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Exploring the Impact of Meta-Analysis in Scientific Research: A Review

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Abstract: Meta-analysis is a well-established statistical analysis method that aims to analyze the number of different studies, which are addressing the same hypothesis. This statistical analysis increases the efficiency of the output and provides us with consensus and significant results. When addressing several datasets, the relevance of the meta-analysis is revealed when some hidden feature or the results are brought up. The available literature also provides us with references to numerous meta-analysis studies in different scientific areas to provide new insight into available research with discoveries and outcomes. In our comprehensive and extensive review study, we will embark upon a thorough investigation into the pivotal role and profound impact of meta-analysis in various fields, encompassing but not limited to bioinformatics, medicine, criminology, ecology, cancer research, education, psychology, pharmaceuticals, food safety, epidemiology, neurodegenerative diseases, diabetes, and hypertension. By immersing ourselves in the intricacies and complexities of these diverse and multifarious subjects, our all-encompassing and in-depth study aims to delve deeply into the very essence of the challenges and opportunities that pervade a vast array of disciplines. From the critical realm of healthcare to the captivating and enthralling realm of social sciences, we seek to unravel the interconnected and interwoven tapestry of issues and possibilities that span across a wide spectrum of scholarly fields.

Keywords: meta-analysis, cancer, bioinformatics, drugs

1. Introduction

Meta-analysis is a research methodology that amalgamates information from various sources, thereby offering a comprehensive and all-encompassing viewpoint on the available evidence. By employing quantitative techniques to scrutinize the data, meta-analysis has the potential to unveil intricate patterns and emerging trends that might not be readily discernible when studying individual research studies in isolation [1]. It is a research method that transcends disciplinary boundaries and entails the amalgamation of previously reported research studies [2]. This analytical approach proves particularly advantageous in scenarios where individual studies possess limited sample sizes or present conflicting findings. Consequently, meta-analysis emerges as an invaluable tool that aids in enlightening decision-making processes and facilitates the implementation of policies in the realm of healthcare by culminating in conclusions that are both more reliable and more generalizable, primarily due to the larger and more diverse pool of data that is considered [3]. The significance of meta-analysis should not be underestimated, as it serves as a cornerstone in the realm of evidence-based medicine, unearthing crucial insights that have the potential to shape and transform the landscape of healthcare practices. Therefore, meta-analysis is a technique that is widely embraced and valued by the scientific community, owing to its ability to provide a comprehensive and robust evaluation of the available evidence, which in turn empowers policymakers and healthcare professionals with the knowledge they need to make informed decisions that have far-reaching consequences [4].

In essence, meta-analysis serves as a powerful tool that unlocks the potential of research studies by merging their findings, enabling the scientific community to gain a more nuanced understanding of the subject matter at hand [5]. Consequently, it stands tall as a fundamental pillar of empirical research, offering a panoramic view of the evidence, and paving the way for advancements and breakthroughs in the field of healthcare.

Meta-analysis is a quantitative synthesis of multiple research studies on a common topic or question, which is performed with the objective of assessing the magnitudes of effects from the studies and quantifying and exploring the variation in those effects [6]. The principles that underlie the process of meta-analysis encompass a series of steps, including the formulation of the problem, the collection and evaluation of data, the conduction of statistical analysis, and the interpretation and presentation of the results [7–9]. To ensure transparency and rigor, it is crucial to develop a study protocol that outlines the objectives, eligibility criteria, and details of planned synthesis methods [10]. In order to obtain reliable and unbiased findings, the meta-analyst undertakes a reproducible and impartial search for relevant studies that fulfill specific inclusion criteria. Furthermore, the extraction of effect indices is carried out to represent the results of each study, while also taking into account the characteristics of the participants, the treatments employed, the methods used, the measures employed, and indicators of study

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quality. In the estimation of overall effect magnitudes and the exploration of predictors of between-study differences, statistical models, such as fixed-effects and random-effects models, are employed. Moreover, the results are typically presented in a standardized format, often depicted graphically in forest plots with confidence intervals. It is worth noting that meta-analysis serves as a vital tool in the realm of evidence-based medicine and decision-making processes.

It is carried out for a diverse range of purposes, not just to support evidence-based policy or to integrate data on the outcomes of interventions. The goal of the meta-analysis, or more broadly, the goal of any scientific synthesis, has an impact on the timing, the models to employ to analyze the data, the sensitivity assessments to do, and the interpretation of the findings. As there is no unique and appropriate approach to conducting a research synthesis, losing sight of the fact that a meta-analysis is a tool with numerous applications leads to confusion and fruitless discussions on how to do it correctly. Everything relies on the goal of the synthesis and the facts at hand. The typical strength of the effect or phenomenon, its variability, its statistical significance, and the nature of the moderator variables from which one can predict the relative strength of the effect are all characterized in quantitative summaries of research domains widely recognized as meta-analytic studies.

