterministic views of disease and health outcomes. To address these biases, training programs and policy-making protocols can help medical professionals interpret genetic test results more effectively. Policymakers can ensure the ethical use and interpretation of genetic testing, while public awareness campaigns can educate the public on hereditary influences on health. Embracing non-genetic factors and promoting research into gene-environment interactions can also help mitigate biases. Implementing these measures can improve diagnostic accuracy, therapeutic interventions, and patient genetic testing results.

3.2. Implications of genetic determinism and essentialism on public health and clinical practice reviewed based on ethical, legal, and social aspects

In general, the emergence of determinism bias and genetic essentialism can have a widespread impact, extending to various aspects of life, including health. Therefore, doctors, nurses, and medical professionals must comprehend the principles associated with genetic determinism and essentialism bias within the healthcare. Table 2 provides information regarding the influence of determinism bias and genetic essentialism on public health and clinical practice, specifically about ethical, legal, and social considerations.

Based on the findings and comprehensive analysis of the data in Table 2, genetic determinism and essentialism bias negatively influence every aspect. These biases can lead to misconceptions about the role of genetics, fostering a belief that individuals have little control over their health outcomes. These biases distort the perception of genetic information and contribute to deterministic mindsets that can limit individuals' beliefs in their ability to influence their health and well-being. Furthermore, the various negative influences of genetic determinism and essentialism on various aspects are summarized in the illustration in Figure 2. This figure highlights how these biases can affect decision-making, personal motivation, and public attitudes toward genetic factors, underscoring the need for more nuanced communication and education about genetics.

Table 2. Implications of genetic determinism and essentialism on ethical, legal, and social aspects of clinical practice

No	Aspect	Information	Reference
1	Ethics	• Some argue that the genetic elements of each individual are a distinct aspect that needs specific ethical guidelines. The concepts of genetic determinism and essentialism may undervalue these distinctive considerations.	[66], [78]
		• Genetic determinism and essentialism stigma could restrict a patient's autonomy in making decisions about their treatment or other medical procedures related to their genetic composition.	[79]
		• Issues related to determinism bias and genetic essentialism frequently arise in the treatment and genetic research of many mental diseases, giving rise to ethical concerns. An ethical concern in genetic research on mental disorders involves the utilization of photography in studying neurodevelopmental problems, the development of antisocial classification systems based on biomarkers, and the availability of genetic testing that can predict suicide risk and is accessible to everyone else.	[29], [80]–[82]
		• The presence of determinism bias and genetic essentialism can create ethical dilemmas when interpreting genetic testing results for individuals with mental disorders. This phenomenon can result in decreased patient motivation to recover, less psychosocial support, and issues related to social justice.	[83]
		• Ethical dilemmas caused by genetic determinism and essentialism can also occur when conducting genomic sequencing on newborns and vulnerable populations, like criminals and women.	[37], [84]
2	Social	• Genetic determinism and essentialism bias resulting from genetic testing of people with mental problems might foster unfavorable societal stigma towards these patients and potentially lead to acts of discrimination.	[33], [83]
		• The presence of determinism bias and genetic essentialism in the genetic test findings of children who have experienced physical violence can impact society's perception of the child's potential risk to others and, consequently, the necessity of medical intervention.	[85]
		• Genetic determinism and essentialism bias could restrict the distribution of clinical resources and the delivery of health services in a restricted manner that prioritizes the preferences of specific populations.	[86]
		• There are still numerous conflicts in practice between different treatment mechanisms based on genetic determinism or essentialism throughout local communities' social, political, and cultural values.	[12], [87]
3	Law and Policy	• The presence of determinism and genetic essentialism can contribute to significant achievements in challenging and complex situations, such as identifying victims in the aftermath of the 2004 Aceh Tsunami disaster. However, the widespread implementation of this concept is not feasible due to the lack of globally accepted guidelines that govern these activities.	[88]
		• The criteria for determining the legitimacy of studies on genetic determinism and essentialism, including research on reprogenetics, have yet to be established.	[78]
		• Numerous technical regulations still need to be explicitly defined to prevent determinism bias or genetic essentialism at different stages of genetic testing. These regulations should cover privacy, planning, interpretation, and the disclosure of test results. Additionally, penalties should be established for any misuse of genetic test results by patients or respondents.	[66], [79], [80]
		• There needs to be more comprehensive global and domestic legislation that monitors the evaluation of research and technology advancements without the potential to increase the tendency towards genetic determinism or essentialism.	[12], [62], [89]
		• Additional moral and legal justification is required to ensure the implementation of genetic quality enhancement in humans is not susceptible to deterministic or genetic essentialist prejudice.	[84], [85]

