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Research Article

Internal and External Determinants of Secondary School Teachers' Digital Literacy Effectiveness: A Systematic Literature Review

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Abstract

This study aims to identify and synthesize the internal and external determinants affecting the effectiveness of secondary school teachers' digital literacy. A systematic literature review was conducted following the PRISMA 2020 guidelines, drawing on empirical studies indexed in Scopus, Web of Science, ERIC, and Google Scholar. The findings show that digital literacy effectiveness emerges from the dynamic interaction between individual capacities and institutional conditions. The most influential internal determinants are digital pedagogical competence, self-efficacy, attitudes toward technology, intrinsic motivation, and prior technological experience. Key external determinants include ICT infrastructure, school leadership, institutional support, educational policy, collaborative school culture, and continuous professional development. At the secondary level, self-efficacy and technological pedagogical content knowledge are particularly important because they shape the quality of technology integration and support students' higher-order thinking skills. The study concludes that teacher digital literacy should be understood as a multidimensional and ecosystem-based competence. Strengthening it therefore requires coordinated policies, sustained professional development, equitable infrastructure, and supportive school cultures that promote inclusive, adaptive, and meaningful digital learning.

Keywords: Digital Competence; Digital Equity; School Leadership; Secondary Education; Teacher Digital Literacy.

INTRODUCTION

Digital transformation has reconfigured education from a predominantly content-delivery model into a connected learning ecosystem shaped by data, platforms, artificial intelligence, and networked communication. Within this environment, information literacy and digital literacy influence not only access to learning resources but also learners' capacity to participate critically in social, civic, and economic life [1], [2]. Teachers are therefore expected to move beyond operating digital tools and to mediate how information is accessed, evaluated, created, communicated, and used ethically [3], [4].

This expectation is particularly important in secondary education, where students increasingly encounter complex information environments and are expected to develop critical, reflective, and evaluative reasoning. Secondary school teachers have a strategic role in helping students distinguish credible evidence from misinformation, understand the consequences of digital participation, and use technology for inquiry and problem solving [5], [6]. However, the quality of such mediation remains uneven because technology integration is shaped by pedagogical beliefs, professional preparation, and the conditions in which teachers work [7], [8].

Information literacy and digital literacy are related but analytically distinct. Information literacy concerns the capacity to recognize an information need and to locate, evaluate, synthesize, and use information responsibly [9], [10]. Digital literacy extends this capacity into technology-rich contexts by combining operational skills, cognitive judgment, communication, media awareness, creativity, and digital safety [11], [12]. Consequently, effective teacher digital literacy should be assessed through the quality of pedagogical decisions and learning experiences it enables, not merely through the frequency of device or platform use.

Despite the expansion of research on teacher digital competence, three gaps remain. First, many studies emphasize technical proficiency or technology acceptance without integrating pedagogical, motivational, organizational, and policy determinants into a coherent explanation [13], [14]. Second, internal factors such as competence, self-efficacy, motivation, attitudes, and prior experience are often examined separately from external factors such as leadership, infrastructure, institutional support, and professional learning [15], [16]. Third, evidence specific to secondary education remains fragmented even though this level combines subject-specialist teaching, complex curricula, high-stakes assessment, and heightened expectations for students' higher-order thinking.

The issue also has an equity dimension. Unequal access to infrastructure, professional support, and accessible digital learning environments can reproduce differences in teachers' opportunities to develop competence and in students' opportunities to participate. Such disparities are especially consequential in under-resourced schools and require attention to gender, location, disability, and socioeconomic context. A systematic synthesis is therefore needed to clarify which determinants consistently shape effective practice, how they interact, and where institutional intervention is most likely to have sustained educational value.

Accordingly, this study aims to identify and synthesize the internal and external determinants that influence the effectiveness of secondary school teachers' digital literacy. Specifically, it examines how digital-pedagogical competence, self-efficacy, attitudes toward technology, motivation, and prior technological experience shape teachers' capacity to

implement meaningful digital pedagogy. It also investigates the contribution of external conditions, including educational policy, technological infrastructure, institutional support, school leadership, collaborative culture, and continuous professional development. Particular attention is given to the interaction between individual capacities and institutional conditions, as well as to evidence-informed strategies that can strengthen teacher digital literacy in secondary education.