1.1. Evolution and application

The introduction of the meta-analysis was made in psychiatric literature, 3 decades ago [11]. With time it gained importance and appeared in gastroenterology literature, for assessing the effectiveness of anti-secretory drug dosing for duodenal ulcers. The application of meta-analysis in most of the conditions of gastroenterology and hepatology such as colon cancer, irritable bowel syndrome, inflammatory bowel disease, and cirrhosis has strengthened the belief in the potential of meta-analysis to statistically reveal the difference in the effect of the interventions. As an illustration, eight studies on streptokinase suggested its effectiveness in treating myocardial infraction but only three proved its significance [12]. Therefore, a meta-analysis study on eight studies concluded the effectiveness of streptokinase in reducing the rate of mortality. It has revolutionized many fields by facilitating evidence-based practice and resolving contradictory research outcomes. Meta-analysis is a quantitative and scientific synthesis of research results, allowing researchers to synthesize findings from multiple studies to gain an overall understanding of a problem and identify sources of variation in outcomes [13]. Figure 1 shows the increasing trend in meta-analysis across different fields in the last 3 years.

Prior to meta-analysis, scientific studies were often summarized in narrative reviews, which became inadequate when dealing with a large number of studies on a particular research question. Carrying out narrative reviews to identify and summarize evidence objectively and transparently became increasingly challenging. In response to these challenges, systematic reviews and meta-analyses emerged as rigorous methods for synthesizing research findings.

1.2. Advancement and future implications

With the advancement in high-throughput technologies and scanning approaches, there is a tremendous increase in the freely accessible and available datasets. These datasets are generated from different research projects going all over the world. The researchers are now targeting these datasets, which differ in sample size, sample collection method, and sample preparation methodology in order to improve the statistical power to detect the significant biological association from the studies [14]. The data that are extensively being used come from freely available public repositories and the databases such as Sequence Read Archive, Gene Expression Omnibus, Array Express, and The Cancer Genome Atlas [15].

These datasets have data generated from platforms, strategies, and tools that are different but, certainly, target the same target. Therefore, an analysis of these datasets with statistical analysis will provide significant effect size outcomes that were not identified during single dataset evaluation. The comparative study of different datasets from the same platform or datasets from different platforms reveals the strengths, limitations, and biases of the existing studies. It provides the qualitative as well as the quantitative finding in the approaches used in the selected studies and the results can be used for recommendations of the treatments or to provide the direction in the design of clinical trials in the future.

The principle of modern scientific study is based on reproducing the results of the experimental study. The concept of reproducibility provides validation of the studies but has increased the availability of datasets from diverse sources. Therefore, meta-analysis aims to combine data from sources and target the issue of replicability crisis [16]. It is a useful method for addressing the reproducibility issue in scientific research. Meta-analysis provides various benefits by merging data from multiple studies on a single topic, which contributes to better accuracy

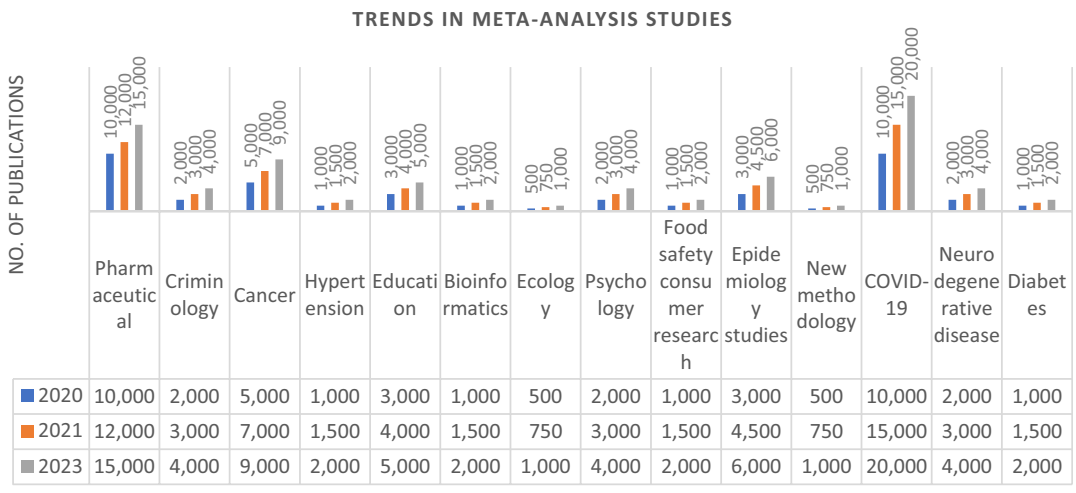

Figure 1. The trend in the number of meta-analyses performed in various fields from 2020 to 2023