Based on Figure 2, several ethical issues related to genetic determinism and essentialism bias are discussed in aspects of clinical practice that predominantly occur in the treatment of individuals with mental disorders [83], as well as noninvasive prenatal testing for babies [43]. A concerning aspect of genetic determinism and essentialism bias in psychiatric research is the application of photography in genetic investigations on neurodevelopmental disorders [80], a classification system based on biomarkers for antisocial behavior [81], and genetic tests to predict the risk of suicide in the population in general [29]. The research has faced criticism from several sources as a result of several genetic biases. These biases have been argued to require ethical guidelines for using individuals' genetic characteristics [78]. When there are biases of genetic determinism and essentialism in a patient's genetic mechanisms, it can lead to an underestimation of the individualized consideration of each patient's genetic state. The negative perception of genetic determinism and essentialism might restrict patients' autonomy in choosing their treatment or other medical procedures associated with their genetic makeup [79].

The ethical problems associated with genetic determinism and essentialism bias can also arise in infants who undergo noninvasive prenatal testing [36]. Usually, commercial laboratories exclusively offer this type of testing and are specifically designed to identify specific trisomy disorders, such as Down syndrome, Patau syndrome, and Edwards syndrome [43]. Despite the extensive implementation of this testing on a large scale, there are concerns regarding increased determinism bias and genetic essentialism. This condition is because the widespread availability of testing through commercial sources is believed to have inadequate regulations and quality control systems [58]. This concern may result in the misinterpretation of patient genetic testing results, causing a decrease in the individual's desire to recover, psychological support, and issues related to social justice [83]. Patient advocacy groups, like the National Down Syndrome Society, have expressed concerns regarding the utilization of noninvasive prenatal testing. They worry that this testing may promote social discrimination against individuals with Down syndrome. This discrimination can occur through higher rates of terminating pregnancies and decreased motivation to develop treatments for patients with Down syndrome [38].

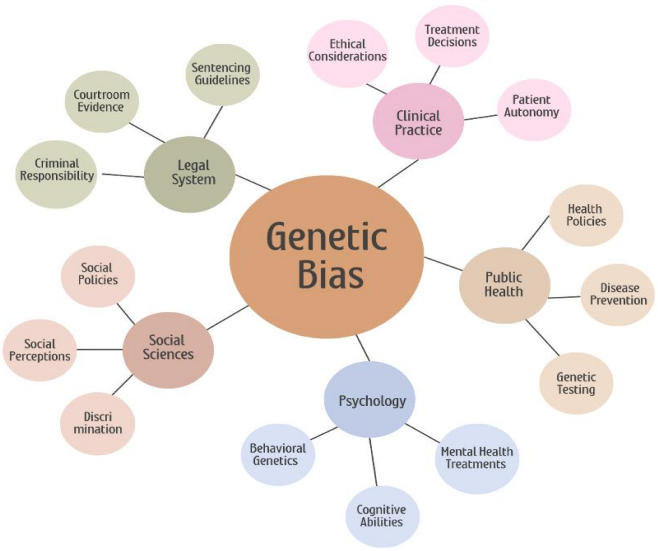

Figure 2. Illustration about the impact of genetic prejudice on various aspects of life source: authors' own elaboration