To achieve these objectives, this study employs a Systematic Literature Review following established procedures for transparent, rigorous, and replicable evidence synthesis [17], [18]. By integrating findings from diverse empirical contexts, the study develops an ecosystem-oriented understanding of teacher digital literacy that extends beyond technical competence. Its principal contribution lies in explaining how teacher agency, institutional capacity, digital equity, and pedagogical quality collectively determine the effectiveness of technology-mediated learning.

METHODS

This study employed a Systematic Literature Review (SLR) guided by PRISMA 2020 reporting principles to support transparent, accountable, and replicable evidence synthesis [18]. The approach was appropriate because the research question concerns a multidimensional phenomenon investigated through quantitative, qualitative, and mixed-method designs.

Formulation of Research Questions

The research questions were formulated using an adaptation of the PICO logic for evidence synthesis [19]. The population comprised secondary school teachers; the exposure concerned digital literacy and its potential determinants; comparison referred to differences across contexts or implementation conditions where reported; and the outcome concerned effective, pedagogically meaningful, and ethically responsible uses of digital technology. This structure was used to organize the search, eligibility assessment, extraction, and synthesis.

Literature Search Strategy

The search covered Scopus, Web of Science, and ERIC, with supplementary searching through Google Scholar using Publish or Perish to broaden retrieval [20]. The publication period was limited to 2015-2025 to capture evidence associated with contemporary digital platforms and post-digitalization policy developments. Search concepts combined terms related to teachers, secondary education, digital literacy or digital competence, technology integration, self-efficacy, leadership, infrastructure, policy, school culture, and professional development. Database-specific syntax was adapted to the indexing structure of each platform.

Inclusion and Exclusion Criteria

Eligibility criteria were established before synthesis to improve consistency and relevance [21]. Included publications were empirical journal articles using quantitative, qualitative, or mixed methods; examined teacher digital literacy, digital competence, information literacy, or closely related technology-integration constructs; included secondary teachers or reported findings applicable to secondary education; were published between 2015 and 2025; and were available

in English or Indonesian. Conceptual papers without empirical evidence, studies focused exclusively on students, editorials, opinion pieces, non-indexed proceedings, and records without accessible full text were excluded.

Study Selection Process

Study selection followed the PRISMA stages of identification, duplicate removal, title and abstract screening, full-text eligibility assessment, and final inclusion [18], [22]. Reasons for full-text exclusion were considered against the predefined criteria. The original review record did not preserve a complete numerical screening log; therefore, this revised manuscript does not retroactively reconstruct article counts or present a numerical PRISMA flow diagram. This decision prevents the introduction of unsupported data while preserving the documented selection procedure [23].

Data Extraction and Synthesis

A structured extraction matrix was used to record author, publication year, country or context, research design, participants, focal constructs, measures, and principal findings [24]. The evidence was synthesized thematically [25]. Initial coding distinguished internal determinants (digital-pedagogical competence, self-efficacy, attitudes, motivation, and experience) from external determinants (infrastructure, policy, leadership, institutional support, school culture, and professional development). Subsequent interpretation examined interactions among determinants, contextual differences, and implications for meaningful and inclusive digital pedagogy.

Quality Assessment and Risk of Bias

Methodological quality was appraised using criteria adapted from the Mixed Methods Appraisal Tool (MMAT) [26]. Appraisal considered the alignment of research questions, design, sampling, measurement or data collection, analysis, and interpretation. Potential selection, publication, and methodological biases were considered during synthesis [27]. Studies with weaker methodological reporting were not automatically discarded when they contributed contextually relevant evidence, but their claims were weighted cautiously.

Reporting of Results

Reporting followed PRISMA 2020 principles [18]. Results are presented as a qualitative characterization of the evidence base, a thematic synthesis of determinants, and an interpretation of their interactions. Because the source review did not retain auditable study counts for each screening stage or determinant, the manuscript avoids numerical prevalence claims and uses conceptual visualizations rather than reconstructed quantitative charts.

RESULTS AND DISCUSSION

Results

Characteristics of the Analyzed Studies

The evidence base represented research from Europe, Asia, North America, and other settings. European studies frequently used competency frameworks such as DigCompEdu, whereas

studies in Asian and developing-country contexts more often emphasized disparities in access, teacher readiness, and institutional capacity [28], [29]. North American work commonly examined the relationship among teacher knowledge, beliefs, confidence, school culture, and technology-supported pedagogical change [30].

Quantitative designs were frequently used to examine relationships among competence, self-efficacy, acceptance, and technology use. Qualitative and mixed-method studies complemented these findings by explaining how leadership, collegial interaction, workload, curriculum, and local infrastructure shape implementation [16], [31]. The methodological diversity supports thematic integration but limits direct comparison of effect sizes across studies.