as well as credibility of study conclusions. To begin, meta-analyses support evidence accumulation by using a larger sample size, which decreases the impact of random variation and improves statistical power for finding real effects. This comprehensive and representative picture of the study question strengthens the findings' dependability. Second, meta-analyses overcome publication bias by adding unpublished studies or estimating the impact of missing studies using statistical approaches [17]. This method ensures that the total evidence base is more accurately represented, reducing the distortion created by selective publication.

In our review study, we will explore the role and impact of meta-analysis in fields such as bioinformatics, medicine, criminology, ecology, cancer, education, psychology, pharmaceuticals, food safety, epidemiology neurodegenerative diseases, diabetes, and hypertension.

The selection of above-mentioned fields for exploration with the implementation of meta-analysis is a strategic decision that is driven by several important reasons. By thoroughly exploring and delving into these diverse and multifaceted topics, our comprehensive study aims to deeply penetrate and unravel the intricate and interconnected web of challenges and opportunities that span across a wide range of fields, from the critical realm of healthcare to the complex and enthralling realm of social sciences (Table 1).

Table 1. The explored fields with some possible identified outcomes of meta-analysis

Field	Outcomes
Criminology	• Insight into the impact of intervention. • Efficacy of various programs for criminals
Education	• Policy making • Comparison of distant and conventional education
Diabetes	• Comorbidity with other diseases
Hypertension	• Association risk factors • Age group association
Pharmaceutical	• Drug development • Strategies for medical devices • Optimal dosage selection
Psychology	• Pattern assessment in patients • Understanding impact of violence
Cancer	• Clinical profiling studies • Metabolomic studies
Food safety	• Consumer behavior • Quality analysis of food
Bioinformatics	• New targets and identification methods • Novel outcomes

These fields encompass a wide range of disciplines that have a significant impact on society and are highly relevant, thus ensuring a diverse and far-reaching effect. Additionally, the utilization of meta-analysis provides an interdisciplinary approach that can be applied across different fields, enabling the synthesis of evidence from various sources within each specific field. This approach is particularly beneficial in the fields of cancer, neurodegenerative diseases, diabetes, and hypertension as it directly aims to inform clinical decision-making, shape public health policies, and guide interventions, thereby offering crucial clinical and policy implications that can greatly impact the well-being of individuals and communities. Moreover, meta-analysis offers the advantage of integrating findings from multiple studies, which enhances the reliability and generalizability of the conclusions drawn in fields like criminology, psychology, medicine, bioinformatics, and pharmaceuticals. By combining data from various studies, this approach strengthens the validity of the results and allows for more robust and comprehensive conclusions to be made. Furthermore, the topics under investigation in these fields often involve complex interactions and multifaceted factors, making it challenging to draw accurate conclusions.

It is through this interdisciplinary and holistic approach that our study aims to make profound and meaningful contributions to multiple fields, fostering collaboration, and addressing the multifaceted and interconnected societal challenges that we face as a global community.

2. Material and Methods

To review the evidence for the literature search, use was made of Google Scholar, PubMed, and Web of Science. The following keywords were used to find the literature: "Meta-analysis," "meta-analysis studies," "application of meta-analysis in research," and "meta-analysis approach." The full-text papers were appraised with emphasis on the objectives to be concluded. This was done to provide the data from each study's characteristics and findings in a more thorough manner, enabling the reader to evaluate the existing literature more thoroughly to get to final interpretations.

3. Results

3.1. Application of meta-analysis in the field of research

3.1.1. Medicine

Meta-analyses, a widely used method in systematic reviews of randomized clinical trials, play a critical role in evaluating the effectiveness of different treatments or interventions. By employing statistical analysis and summarization techniques, meta-analyses enable clinicians and researchers to make well-informed decisions based on data derived from multiple studies [18]. Furthermore, these analyses also have the capability to detect any heterogeneity or disparities that may exist among the included studies. Consequently, a comprehensive understanding of the underlying principles of meta-analysis is of utmost importance when it comes to assessing the quality of the results and their applicability to individual patients [19]. Therefore, it is crucial for healthcare professionals and researchers alike to grasp the intricacies of meta-analyses as they navigate the complex landscape of evidence-based medicine.

