

Social Justice Mathematics and Public Health Equity: A Systematic Review of Quantitative Literacy in Health Decision-Making

Terungwa James Age

The Independent Institute of Education, 116 Clearwater Road, Emeris, Pretoria, South Africa 0081.

*Corresponding author's e-mail: ajaster2018@gmail.com

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ABSTRACT

Background: Public health decision-making increasingly requires individuals to interpret numerical information such as risks, probabilities, treatment benefits, and epidemiological trends. However, disparities in quantitative literacy may contribute to inequitable health outcomes and reduced participation in informed decision-making. Despite growing interest in health literacy and equity, systematic reviews have examined health numeracy, risk communication, and health literacy; however, limited research has specifically examined the role of social justice mathematics in strengthening equitable health decision-making.

Aim: This systematic review examined how quantitative literacy and health numeracy influence health decision-making, explored how numeracy disparities contribute to public health inequities, and assessed how social justice mathematics may support equitable engagement with health information.

Methods: Guided by PRISMA 2020, a systematic search of Scopus, Web of Science, PubMed, and ERIC was conducted for studies published between 2000 and 2025. Following screening and eligibility assessment, 50 studies were included in the final synthesis. Two independent reviewers conducted article screening and quality appraisal, with disagreements resolved through discussion and consensus. A narrative synthesis approach was adopted due to methodological heterogeneity across studies.

Findings: The review found that limited numeracy contributed to misinterpretation of health risks, reduced screening participation, difficulties in treatment decision-making, and lower engagement in preventive healthcare, particularly among socioeconomically disadvantaged populations. The findings further showed that social justice mathematics may strengthen critical interpretation of health data, improve engagement with public health issues, and support awareness of structural inequities. However, empirical evidence directly linking social justice mathematics interventions to measurable health outcomes remains limited.

Conclusion: Quantitative literacy is a critical determinant of equitable health decision-making. Public health systems should adopt numeracy-sensitive communication strategies, while education systems should integrate socially responsive quantitative literacy and authentic health data into mathematics curricula to strengthen informed participation and reduce health inequities.

Keywords: *Quantitative literacy; Health numeracy; Public health equity; Social justice mathematics; Health decision-making.*

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1. Introduction

The decision-making process in public health is increasingly reliant on the capability of people to interpret numerical data, such as the data on disease rates, screening accuracy, treatment benefits, probabilities, risk ratios, and epidemiological trends. This puts quantitative literacy and health numeracy at the core of fair engagement in health systems. Health literacy is becoming a concept of a social determinant of health because it determines how individuals access, understand, appraise and use health information (Nutbeam & Lloyd, 2021). Poor health literacy and numeracy can undermine informed decision-making and result in health inequities, especially among populations affected by socioeconomic disadvantage (Stormacq et al., 2019; Svendsen et al., 2020). In particular, numeracy is crucial in situations where an individual must compare risks, assess probabilities, comprehend laboratory results, or decide to use screening, treatment, or prevention services. Evidence of this can be found in the research of risk communication and shared decision-making where numerical format is strongly associated with the comprehension (Ancker et al., 2025). Relative risks or complex conditional probabilities can be generally more difficult to understand than absolute risks, natural frequencies, visual displays, and plain-language explanations (Bonner et al., 2021; Muscat et al., 2021). This fact indicates that individual numeracy and the transparency of social health communication influence health decision-making.

These concerns are directly related to the equity of public health. Populations that are socioeconomically disadvantaged tend to have less access to high-quality education, digital health information, culturally appropriate communication and numeracy-supportive health services. Consequently, quantitative literacy differences might be associated with disparities in comprehending health information, engaging in shared decision-making, and achieving poorer health outcomes. Quantitative literacy is increasingly recognized as a structural determinant of health because the ability to interpret numerical information directly influences healthcare access, treatment adherence, screening participation, and risk perception. Individuals with limited numeracy are more likely to misunderstand probabilities, medication instructions, and statistical health information, thereby experiencing reduced participation in evidence-informed healthcare decisions (Gigerenzer et al., 2007; Reyna et al., 2009). These disparities are often intensified by broader structural inequalities associated with poverty, unequal educational opportunities, digital exclusion, and culturally inaccessible health communication (Berkman et al., 2011; Schillinger, 2021; Stormacq et al., 2019). Within this context, social justice mathematics extends beyond mathematics education by positioning quantitative reasoning as a critical tool for analyzing inequities embedded in health systems, epidemiological representations, and resource allocation. Although scholarship on health literacy, numeracy, and equity-oriented mathematics education continues to grow, limited systematic synthesis has integrated these domains within a unified public health framework. This review addresses that gap. Unlike previous reviews that have examined health literacy, health numeracy, or risk communication separately, this review integrates quantitative literacy, public health equity, and social justice mathematics within a single analytical framework. In doing so, it extends current scholarship by exploring how quantitative reasoning functions not only as a cognitive competency but also as a mechanism through which health inequities may be reproduced or challenged.