Across the literature, digital competence and self-efficacy were closely connected with TPACK, technology acceptance, leadership, organizational readiness, and professional learning [15], [32]. This pattern indicates that teacher digital literacy is not a single attribute. It is a situated professional capability produced through the interaction of knowledge, judgment, confidence, motivation, and organizational opportunity.

Thematic Synthesis of Determinant Factors

The thematic synthesis identified five recurrent internal determinants. First, digital competence includes technical proficiency and the capacity to integrate technology with subject content, pedagogy, assessment, and learner needs [4], [16]. Second, self-efficacy influences whether teachers experiment with technology, persist when difficulties occur, and use digital tools with instructional confidence [28]. Third, attitudes toward technology mediate the movement from available competence to actual classroom use [33], [34]. Fourth, intrinsic motivation supports self-directed exploration and continued learning [16]. Fifth, prior personal and professional experience can reduce uncertainty and strengthen readiness for pedagogical adaptation [28].

Six external determinants were repeatedly associated with implementation. ICT infrastructure and reliable access are foundational, particularly in contexts marked by uneven connectivity and device availability [1], [35]. Nevertheless, access alone does not ensure instructional quality; technology must be accompanied by pedagogical guidance and opportunities for supported experimentation [30]. Leadership, institutional support, and policy provide direction, time, legitimacy, and resources for change [16], [36]. Collaborative school cultures promote knowledge sharing, while continuous, practice-based professional development is more likely than isolated technical workshops to strengthen competence and confidence [31], [37].

Table 1. Thematic synthesis of determinants of secondary school teachers' digital literacy

Category	Sub-factor	Synthesis of evidence	Implication for effectiveness	Main references
Internal	Digital-pedagogical competence	Technical, pedagogical, content, assessment, and ethical use of technology.	Shapes the quality and relevance of digital learning design.	[4], [15], [32]
	Self-efficacy	Confidence in planning, implementing, and troubleshooting	Supports persistence, experimentation,	[14], [16], [28]

Category	Sub-factor	Synthesis of evidence	Implication for effectiveness	Main references
		technology-supported learning.	and confident classroom use.	
	Attitudes toward technology	Perceived usefulness, value, risk, and compatibility with teaching beliefs.	Mediates whether competence is translated into practice.	[14], [33], [34]
	Intrinsic motivation	Self-directed willingness to learn, explore, and refine digital practice.	Sustains innovation and professional learning beyond formal training.	[16]
	Prior experience	Personal and professional familiarity with digital tools and learning environments.	Reduces uncertainty and strengthens readiness for adaptation.	[16], [28], [30]
External	ICT infrastructure and access	Availability, reliability, affordability, accessibility, and technical support.	Creates the material conditions for consistent implementation.	[1], [29], [35]
	Leadership and institutional support	Vision, time, resources, coordination, recognition, and technical-pedagogical support.	Enables sustained and coherent technology integration.	[16], [36]
	Educational policy	Standards, curriculum direction, funding, governance, and accountability.	Provides strategic direction, legitimacy, and equity safeguards.	[1], [2], [3]
	Collaborative school culture	Collegial learning, peer assistance, shared experimentation, and knowledge exchange.	Accelerates adoption and reduces isolated practice.	[7], [16], [30]
	Professional development	Continuous, practice-based, subject-sensitive, and collaborative learning.	Strengthens competence, confidence, and transfer to classroom practice.	[8], [31], [37]
	Pedagogical and accessibility support	Guidance for meaningful, inclusive, safe, and learner-centered technology use.	Ensures that technology use improves learning rather than merely digitizing content.	[7], [15]

Table 1 shows that the determinants operate as an interdependent system rather than as isolated variables. Internal factors function as teacher-level drivers that shape readiness, decision making, and adaptive action. Digital-pedagogical competence provides the knowledge base, self-efficacy supports enactment, positive attitudes increase acceptance, motivation sustains learning, and experience helps teachers manage uncertainty.

External factors function as system-level enablers or constraints. Infrastructure creates the material possibility for digital practice, while leadership, policy, professional learning, and collaborative culture determine whether that possibility becomes meaningful pedagogy. Technology provision without instructional support can result in superficial or administrative use, whereas strong institutional support can enable teachers to redesign learning, assessment, and participation.