3.1.2. Pharmaceutical

Meta-analysis is widely used in the field of pharmaceutical research for various purposes. It is employed to assess the effectiveness, quality, and potential bias in the overall research environment, including the literature related to pharmaceutical services [20]. The effectiveness of a medicine is often evaluated through a number of studies that pharmaceutical companies conduct. They combine the data from numerous studies using meta-analysis, producing a more robust test (and more accurate estimate) of the drug's impact [21]. Furthermore, meta-analysis is utilized to provide insights into important decisions in drug development, such as evaluating the balance between benefits and risks of a treatment being investigated, as well as determining the optimal dosage and dosing regimen for an experimental compound [22]. This methodology offers a means of synthesizing research findings by gathering and summarizing empirical evidence, often incorporating statistical techniques for quantitative synthesis [21]. Additionally,

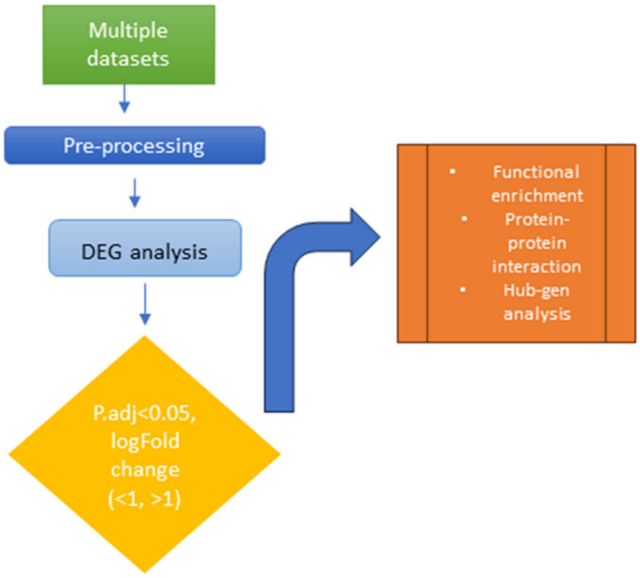

Figure 2. The figure represents the methodology followed for gene expression data analysis in meta-analysis for potential biomarker and target identification

meta-analysis plays a critical role in guiding strategic decisions in the development of drugs and medical devices, particularly in the creation and maintenance of clinical evaluation reports [23]. These evaluations are useful for marketing, internal research, and submissions to governmental bodies. Since adverse occurrences are often uncommon and require information to be gathered throughout a number of studies to be fully assessed, meta-analyses are also used to synthesize data on adverse events [24, 25]. In conclusion, meta-analysis is a valuable tool in pharmacy research as it allows for the evaluation of evidence, supports decision-making, and enhances the overall quality of research in this field.

3.1.3. Education

Meta-analysis plays an essential role in the field of education by providing a quantitative synthesis of research studies focused on a specific topic or question. It enables the evaluation of the impact of these studies and facilitates the measurement and exploration of variations in their effects [5]. Meta-analysis has been used in the field of education to examine a wide range of subjects, including the comparison between distance learning and conventional classroom instruction, the effect of education on developing nations' economies, and the connection between teacher credentials and student achievement [26–28]. Meta-analysis is utilized to amalgamate previous research and validate theoretical frameworks through empirical evidence, making it a potent tool in educational research [7]. It contributes to decision-making and the advancement of knowledge across various disciplines by statistically combining the findings of primary research studies [29]. Particularly in the realm of educational technology, meta-analysis holds significant importance as it guides practice and eliminates biases by identifying and utilizing only the most reliable evidence-based research [30]. Moreover, meta-analysis can be effectively employed to comprehend the impact of artificial intelligence in education, thereby highlighting its potential and advantages in enhancing the learning experience for both educators and students [31].

3.1.4. Psychology

Meta-analysis plays a crucial role in psychology research by integrating the results of multiple studies and providing a statistical analysis of the data. It allows researchers to obtain summary estimates of the effects of interventions or treatments, identify patterns or associations across studies, and assess the overall effectiveness of a particular intervention. It has been used in psychology to support both evidence-based practice and basic science and to explore gender differences in nonverbal communication, leadership, and nonverbal personality change over the lifespan, as well as the impact of media violence on violent behavior [32–35]. Meta-analyses can help to overcome the limitations of individual studies, such as small sample sizes or conflicting results, by combining data from multiple sources and increasing statistical power. They provide a comprehensive and objective evaluation of the available evidence, which can inform clinical decision-making and guide future research directions. Meta-analyses are particularly important in fields like physiotherapy, where the effectiveness of interventions may be controversial or uncertain [36–38].