Social justice mathematics can offer a beneficial model of education to resolve this issue. It relates the study of mathematics to real-world problems like inequality, food insecurity, disparities in the distribution of resources among various groups of people, environmental risk, and resource allocation. It can make learners more competent in their ability to process data, challenge injustices and use mathematical reasoning to social complexities (Gutstein, 2003; Gutstein, 2006; Age et al., 2025). Even though this literature is primarily found in the field of education as opposed to the domain of the public health, it provides a valid avenue to be taken in developing the quantitative skills required to interpret health data and oppose the systems that are unjust. Although there is a growing literature on health literacy, numeracy, risk communication, and equity-oriented mathematics education, these domains still lack integration. Guidance on systematic reviews highlights the significance of transparent synthesis across multidisciplinary evidence, especially when the research designs, populations, and conceptual focus vary (Page et al., 2021; Campbell et al., 2020). This paper hence assumes a systematic review design to explore how quantitative literacy affects health decision-making and the role social justice mathematics can play in ensuring equity in health decision-making among the populace.

The objectives of this review are:

- i. To examine how quantitative literacy and health numeracy influence risk interpretation and health decision-making.
- ii. To identify how disparities in numeracy and health literacy contribute to public health inequities.
- iii. To assess how social justice mathematics may support critical understanding of health data and equitable participation in health decision-making.

The review is guided by three research questions:

- i. What role does quantitative literacy play in health decision-making?
- ii. How do disparities in health literacy and numeracy contribute to public health inequities?
- iii. How can social justice mathematics support critical understanding of health data and promote equitable participation in health decision-making?

2. Methods

Study Design

The paper selected systematic review design based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework (shown in Figure 1). The choice of PRISMA was because of its ability to present a clear structure for identifying, screening, selecting, and reporting studies in systematic reviews (Page et al., 2021). The review combined empirical, theoretical, and review-based studies because the relationship between quantitative literacy, social justice mathematics, and public health equity remains an emerging interdisciplinary field. Including multiple forms of evidence enabled a more comprehensive synthesis of the available scholarship.

Search Strategy

A systematic literature search was conducted across four major databases: Scopus, Web of Science, PubMed, and ERIC. The review included studies published between January 2000 and December 2025 to capture contemporary developments in quantitative literacy, health literacy, social justice mathematics, and public health equity. These databases were selected because they cover interdisciplinary scholarship in public health, education, psychology, social sciences, and mathematics education. Search strings combined terms related to mathematics education, quantitative reasoning, public health, equity, and decision-making. The main search terms included “social justice mathematics” OR “critical mathematics,” “quantitative literacy” OR “statistical literacy,” “public health” OR “health equity,” and “decision-making” OR “health policy.” Boolean operators and truncations were applied to optimize retrieval and ensure broad coverage of relevant studies.

Search Strings

The primary Boolean search strategy was:

("social justice mathematics" OR "critical mathematics") AND ("quantitative literacy" OR "health numeracy" OR "statistical literacy") AND ("public health" OR "health equity") AND ("decision-making" OR "risk communication").

Eligibility Criteria

Eligible publications included empirical studies, theoretical papers, and review articles published in peer-reviewed journals. Studies were included if they addressed quantitative literacy, statistical literacy, health numeracy, social justice mathematics, public health equity, or health decision-making. Studies were excluded if they were not related to health, equity, or decision-making; focused only on mathematics education without a public health connection; were not available in English; or lacked sufficient methodological or conceptual relevance to the review topic.