The relationship between the two levels is reciprocal. Practice-based professional development can enhance technical and pedagogical knowledge while also strengthening confidence and attitudes. Conversely, teachers with stronger motivation and self-efficacy are more likely to use available infrastructure, seek collegial support, and participate actively in professional learning [16], [31]. The same external intervention may therefore produce different outcomes depending on teacher agency, while individual competence may remain underused when organizational conditions are weak.

Figure 1 integrates these findings into an ecosystem model. Effective teacher digital literacy is positioned at the intersection of individual capacity and educational support, leading to meaningful digital pedagogy, students' higher-order thinking, inclusive participation, and learning well-being. These outcomes should be interpreted as pathways identified in the literature rather than as effects directly estimated by this review.

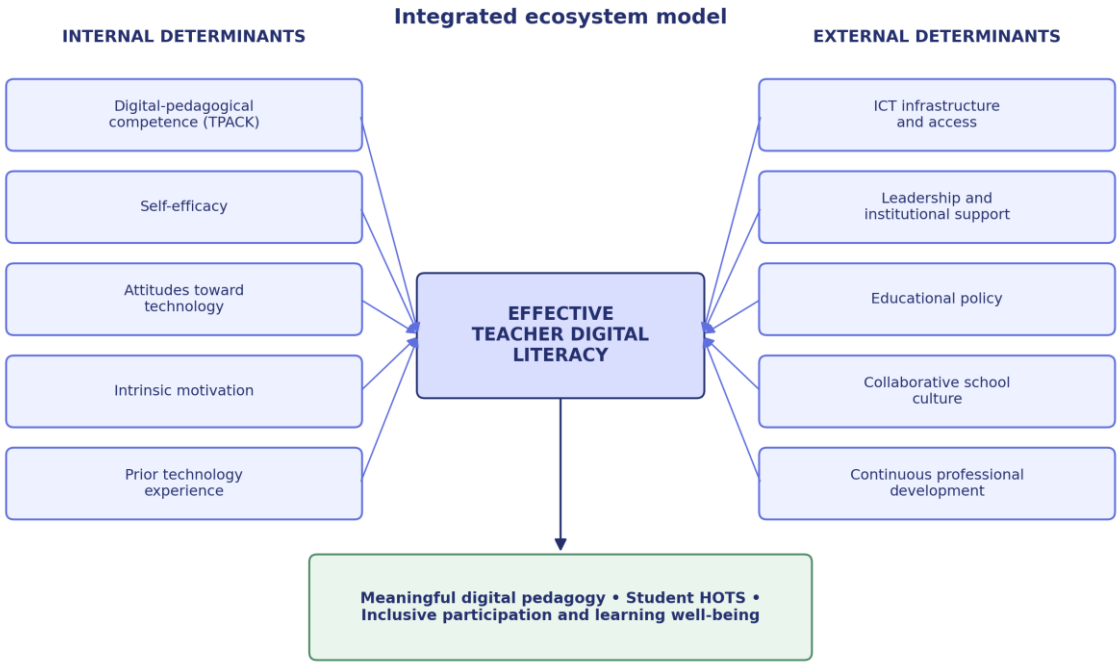

Figure 1. Integrated ecosystem model of determinants of secondary school teachers' digital literacy effectiveness.

An ecosystem perspective also widens the analytical frame beyond the classroom. Schools are connected to families, communities, policy systems, and commercial or public digital platforms. Teachers must therefore make pedagogical decisions within broader conditions of access, safety, ethics, and social participation. Strengthening digital literacy consequently requires attention to both professional competence and the fairness of the environments in which digital learning occurs.

Key Findings at the Secondary Education Level

At the secondary level, self-efficacy and digital-pedagogical competence emerged as especially influential because teachers must align technology with specialized subject content, assessment demands, and adolescent learners' growing capacity for critical inquiry [14], [28], [32]. Institutional support and leadership are also consequential because secondary schools often involve departmental structures, complex scheduling, and multiple technology systems [36]. Professional learning can connect these levels by strengthening competence and confidence through authentic planning, teaching, reflection, and peer feedback [37].

The synthesis further suggests that teacher digital literacy is relevant to students' higher-order thinking when technology is used for inquiry, evaluation, creation, and problem solving rather than for content transmission alone [6], [35]. Persistent constraints include disparities among regions and schools [1], resistance to pedagogical change [30], and limited integration of digital competence into curriculum and professional standards [13]. These constraints reinforce the need for coordinated rather than teacher-only interventions.