3.1.5. Criminology

Meta-analysis plays a significant role in the field of criminology by combining empirical relationships from various studies and identifying any existing weaknesses in the knowledge base [39]. Its main focus lies in determining the magnitude and direction of effects across studies, while also assessing the consistency of these effects and the correlation between study characteristics and observed effects [40]. Meta-analyses can offer valuable insights into the impact of interventions, such as the effectiveness of prevention systems in reducing delinquent behavior [26]. Additionally, they can help identify factors that influence differential effects among units or matched pairs in randomized controlled trials [41]. However, it is crucial to carefully consider the methods employed in meta-analyses to avoid generating results of limited value. Meta-analysis enables researchers to integrate studies addressing the same issue or compare different studies to test hypotheses. It is increasingly common in the field of criminal justice and criminology literature, although ongoing debates persist regarding its conditions of use, inclusion of unpublished work, and choice of effect size estimates. Government organizations have supported meta-analyses in the field of criminology to assess the relative efficacy of various programmers in lowering criminal behavior. These include programs to prevent delinquency, lower recidivism, evaluate the efficacy of various police patrol techniques, and use specialized courts to handle drug-related offences [42, 43].

3.1.6. Ecology

Meta-analysis plays a vital role in the field of ecology as it provides a quantitative synthesis of research findings and generates new hypotheses. It enables the integration of results from various ecological studies, encompassing both experimental and observational studies, and aids in generalizing outcomes in the realms of ecology, conservation, and evolutionary biology [44]. Meta-analysis can be utilized not only to examine mean effects but also to analyze effects on trait variance, revealing previously unnoticed patterns and insights [45]. Furthermore, meta-analysis of variance can assist in making well-informed methodological decisions and enhancing the understanding of biological processes [46]. Moreover, meta-analysis has the potential to improve decision-making in conservation, restoration, and risk management by exploring the spatial

interdependencies among ecological systems through the movement of organisms, energy, and matter [47]. Additionally, by integrating ecological information into meta-ecosystem theory, new hypotheses can be developed and our comprehension of ecological dynamics across spatial and temporal scales can be enhanced [48]. Meta-analyses in the field of ecology has been used to determine the effects of wind farms on the environment, biotic resistance to exotic plant invasion, the effects of changes in the marine food chain, plant responses to climate change, the efficacy of conservation management interventions, and to direct conservation efforts [49–51].

3.2. Design of new methodology

The design of new methodologies is one of the key functions of meta-analysis. It enables the quantitative synthesis of evidence from previously conducted studies, offering a combined estimation of the effect size and investigating variations in the results [52]. Meta-analysis holds significant value in educational research as it provides accuracy, impartiality, and reproducibility in the integration of research findings [53]. In the realm of design, meta-design serves as a conceptual framework that empowers students with the necessary skills to become independent thinkers and lifelong learners [54]. It allows for adaptability and responsiveness in pedagogical approaches, facilitating continuous adjustment to evolving industry and academic standards. Additionally, meta-design aids in the decision-making process for product design by assisting designers in the selection of suitable design tools and methods [55]. In summary, both meta-analysis and meta-design contribute to the advancement of innovative approaches and frameworks across various fields, ultimately enhancing the effectiveness and efficiency of research and design processes.

3.3. Food safety consumer research

Meta-analysis is a statistical technique that combines the findings of multiple primary research studies to offer a comprehensive examination of a specific question [56]. In the realm of food safety, meta-analysis enables researchers to integrate data from different studies in order to gain a deeper comprehension of consumers' willingness to pay for attributes related to food safety (55). Its focus lies in the identification of consumer behavior within subpopulations. Numerous meta-analysis studies have shed light on the understanding and distinctions in food trends among different age groups, genders, and ethnicities [57]. By providing a systematic overview of research findings, it facilitates decision-making and the advancement of knowledge [5]. Meta-analysis also aids in identifying the heterogeneity of study outcomes and evaluating the quality of the analysis [58]. It serves as a valuable tool for researchers to analyze and interpret the vast amount of data accumulated in the field of food safety consumer research [59].

3.4. Epidemiology studies

Meta-analysis plays a crucial role in epidemiology studies by providing an objective and quantitative method to integrate evidence from multiple studies. It allows for the compilation of evidence to address causal inference and inform decision-making. The importance of meta-analysis on epidemiological data is in assisting government to form policies. These policies focus on disease interventions and preventing measures for outbreak of diseases causing factors in the population [60]. Here, meta-analysis highlights the connecting dots or the factors between developing disease and its cause of outbreak. The results of these studies help the government in upgrading the efficacy of governed plans or policies for eradication of the outbreaks [61]. It offers clear benefits over subjective approaches, such as expert review, by guarding against arbitrary selection of studies and allowing for replication of the review protocol. Despite the debate surrounding its merits, meta-analysis has become the default approach for summarizing and evaluating evidence in epidemiology. However, it is important to acknowledge the potential negative features of this approach, as the results of meta-analysis can be influenced by characteristics of component trials and may be subject to bias. Therefore, it is essential to fully investigate these characteristics to ensure the reliability and validity of meta-analytic findings [62–64].