Study Selection and Data Extraction

Two independent reviewers conducted title and abstract screening followed by full-text eligibility assessment. Disagreements regarding study inclusion were resolved through discussion and consensus to minimize selection bias and enhance reliability. The study selection process followed three stages. First, duplicate records were removed.

Second, titles and abstracts were screened to identify potentially relevant studies. Third, full-text articles were assessed against the inclusion and exclusion criteria. Data were extracted on author, year of publication, study design, geographical context, population or setting, key concepts, major findings, and relevance to quantitative literacy in health decision-making.

Quality Assessment and Risk of Bias

Methodological quality and risk of bias were assessed using appraisal criteria appropriate to the study design. Qualitative studies were evaluated using the Critical Appraisal Skills Programme (CASP) framework, while quantitative studies were assessed based on sampling adequacy, validity, analytical transparency, and reporting clarity. Studies were not excluded solely on quality grounds; however, methodological limitations were considered during synthesis and interpretation. Most empirical studies demonstrated moderate to high methodological quality. Common limitations included restricted sample diversity and inconsistent reporting of numeracy measures. These limitations were considered during interpretation of findings.

Data Synthesis

Due to differences in study designs, populations, and disciplinary focus, a narrative synthesis approach was used rather than meta-analysis. Findings were organized thematically around the role of quantitative literacy in health decision-making, the contribution of statistical and health literacy to public health equity, and the relevance of social justice mathematics for developing critical engagement with health data and policy. Narrative synthesis was appropriate because the included studies varied conceptually and methodologically, making statistical pooling unsuitable (Campbell et al., 2020). No formal protocol was registered for this review. However, the review was conducted and reported in accordance with PRISMA 2020 guidelines (Page et al., 2021).

3. Results

The database search identified a broad body of interdisciplinary literature across public health, education, and the social sciences. A total of 1,250 records were identified through database searching, including Scopus (n = 450), Web of Science (n = 300), PubMed (n = 300), and ERIC (n = 200). After removal of duplicate records (n = 250), 1,000 records remained for title and abstract screening. Of these, 800 records were excluded. The remaining 200 full-text articles were assessed for eligibility, and 150 were excluded due to lack of relevance, absence of a quantitative literacy focus, non-peer-reviewed status, and insufficient methodological relevance. A total of 50 studies were included in the final synthesis. Out of the 50 included studies, 31 were empirical investigations, 12 were theoretical or conceptual papers, and 7 were review-based studies. Most studies originated from North America and Europe, while relatively limited evidence emerged from low- and middle-income contexts despite the disproportionate burden of health inequities within these regions. The study selection process is presented in Table 1.

Table 1. Characteristics of Included Studies (n = 50)

Characteristic	Frequency
Empirical studies	31
Theoretical studies	12
Review studies	7
North America	22
Europe	15
Asia	6
Africa	4
Oceania	3

Table 1 also highlights the uneven geographical distribution of the evidence base, suggesting the need for greater research attention in underrepresented regions where health inequities are often most pronounced. The synthesis of included studies identified five interrelated themes reflecting the role of quantitative literacy in health decision-making and its implications for public health equity. A summary of these themes, including supporting evidence, synthesized findings, and equity-related implications, is presented in Table 2.

First, quantitative literacy and health numeracy were consistently associated with the ability to interpret risks, understand probabilities, and make informed health decisions. Evidence shows that individuals with lower numeracy skills are more likely to misinterpret statistical information, overestimate or underestimate risks, and experience difficulty understanding screening outcomes and treatment effects (Peters et al., 2007; Gigerenzer et al., 2007). These limitations influence key health behaviours, including uptake of preventive services, adherence to treatment, and participation in shared decision-making. Furthermore, difficulties in probabilistic reasoning were observed even among highly educated individuals when health information was presented in complex or non-transparent formats (Reyna et al., 2009).