Discussion

Interpretation of Findings within Theoretical Frameworks

The findings can be interpreted through three complementary frameworks: the Big6 approach to information problem solving, the ACRL Framework for Information Literacy, and DigCompEdu. Together, they show that effective teacher digital literacy combines information judgment, pedagogical design, technological competence, professional engagement, and social responsibility.

The Big6 tradition emphasizes the sequence of defining an information problem, selecting strategies, locating and accessing sources, using information, synthesizing evidence, and evaluating both process and product [10], [38]. Applied to teaching, this sequence shifts the focus from operating devices to designing inquiry in which students learn to locate, assess, combine, and communicate information. It therefore supports the interpretation of digital competence as cognitive-procedural and pedagogical, not merely operational.

The ACRL Framework positions information literacy as a situated social practice involving authority, inquiry, knowledge creation, and ethical participation [9]. Research on civic online reasoning demonstrates that learners require explicit instruction and repeated practice to evaluate online claims, trace sources, and compare evidence across the curriculum [39], [40]. Teachers consequently act as epistemic mediators: their confidence and judgment shape whether digital resources become objects of critical investigation or are accepted uncritically.

DigCompEdu provides the most direct operational bridge between internal and external determinants. Its domains connect professional engagement, digital resources, teaching and

learning, assessment, learner empowerment, and the facilitation of learners' digital competence [41], [42], [43]. Internal factors are expressed through pedagogical decision making, while external factors influence access to resources, professional collaboration, institutional expectations, and continuing development. Integrating the three frameworks therefore produces a multi-layered account of teacher digital literacy.

Consistency and Contradictions Across Studies

There is broad consistency across studies that digital competence, self-efficacy, and supportive organizational conditions are associated with stronger technology integration [4], [14], [16]. The relationship is nevertheless conditional rather than automatic. Competence may not translate into practice when teachers lack time, infrastructure, leadership support, or curriculum flexibility; conversely, technology provision may have little instructional effect when teachers lack pedagogical confidence.

Several tensions refine this interpretation. First, increased access does not necessarily improve learning quality because technology can remain administrative, transmissive, or disconnected from pedagogy [13], [44]. Second, age and experience do not operate uniformly. Some studies associate greater familiarity with digital tools with stronger confidence, while others show that pedagogical expertise and supported professional learning can outweigh age-related differences [7], [15], [28]. Third, structural barriers tend to be more visible in developing contexts, where connectivity, device access, technical support, and policy implementation can constrain even highly motivated teachers [45].

Implications for Educational Policy and Practice

The findings imply that educational policy should move from device provision toward capacity-building ecosystems. Investment should combine reliable and accessible infrastructure with teacher competency standards, time for collaborative planning, responsive technical support, and pedagogically grounded professional learning [1], [2]. At school level, leaders should establish a coherent vision, distribute responsibility, protect time for experimentation, and use evidence from classroom practice to guide improvement [16], [46]. Professional development should be sustained, collaborative, subject-sensitive, and connected to authentic teaching tasks rather than limited to one-off software demonstrations [31], [37]. Implementation should prioritize authentic, learner-centered uses of technology rather than the mere digital reproduction of conventional instruction [47].

Future Research Agenda

Future research should test integrative models that link internal, external, and contextual determinants over time. Longitudinal and multilevel designs are needed to explain how competence develops, how school conditions moderate teacher agency, and how digital literacy relates to student outcomes. Research should also incorporate gender-responsive and intersectional analysis, including location, disability, socioeconomic context, subject area, and career stage. Inclusive human-computer interaction and accessibility should be examined as pedagogical and institutional responsibilities, not as optional technical features. Figure 2 summarizes this multilevel pathway and emphasizes continuous feedback and an explicit equity lens.