3.5. Bioinformatic studies

Meta-analysis plays a crucial role in bioinformatics by integrating the outcomes of multiple studies and applying statistical analysis to the data [65] (Figure 2). It allows for the comparison of outcomes from various studies, identification of models within the results, and recognition of interesting associations that may arise [66]. Meta-analysis is particularly useful when it is not possible to apply statistical analysis to the data, as it provides a tool to make better decisions through systematic review [37]. It has become increasingly popular in medical research, including the field of computational biology, where it is used to test and make inferences about biological data [67]. Meta-analysis also helps in the development of bioinformatic inference systems, providing accurate prediction capabilities for classification tasks [68]. Overall, meta-analysis is an important tool in bioinformatics for synthesizing and interpreting data from multiple studies, enabling better decision-making and advancing research in the field. In the domain of bioinformatics, meta-analysis is often used to highlight specific meaningful findings that were overlooked parameters in individual investigations. Multiple studies show that we have obtained novel and important results from a meta-analysis of bioinformatics at microbiome-level data. Pathogenic bacteria and microorganisms in the microbiome have been identified as possible disease markers by meta-analysis and bioinformatics. Bioinformatics-assisted meta-analysis of studies is highlighting potential new approaches to disease prevention, diagnosis, and management through the data gathered from the studies [69]. Additionally, rather of being disease-specific, these investigations have uncovered microorganisms and bacteria that are linked to general health [70].

Meta-analysis studies conducted in the field of bioinformatics have provided valuable insights into a wide range of research areas, bringing forth a wealth of knowledge and understanding. One such meta-analysis delved into the expression levels of FBXW7 in gastric cancer, unearthing compelling findings that shed light on the intricacies of this disease. The study discovered a significant downregulation of FBXW7 expression in gastric cancer when compared to normal mucosal tissues, unraveling a potential link between FBXW7 and the development of this malignant condition. Furthermore, it was revealed that the expression of FBXW7 exhibited a positive association with lymph node metastasis, Tumor, Nodes and Metastasis (TNM) stage, and differentiation, indicating its involvement in the progression and severity of gastric cancer. Additionally, the analysis highlighted that FBXW7 mRNA expression was higher in gastric cancer than in normal tissue, further solidifying its significance in the context of this disease. Interestingly, FBXW7 expression was also found to be downregulated in gastric cancer compared to normal tissue, suggesting its potential as a prognostic marker for patients afflicted with this form of cancer [66]. In another enlightening

meta-analysis, the focus shifted toward unraveling the intricate association between formaldehyde exposure and neurodegenerative diseases as well as brain tumors. The findings of this study were nothing short of groundbreaking, as they unveiled a concerning link between high exposures to formaldehyde and an increased risk of developing Amyotrophic lateral sclerosis (ALS) and brain cancer. Furthermore, employing the powerful tools of bioinformatics analysis, the researchers discovered that oxidative stress genes and pathways related to formaldehyde metabolism played a pivotal role in the development of these devastating diseases. The multifaceted approach employed in this study not only provided robust evidence supporting the association between formaldehyde exposure and brain diseases but also shed light on the potential biological mechanisms underlying this link, thus enriching our understanding of this intricate relationship [71].

Within the realm of cancer research, a remarkable meta-analysis coupled with bioinformatics analysis unveiled a captivating insight into the crucial role played by DNA repair genes in the realm of carcinogenesis and cancer prognosis. The analysis revealed lower levels of XPA and XPC in various types of cancer, implying their involvement in the development and progression of these malignancies. Conversely, higher levels of XPD, XPF, and WRN were associated with worse cancer prognosis, hinting at their potential as prognostic markers in the realm of cancer. Furthermore, this comprehensive analysis delved even deeper, uncovering specific genetic variations within these DNA repair genes that were found to influence the overall risk of developing cancer. These compelling findings underscore the paramount importance of DNA repair genes in the complex landscape of cancer development and prognosis, providing a stepping stone for further research and exploration in this intriguing field [72].