Several comprehensive genetic investigations have been conducted to determine several aspects of behavior, including moral judgments [9] and the dimensions and cognitive capabilities of brain regions associated with language, memory, decision-making, and judgment [27]. A study conducted in 2011 discovered a correlation between "innate number sense" before receiving mathematics education and achievement in mathematics learning. Those investigations suggest that genetics may play a role in determining mathematical ability to some extent [90]. Genomics has gained widespread popularity and is no longer limited to laboratories or clinics. It is now a regularly discussed issue in popular media and has partially been used to explain the underlying. Reasons for different common behaviors. Using genetic findings to explain this behavior will subsequently be regarded as having policy implications and holds the potential for targeted implementation.

When a social policy is implemented with a predisposition towards genetic determinism and essentialism, it has a high likelihood of causing stigmatization and prejudice among the public. Discrimination can manifest in vulnerable groups, including criminals [31], [34]. Criminals' illegal behavior may be perceived by society as having a genetic basis, making them more likely to engage in similar activities in the future. Consequently, these individuals may be excluded from several aspects of life, including access to healthcare services [91]. The tendency towards genetic determinism and essentialism may restrict the allocation of clinical resources and the supply of health services, as it prioritizes specific races or groups [86]. Children who have been victims of physical violence and have undergone genetic testing may experience similar issues [85]. Given the outcomes of conducted tests and the presence of determinism bias and genetic essentialism, society will become increasingly convinced of the child's potential risk to other children. Therefore, it is imperative to establish a distinct group apart from the wider society. Henceforth, this act of discrimination may have consequences on the categorization of children, impacting their prospects for employment or involvement in other domains of life, such as culture or politics [41].

Determinism bias and genetic essentialism not only influence ethical and social aspects, but they can also have an impact on related legislation. Genomic testing has been extensively utilized as evidence in court [92], and it has the potential to have a lasting impact on the field of law and criminal justice in the future [91]. In the criminal procedure, the determination of responsibility for an act requires the identification of two essential aspects of the crime: actus reus, which refers to the actual violation of the law, and mens rea, which refers to the mental state that demonstrates responsibility [93]. Genetic proof can be used in this phase of the trial to deny actus reus by asserting that the defendant's actions are consistent with innocence, such as self-defense or accidental behavior, or to confront or mitigate mens rea by claiming that the defendant had no intention to commit a crime, such as pleading insanity [38]. Consistent with this idea, behavioral genetic data can be presented to diminish criminal responsibility by decreasing the quantity or severity of punishments given [34], [94]. However, the presence of genetic data is also extremely vulnerable to determinism and genetic essentialism bias. This bias assumes that a person's identity is exclusively shaped by their inherent genetic makeup, implying that aspects of their biology have affected the defendant's ability to make choices freely. Situations like this are increasingly common in hypothetical situations, illustrating that, on average, surveyed judges tend to impose reduced prison terms on offenders when there is biological evidence indicating that the suspect has a predisposition to psychopathy [94].

3.3. The potential of genetic learning in improving the level of genetic determinism and essentialism in the health sector

As the health sector expands rapidly, handling determinism bias and genetic essentialism is crucial to avoid potential risks to future health services. Genetic education is a key pathway to enhancing the degree of genetic determinism and essentialism in the future. Table 3 provides information on how genetics education might enhance the awareness of genetic determinism and essentialism in healthcare.