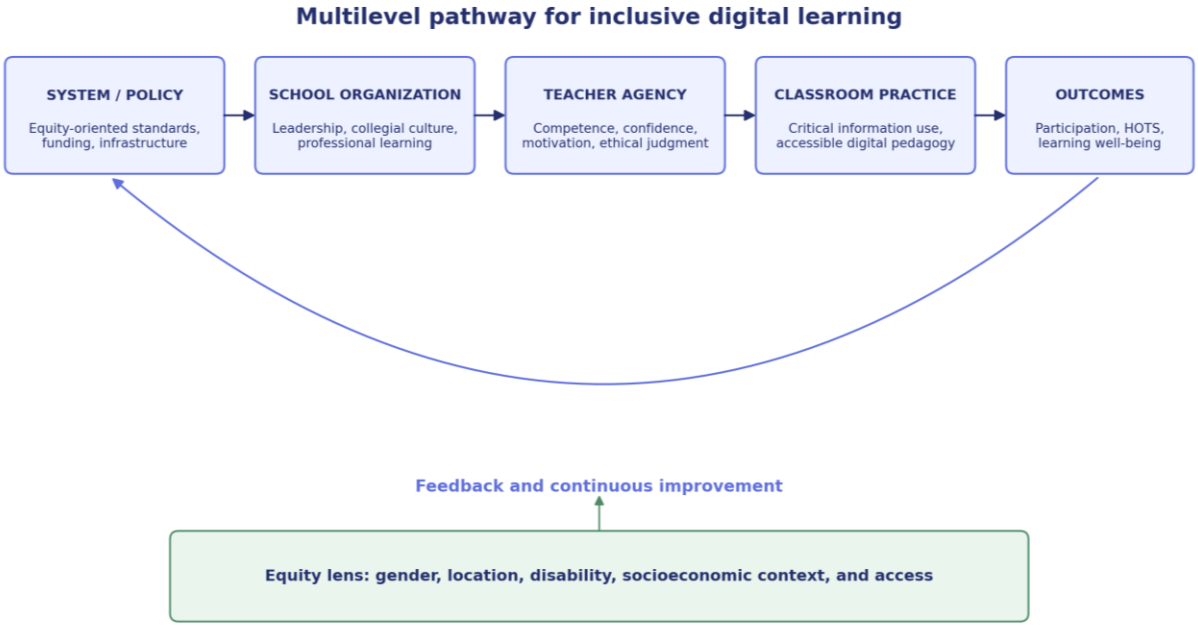

Figure 2. Multilevel pathway from institutional enablers to inclusive digital learning outcomes.

CONCLUSION

This review synthesized internal and external determinants associated with the effectiveness of secondary school teachers' digital literacy. Internal determinants comprise digital-pedagogical competence, self-efficacy, attitudes toward technology, motivation, and prior experience. External determinants comprise ICT infrastructure, leadership and institutional support, educational policy, collaborative school culture, pedagogical support, and continuous professional development. Their influence is interdependent: teacher agency requires enabling conditions, while institutional investment requires competent and reflective teachers to generate educational value. The theoretical synthesis shows that teacher digital literacy is best understood as a multidimensional professional capability integrating information problem solving, critical source evaluation, pedagogical design, ethical judgment, and participation in a wider digital ecosystem. It is therefore insufficient to measure effectiveness through access or frequency of use alone. More meaningful indicators concern how teachers use technology to support inquiry, assessment, inclusion, higher-order thinking, and responsible participation. For policy and practice, the central implication is a coordinated approach that develops both people and systems. Governments and school leaders should combine equitable infrastructure, adaptive leadership, collaborative professional cultures, and sustained practice-based learning. Such an approach is more likely to support meaningful and inclusive digital pedagogy than isolated technical training. Future studies should verify these relationships through longitudinal, multilevel, and equity-sensitive designs.

LIMITATIONS

This review has several limitations. First, the databases and language criteria may have excluded relevant evidence. Second, methodological heterogeneity prevented statistical meta-analysis and limits direct comparison across studies. Third, the original review documentation did not retain complete numerical records for every PRISMA stage; accordingly, no screening counts were reconstructed in this revision. Fourth, most evidence was cross-sectional, restricting conclusions about change over time or causality. Fifth, the protocol did not systematically extract findings by gender, disability, socioeconomic position, location, or other equity characteristics, which limits assessment of whether determinants operate similarly across groups and contexts. These limitations should guide more transparent, longitudinal, and intersectional research.

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AUTHOR CONTRIBUTION

A.R. conceptualized the study, formulated the research questions, developed the systematic review design, and coordinated the overall research process. S. contributed to the methodological development, literature screening, quality appraisal, and interpretation of the synthesized findings. F.M. contributed to the literature search, data extraction, thematic synthesis, and preparation of the initial manuscript draft. A.R., S., and F.M. jointly reviewed the analytical results, strengthened the theoretical and practical implications, and critically revised the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST

""The authors declare no conflict of interest."

DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

The author used Deepseek during the preparation of this work for language refinement, translation of selected sections from Indonesian to English, and grammatical editing. After utilizing the tool, the author thoroughly reviewed and revised the content as necessary and assumes full responsibility for the accuracy, originality, and integrity of the final manuscript.

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