3.6. Meta-analysis study in COVID-19

Meta-analysis has found its major contributing role in the analysis of association of different diseases with COVID-19. These contributing studies emphasized on effect of drugs and the outcomes of the drug-dosage criteria in infected patients. A study by Du et al. [73] highlighted significant association between D-dimers and COVID-19, showing that the concentration of D-dimer is responsible for severity in COVID-patients. Another meta-analysis study with 10 different datasets presented the reduction of mortality in COVID patients with the use of aspirin. Aspirin is a well-known anti-platelet drug that inhibits thromboxane A2, which is the underlying factor for thrombo-inflammation and thrombosis in affected individuals [74]. Meta-analysis study has been of great significance in analyzing the factors responsible for COVID, the association of diseases and symptoms in COVID patients. A study showing association of mortality in COVID-19 patients with acute respiratory distress syndrome (ARDS) and corticosteroid use revealed that high mortality is associated with ARDS, which requires treatment with corticosteroids. As a result, low-dose therapy has been proven to be beneficial in managing severe cases of COVID-19 [75]. Another meta-analysis study showed a correlation of blood pressure variability and cognitive functions in hypertension. Meta-analysis of 13 studies with 2754 patients showed that cognitive impairment is associated with elevated blood pressures in COVID patients [76]. The critically affected patients of COVID-19 showed organ failure and heart stokes, which raised the question of analysis of the relation between the intersecting pathways. The study included a meta-analysis of 159,698 COVID patients. The calculation of odd ratio and confidence interval revealed the association of the critical COVID patients with heart failure, arrhythmia, acute cardiac injury, and coronary heart disease. A meta-analysis conducted by Jie Li et al. revealed several key clinical characteristics and outcomes of COVID-19 patients. The study found that 22.9% of patients had severe disease, and the overall mortality rate was 5.6%. Comorbidities such as immunosuppression, diabetes, and malignancy were strongly associated with severe COVID-19, while older age, male gender, diabetes, and hypertension were associated with higher mortality. Gastrointestinal and respiratory symptoms were linked to severe COVID-19, while pneumonia and end-organ failure were associated with mortality [77].

3.7. Meta-analysis study in neurodegenerative diseases

The meta-analysis in the domain of these neurodegenerative diseases has revealed specific miRNA, associated with non-coding RNA, which contributes to our understanding of their progression. A meta-analysis study by Lining *et al* using microarray datasets to screen Parkinson's disease (PD)-specific genes revealed DEGs that were common among these datasets. Total of 8 datasets from blood and SN tissue were analyzed, which revealed 36 DEGs in blood and 17 DEGs in SN studies. Nineteen DEGs from blood tissue were previously known to be associated with Alzheimer's and 4 were associated with Parkinson's. Among the 17 from SN studies, 11 were already known and one gene was significantly Parkinson specific [78]. The vast application of meta-analysis is not only restricted to microarray or RNA-seq data, it is also applied to transcriptomics data. Analysis of transcriptomics dataset of PD showed 10 significantly up- and downregulated segments that map on 8 different chromosomes from SN whole tissue and 4 mapping on DA neurons. This study revealed the genomic regions and the loci of chromosomes responsible for key pathways regulating neurodegeneration [79].

Meta-analysis study not only targets one disease for its comparison in different datasets, but it is also applicable to evaluate the association between different diseases. PD and Alzheimer's both are neurodegenerative diseases, and it is quite possible for them to have some association or similarities of their pathways. A study by Wang et al. revealed commonly impaired pathways and dysregulation of NRF2-dependent genes. Totally, 16 datasets were analyzed, which revealed 54 common genes were shared by 6 tissues. Among them, 31 were downregulated and associated with NRF2 in which upregulated MAFF was correlated with these dependent genes in diseased conditions [80].

3.8. Meta-analysis study in cancer

The meta-analysis of cancer studies has given us accessibility to identify and report underlining factors, genes, metabolites, and even the effects of drugs on cancer patients.

A study by Goveia et al. [81] was performed on clinical metabolic profiling studies in cancer. They accessed all the published work in the field of cancer metabolomics from the last 5 years, and an analysis of the metabolites in the tumor tissue and blood was done. A novel highlight of their study was the upregulation of ketone body 3-hydroxybutyric acid in the blood of cancer patients. Their study highlighted the fact that there is a tremendous gap in metabolite identification and their reporting, which is hampering the metabolomics study for cancer studies. Another meta-analysis study by Feng et al. [82] was performed to reveal the association between the miR-497 expression level and the prognosis of cancer. They searched and collected a total of 12 publications with more than 900 cancer patients to assess

the significance of the association. The outcome of their study revealed that high-level expression of miR-497 in patients favors the tumor-node-metastasis stage, and there is less possibility of lymph node metastasis.