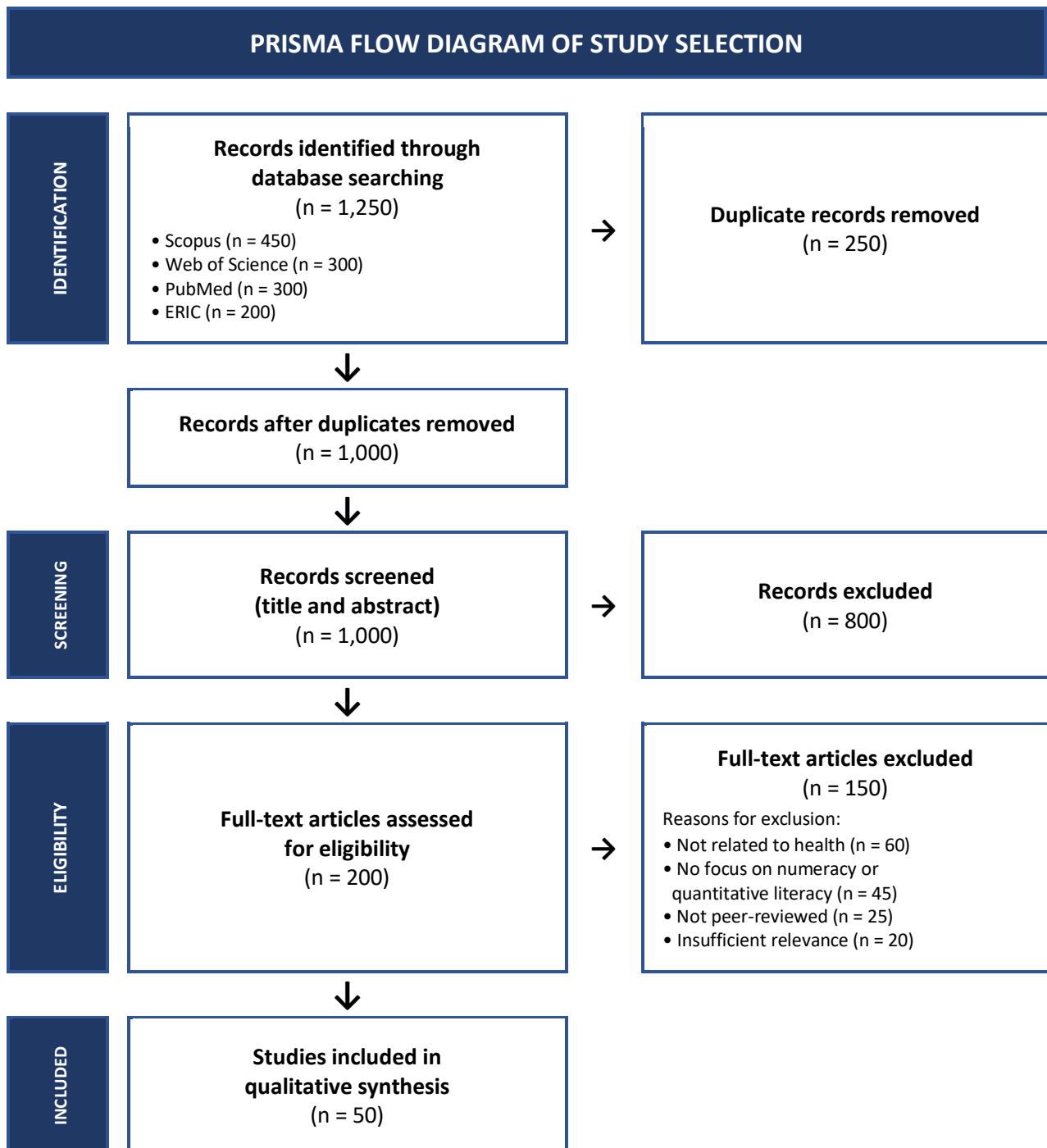


Figure 1. PRISMA flow diagram of study selection. (PRISMA 2020; Page et al., 2021)

Second, disparities in quantitative literacy were closely linked to broader social determinants of health. Studies consistently showed that populations with lower socioeconomic status, limited educational opportunities, and reduced access to quality information exhibited lower levels of health literacy and numeracy (Berkman et al., 2011). These disparities contributed to unequal understanding of health information, reduced engagement in decision-making, and poorer health outcomes. The findings therefore indicate that quantitative literacy functions not only as an individual cognitive skill but also as a structural determinant of health equity.