Table 3. The role of genetics education in improving the level of genetic determinism and essentialism in the health sector

No	Aspect	Information	Reference
1	Knowledge	• The presence of determinism and genetic essentialism in an individual's comprehension of genetic test results can be influenced by: (a) their personal and familial experiences with disorders or diseases they have endured, and (b) their prior experiences with healthcare services. To mitigate the bias of both components, it is necessary to provide a genetic explanation that is conceptually relevant and understandable to the general audience.	[35], [95]
		• To enhance the effectiveness of public health research in promoting better health outcomes and avoiding biased views on determinism and genetic essentialism, it is crucial to address the knowledge gaps in society, particularly those connected to genetic concepts.	[67], [70]
		• Providing factual education about the impact of non-absolute genes in developing a specific condition can enhance the patient's motivation to recover.	[67]
		• Public opinions of science are frequently influenced by cultures that may only sometimes provide correct information. Culture is frequently regarded as the source of erroneous information in education and science. However, culture can also serve as a source of narratives and metaphors that facilitate discussions on genetics, which are more accurate and free from the influences of determinism or genetic essentialism.	[96]
2	Skills	• In the current genomics era, numerous programs have been developed to assist the public in enhancing their understanding of genetic ideas. Within higher education programs, multiple projects involving investigating the CCR5 gene using bioinformatics databases have been conducted. Students can develop the ability to examine preexisting data to avoid oversimplification and biased interpretations of genetic concepts, including both deterministic and essentialistic biases.	[46]
		• Nurses must have a strong understanding of consumer genetic testing to help patients interpret their genetic test results. This knowledge is crucial for helping patients make educated medical choices and preventing the influence of genetic determinism and essentialism biases.	[56]

According to Table 3, genetic education can diminish the prejudice of genetic determinism and essentialism through two main aspects: knowledge and skills. The main focus in this knowledge domain is on individual expertise in an accurate and thorough understanding of genetic information and literacy. Whenever it involves skills, the focus is on the specific competencies of medical professionals in delivering healthcare services. Moreover, the capacity of genetic learning to decrease negative stigma is supported by several fields, as seen in Figure 3. By providing specific support and implementing a robust educational framework, we can achieve a significant educational experience that will mitigate genetic prejudice and enhance overall well-being and comprehension in diverse domains, including healthcare, education, and social matters.

Genetic education can effectively diminish ideas in determinism and genetic essentialism bias when conducted with commitment and by including multiple educational components. Curriculum [97], learning activities [98], teaching materials, and learning media [99] significantly encourage meaningful genetics

education. A well-planned curriculum should include a complete understanding of genetics, ranging from fundamental concepts such as genes and gene-environment interactions to the development of genetic diversity within society [100]. The Weldonian curriculum has been identified as having the capacity to offer effective genetics education and can decrease individual belief in the concept of excessive genes [100]. The Weldonian curriculum educates students on the complexity of genetic factors in early learning. As an example for illustrating the challenge of explaining complex diseases, students are presented with a schematic representation of the various elements that are recognized to impact the probability of an individual having an illness, such as cardiovascular disease (CVD). Subsequently, students are challenged to establish connections between the factors and the disease CVD and the interrelationships among the factors themselves. Relationships can be established by employing solid lines to represent verified causal connections and dotted lines to represent hypothesized causal connections. Subsequently, students are stimulated to think about the potential hereditary factors responsible for CVD and whether they believe an effective genetic treatment for the problem would ever be accessible. Students commonly think that this is unreliable, as they comprehend that a certain phenotypic or disease can arise from both environmental and genetic causes in the same proportion. The primary focus of the Weldonian curriculum is to explain the significance of both genes and the environment in the development of a specific phenotype or disease, emphasizing their equal significance. A Weldonian curriculum typically relies on the implementation of progressive educational approaches, such as project based learning (PjBL) [101], reading, questioning, and answering (RQA) [98], problem-based learning (PBL), or a combination of PBL and RQA [101]. These approaches are designed to promote active and logical learning experiences, thus mitigating the influence of genetic determinism and essentialism. Genetic learning activities often rely on teaching materials and media to enhance the learning experience. These include virtual classrooms [101], and augmented reality-based media [99]. Augmented reality allows students to understand better the processes of personality formation in individuals, including genetic and environmental factors, more realistically [102].