3.9. Meta-analysis study in diabetes

The application of meta-analysis study on the data available for diabetes has shown its increased association with a number of diseases, for example, cancer, COVID, hypertension, heart diseases, and depression. A study by Moulton et al. [83] focused on understanding the linking and association of diabetes and depression. The need for this study originated because of the inconsistencies in the results given by a number of different studies. They retrieved and analyzed 33 studies concerning depression and diabetes. The combined effect value and the risk for biasness were calculated using the Egger regression asymmetry test, which revealed that depressed people have a 41% increased chance to develop diabetes. The association of diabetes with cancer affecting the kidney, colon, liver, esophagus, biliary tract, and endometrium has been reported several times. A meta-analysis study had revealed that the development of prostate cancer in diabetic men has been reduced by 16% because of the pathway alteration underlying them [84]. The diabetic patients have also shown increased associations with Alzheimer's disease, which was proven in the study performed by Zhang et al. [85]. A total of 17 studies with 1,746,777 were analyzed and revealed that diabetic patients show high level of Alzheimer risk in comparison to non-diabetic patients. Another comparison was done in the same study for prevalence rate of Alzheimer's with diabetes in western and eastern population. It showed that relative risk (RR) was higher in the eastern population for diabetes-associated Alzheimer's.

3.10. Meta-analysis study in hypertension

Meta-analysis provides us the benefit to compare the different biological states, evaluating the outcome of different studies, revealing the output of the therapeutic approaches, and even analyzing the effect of drugs, therapies, and exercises on targeted conditions. The lifestyle of today's population is known as an inviting factor for a number of critical health diseases cancer, diabetes, asthma, and hypertension. Meta-analysis study to determine the changing patterns in the occurrence of hypertension in urban and rural areas has been conducted in 1997. The first study of this kind was published in 1942 by Chopra and since then graph of the related study has been increased to measure the prevalence rate of the diseases. This study focused on analyzing the mean of the data on diastolic and systolic blood pressure in urban and rural areas in age groups. This study revealed that urban people are more prone to hypertension in comparison to rural people [86]. Hypertension, elevated blood pressure not only affects the blood vessels of the organs but is also related to various other medical conditions and cataract is one of them. Cataract has been the major cause of blindness across the globe with an increased prevalence rate in aged people. A meta-analysis study to associate cataracts with hypertension was done by Yu et al. [87] in 2014. A total of 25 studies involving case–control, cohort, and cross-sectional studies were taken. The RR factor for cohort and case–control studies of 1.08 and 1.28 revealed the association between hypertension and cataract in the population.

4. Discussion

The significance of the meta-analysis is its increased statistical power in coherence with effect size of the sample, which is extremely important to evaluate the studies having limitation of sample size. It also evaluates the heterogeneity among the different datasets targeting same biological question and reveals the variation across the studies. The major setback of performing meta-analysis is the mixing of datasets having high percentage of heterogeneity which when treated can be of higher importance. The targeting of heterogeneity is through sub-group analysis, which provides more significant results for each dataset evaluation. The meta-analysis also reveals some rare and novel outcomes that were not tested or detected in single dataset analysis. Furthermore, it can conclude the conflicts in the various studies determining whether there is need for further hypothesis generation on the same biological condition. Apart from having multiple importance and significance, there are certain outcomes of meta-analysis evaluations: It involves combined evaluation of number of datasets, which are targeting same conditions, but the quality of each dataset does not match the standard criteria. The involvement of the low-quality datasets influences the outputs creating more incorrect and bias results. Therefore, in order to perform the meta-analysis study of higher significance the inclusion criteria for datasets must be very strict [88].

5. Conclusion

In conclusion, meta-analysis is critical in scientific research since it provides a quantitative and methodical technique for synthesizing study data. It has had a considerable impact on developing evidence-based practice, resolving conflicting research findings, and assisting decision-making in a variety of disciplines. It precisely identifies the variations and explores how the selected datasets differ from one another. In addition to being able to estimate the unknown impact size, meta-analyses also have the ability to compare the findings of several research and spot trends, areas of disagreement, or other intriguing connections that may emerge from a large range of studies. It also provides valuable insight into improving the issue of reproducibility in research. Through addressing the publication bias, and enhancing transparency and documentation, it increases the credibility and accuracy of the findings in the results. The article's distinctness derives from its thorough investigation of how meta-analysis has transformed various scientific fields by facilitating evidence-based practice, resolving contradictory research outcomes, and revealing significant effect size outcomes that would have been missed in single dataset evaluations. It emphasizes the advantages of meta-analyses in accumulating evidence, eliminating publication bias, and providing a more accurate portrayal of the complete evidence base. Overall, the research indicates that meta-analysis is a strong tool for improving the credibility, precision, and reliability of study conclusions in a variety of scientific areas.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Ritika Patial: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Ranbir Chander Sobti:** Supervision, Project administration.

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