Third, the literature on social justice mathematics emphasized its possible role in correcting inequities in quantitative understanding by placing mathematics into the real-life social and health contexts. Educational studies demonstrated that engaging learners with authentic datasets on disease prevalence, vaccination disparities, environmental exposure, and healthcare resource allocation improved both quantitative reasoning and critical awareness of structural inequities. These findings suggest that social justice mathematics may strengthen long-term population-level capacity to interpret public health information and engage critically with evidence-based policy discussions (Gutstein, 2006; Age, 2026). This approach reframes mathematics as a tool for civic engagement and informed decision-making. However, the review identified limited empirical evidence directly linking social justice mathematics interventions to measurable improvements in health decision-making, indicating an important area for future research.

Table 2. Summary of Included Studies and Thematic Findings

Theme	Evidence from Included Studies	Synthesis of Findings	Implications for Public Health Equity
Quantitative literacy and health decision-making	Empirical studies across healthcare settings show that individuals with lower numeracy struggle to interpret probabilities, screening outcomes, and treatment risks (Peters et al., 2007; Reyna et al., 2009)	Quantitative literacy directly influences the ability to make informed health decisions, particularly under conditions of uncertainty and risk.	Strengthening numeracy and simplifying communication can improve informed consent and shared decision-making.
Risk communication and interpretation of statistics	Studies demonstrate that risk formats (e.g., relative vs absolute risk) affect comprehension; natural frequencies improve understanding (Gigerenzer & Edwards, 2003; Gigerenzer et al., 2007).	Misinterpretation of statistical information is widespread and not limited to low-education groups.	Public health messaging should adopt transparent, standardized numerical formats.
Health literacy, numeracy, and disparities	Large-scale reviews show associations between low health literacy, reduced service utilisation, and poorer outcomes, particularly among socioeconomically disadvantaged groups (Berkman et al., 2011).	Quantitative literacy disparities mirror broader social inequalities in education and access to resources.	Numeracy should be treated as a structural determinant of health equity.
Numeracy and risk perception	Evidence indicates that limited numeracy distorts perceptions of risk and benefit, affecting screening uptake and treatment adherence (Reyna et al., 2009; Peters et al., 2006).	Risk perception is shaped by both cognitive skills and how information is presented.	Numeracy-sensitive interventions can reduce inequities in health decision-making.
Social justice mathematics and equity-oriented education	Theoretical and empirical education studies link critical mathematics approaches to improved engagement with real-world issues, including health disparities (Gutstein, 2006).	Social justice mathematics provides a framework for connecting quantitative reasoning with civic and health contexts.	Integrating equity-oriented mathematics education may build long-term population-level health literacy.

In general, the results indicate that quantitative literacy is a major factor in determining effective health decision-making and that numeracy disparities are one reason why some people continue to face health inequities. While improvements in health communication may mitigate some challenges, integrating equity-oriented mathematics education may provide a more sustainable pathway to strengthen population-level capacity to interpret and use health information.

4. Discussion

This systematic review examined the role of quantitative literacy in health decision-making and its implications for public health equity, with particular attention to the potential contribution of social justice mathematics. The findings demonstrate that quantitative literacy is central to interpreting risks, probabilities, screening outcomes, and treatment benefits, thereby directly shaping the quality of health decisions and participation in shared decision-making processes.

The initial significant discovery is that a low level of numeracy suppresses individuals in their quest to interpret health information accurately. As illustrated in the Results, less quantitatively literate individuals are more prone to misunderstand probabilities, misconceive the value of treatment, and make decisions about situations of uncertainty. This is consistent with previously established findings that numeracy plays a crucial role in understanding risks and decision making (Reyna et al., 2009; Peters et al., 2007). These results imply that to enhance health decision-making, it is necessary to not only increase access to information but also to ensure that such information is presented in formats that are comprehensible at different levels of numeracy.