Understanding genetic ideas is crucial for medical professionals and society. The interpretation and decision-making process regarding medical processes performed by patients is mainly based on several genetic notions, ranging from the gene level to the influence of the environment on the production of effects or variations in features at the level of life organization [25], [41], [42]. In addition to its role in action, genetic knowledge is also a significant tool for resolving determinism bias and genetic essentialism in the field of health [2], [19], [44]. The presence of biases in genomic mechanisms within the medical field can often be attributed to the limited genetic knowledge of individuals or a lack of experience among healthcare professionals [3]. From the standpoint of theory, only about 2% of the characteristics that everyone has can be attributed to a robust genetic or monogenic-based explanation [9]. Typically, the connection between genotype and phenotype in human health phenomena is complex, involving the interplay of many genes or influenced by environmental factors [46], [56], [96]. Engaging in meaningful genetic learning is a practical approach to enhance genetic understanding [101]. Genetic learning contributes to the understanding that social qualities, including intelligence, social behavior, and some diseases, are not only determined by genes but also by social interactions [103]. Previous research investigations have shown that teaching individuals scientifically accurate knowledge about human genetic variations might significantly diminish racial biases and inaccurate views of genetic racial categorizations [17]. Explicit genetic learning can also help students not view genetic information simply as an incomprehensible concept but rather comprehend the fundamental principles of genetics that contribute to the diversity of features in all individuals [104].

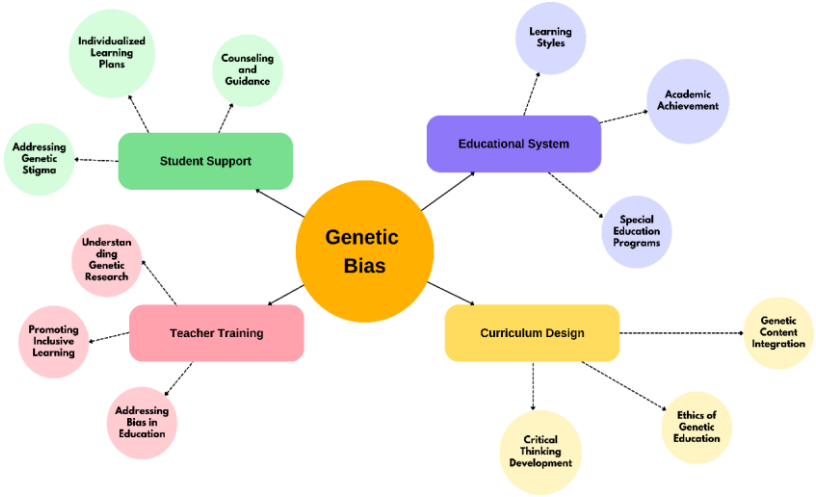

Figure 3. Understanding the role of genetics in education to overcome the beliefs of determinism and essentialism

4. CONCLUSION

This research shows the negative impacts of genetic determinism and essentialism bias in diagnosis and healthcare, potentially resulting in misdiagnosis and limiting treatment efficacy. These biases have significant implications in ethical, legal, and social domains, suggesting additional research for effective mitigation. A proposed solution is to enhance the public's and medical professionals' comprehension by integrating genetics education within the curriculum, organized instructional methodologies, and reliable educational resources. This research is limited by restrictions in the literature search since using keywords that do not specifically include educational elements may result in the absence of significant studies. A comprehensive interdisciplinary research integrating genetics, medicine, law, and ethics may be crucial in mitigating the negative impacts of genetic bias and optimizing the advantages of genetic data within the healthcare system.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration. This article is part of a student's dissertation, which is the first author. The roles of each author in more detail include:

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This research has received Ethical approval from the State University of Malang with the number No.17.10.2/UN32.14.2.8/LT/2024.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [SZ]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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