Secondly, findings demonstrate that disparities in quantitative literacy are closely linked to broader social determinants of health. Consistent with the Results, populations with lower socioeconomic status and limited educational opportunities tend to exhibit lower levels of health literacy and numeracy, resulting in unequal engagement with health information and poorer outcomes. This supports the view that quantitative literacy should be conceptualised as a structural determinant of health equity rather than merely an individual skill deficit (Nutbeam & Lloyd, 2021; Stormacq et al., 2019). Public health strategies that fail to account for these disparities risk reinforcing existing inequities.

Relatedly, the findings identify social justice mathematics as a promising, though underdeveloped, approach for addressing inequities in quantitative understanding. By linking mathematical reasoning to real-world contexts such as epidemiological trends, resource allocation, and health disparities, this approach can enhance both technical competence and critical awareness (Gutstein, 2003, 2006). As reflected in the Results, however, empirical evidence directly connecting social justice mathematics interventions to improved health decision-making remains limited, highlighting a critical gap for future interdisciplinary research. The limited empirical evidence identified in this review may reflect the historical separation between mathematics education and public health research as disciplinary domains. Numeracy has frequently been conceptualized as an individual cognitive skill rather than a socially situated determinant of equity and participation. Consequently, interdisciplinary frameworks linking social justice mathematics to measurable public health outcomes remain underdeveloped.

The implications of these findings are significant for public health practice, education, and policy. Public health communication should adopt numeracy-sensitive strategies, including plain language, absolute risk estimates, and visual representations of data. Healthcare providers should assess patient understanding of numerical information as part of shared decision-making. Education systems should integrate authentic public health data into mathematics curricula to develop applied quantitative literacy. At the policy level, strengthening numeracy should be incorporated into broader health equity frameworks, particularly in underserved populations. Beyond classroom contexts, social justice mathematics may contribute to community-based public health interventions by improving citizens' capacity to critically interpret statistical claims, evaluate misinformation, and engage in evidence-informed health advocacy (Gutstein, 2006; Nutbeam & Lloyd, 2021). Integrating equity-oriented quantitative literacy into health campaigns, vaccination communication, and preventive healthcare initiatives may strengthen trust, participation, and informed decision-making within vulnerable communities. This review contributes to the literature by integrating insights from public health, health literacy, risk communication, and mathematics education. It advances existing work by positioning quantitative literacy at the intersection of cognitive capability and structural inequality. Most importantly, it highlights the need for coordinated, multi-level interventions that address both individual skills and systemic barriers to equitable participation in health. Implementing socially responsive quantitative literacy initiatives may face challenges, including unequal educational access, digital inequalities, limited teacher and healthcare worker preparation, and resistance to critical or politically engaged pedagogies. Addressing these barriers will require interdisciplinary collaboration among educators, public health practitioners, policymakers, and community organizations. Several limitations were acknowledged. The included

studies varied in design, population, and disciplinary focus, which limited the potential for quantitative synthesis. The restriction to English-language peer-reviewed literature may have excluded relevant evidence from low- and middle-income settings. In addition, the limited empirical linkage between social justice mathematics and health outcomes constrains the strength of conclusions in this area. Overall, the methodological quality of included studies was satisfactory. However, evidence directly examining the relationship between social justice mathematics and measurable health outcomes remained limited. Consequently, findings relating to social justice mathematics should be interpreted cautiously and require further empirical investigation.

5. Conclusion

This systematic review examined how quantitative literacy influences health decision-making, how disparities in numeracy contribute to public health inequities, and how social justice mathematics may support more equitable engagement with health information. The findings demonstrate that quantitative literacy is not merely an individual cognitive skill but also a structural determinant that influences risk interpretation, healthcare participation, treatment decisions, and access to preventive services. The review further highlights the potential of social justice mathematics to strengthen critical engagement with health data and increase awareness of structural inequities embedded within health systems. Despite these contributions, empirical evidence directly linking social justice mathematics interventions to measurable health equity outcomes remains limited. Future research should therefore prioritize interdisciplinary empirical studies examining how socially responsive quantitative literacy programs influence healthcare participation, public health behaviour, and evidence-informed decision-making across diverse populations. From a policy and educational perspective, integrating numeracy-sensitive communication with equity-oriented mathematics education represents a promising but under-evaluated strategy for promoting equitable participation in health decision-making. Further empirical research is required to determine its impact on measurable health equity outcomes.

Conflict of Interest

There is no conflict of interest.

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