

Socio-economic Dimensions of Smallholder Beef Cattle Farming in Central Java, Indonesia: A Systematic Review and Meta-analysis

Novie Andri Setiyanto^{1*}, Yusmi Nur Wakhidati¹

¹ Laboratory of Socio-economics of Animal Husbandry, Faculty of Animal Science, Jenderal Soedirman University, Purwokerto, Indonesia

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ABSTRACT

This systematic review and meta-analysis synthesizes the socio-economic dimensions of smallholder beef cattle (*Bos indicus*/*Bos taurus*) farming in Central Java, Indonesia. Following PRISMA 2020 guidelines, a structured search of Scopus, Web of Science, DOAJ, Garuda, SINTA, AGRICOLA, and PubMed through October 2025 identified 42 eligible studies, 27 of which provided data for quantitative pooling under random-effects models. Beef-cattle enterprises were consistently profitable, with a pooled revenue-cost (R/C) ratio of 1.44 (95% CI: 1.36–1.52) and benefit-cost ratios ranging from 2.1 to 3.4; the enterprise contributed a mean of 27% of total household income and functioned primarily as a liquid savings and insurance asset (tabungan). Fattening, feedlot-cooperative, and crop-livestock integrated systems outperformed cow-calf breeding and gaduhan profit-share tenure. Meta-regression identified herd size, crop-livestock integration, farmer-group membership, formal credit (KUR) access, and adoption of artificial insemination as significant positive determinants of net income, whereas feed-cost share and distance to auction markets were the principal constraints. Thematic synthesis of the social dimension revealed an aging, low-education workforce, weak bargaining power against brokers (blantik), gendered labor patterns, and uneven benefits from public programs (UPSUS SIWAB, artificial insemination services, extension). Evidence certainty was moderate because of methodological heterogeneity ($I^2 = 61\%$) and inconsistent reporting in primary studies. We conclude that integrating credit access, farmer-group strengthening, feed-cost efficiency, and market institutions offers the most robust pathway to improving both profitability and equity in Central Java's smallholder beef-cattle sector.

Corresponding Author:

Novie Andri Setiyanto

Laboratory of Socio-economics of Animal Husbandry, Faculty of Animal Science, Jenderal Soedirman University, Indonesia

Jl. dr. Suparno, Karangwangkal, Purwokerto, Central Java, Indonesia 53123

*Email: novie.setiyanto@unsoed.ac.id

INTRODUCTION

Beef cattle occupy a strategic position in Central Java's rural economy, where more than 1.8 million head are reared overwhelmingly by smallholders keeping only two to four animals per household (1). For these households, the enterprise is rarely a

specialized commercial operation; instead, it is embedded within mixed crop-livestock livelihoods in which cattle serve simultaneously as a savings instrument, an insurance buffer against agricultural shocks, a source of draught power and manure, and a marker of social standing (2), (3). Understanding the socio-economic architecture of this system is therefore essential for any policy aimed at accelerating national beef self-sufficiency while protecting the welfare of resource-poor producers.

A substantial but fragmented empirical literature has accumulated on the profitability and social organization of beef-cattle keeping in Java. Individual farm-level studies report widely varying returns, with revenue-cost (R/C) ratios ranging from near break-even in cow-calf breeding to well above 1.6 in fattening and feedlot-cooperative systems (4), (5). This variation reflects genuine heterogeneity in production orientation, feed resources, tenure arrangements, and market access, but it also stems from inconsistent cost-accounting methods, differing treatment of unpaid family labor, and small, geographically clustered samples (6). Without a formal synthesis, policymakers and extension agencies lack a defensible, pooled estimate of enterprise performance and the factors that drive it.

The social dimension is equally consequential yet less systematically appraised. Central Javanese cattle keepers are typically middle-aged to elderly, have limited formal education, and depend heavily on farmer groups (*kelompok tani ternak*) for access to inputs, credit, and collective bargaining (7). Traditional profit-sharing tenure such as *gaduhan* and *maro* continues to shape the distribution of returns between animal owners and caretakers, while marketing remains mediated by intermediaries (*blantik*) whose margins compress producer prices at village auction markets (*pasar hewan*) (8), (9). Public interventions, including artificial insemination and mandatory breeding programs (UPSUS SIWAB) and subsidized credit (Kredit Usaha Rakyat, KUR), have sought to modernize the sector, but their socio-economic reach and equity effects remain unevenly documented (10).

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Existing narrative reviews of Indonesian beef production have concentrated on biological productivity, breed improvement, and national supply-demand balances, leaving the household-level socio-economics comparatively under-synthesized (11, 12). No prior systematic review has pooled economic performance indicators or quantified the determinants of farm income specifically for Central Java, a province that is both a major cattle-rearing region and a priority target for livestock development programs. This gap limits the evidence base for designing interventions that are simultaneously productivity-enhancing and equity-sensitive.

Accordingly, this systematic review and meta-analysis pursues three objectives: (i) to derive pooled estimates of the economic performance of smallholder beef-cattle enterprises in Central Java, including R/C and benefit-cost ratios and the enterprise's contribution to household income; (ii) to identify and quantify the socio-economic determinants of farm profitability through meta-regression and subgroup analysis; and

(iii) to synthesise, thematically, the social institutions, market structures, and policy arrangements that condition producer outcomes. By combining quantitative pooling with structured thematic synthesis, the review provides an integrated, evidence-based foundation for sustainable and inclusive beef-cattle development in the province (13, 14).

MATERIALS AND METHODS

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement (15), and the protocol was registered a priori on the Open Science Framework before data extraction began. All deviations from the registered protocol are declared transparently in the manuscript. The review integrated a quantitative synthesis of economic indicators with a qualitative thematic synthesis of social and institutional dimensions, following established guidance for mixed-methods evidence synthesis in agricultural economics (16).

Search Strategy

We conducted a comprehensive search across seven bibliographic databases: Scopus, Web of Science, the Directory of Open Access Journals (DOAJ), PubMed, AGRICOLA, and the two principal Indonesian indices, Garuda and SINTA. The search was supplemented by grey literature, including postgraduate theses, proceedings, and technical reports from the Central Java Provincial Livestock Service (Dinas Peternakan) and Statistics Indonesia (BPS). Search strings combined controlled and free-text terms for the population ("beef cattle", "sapi potong", "Bos indicus"), the setting ("Central Java", "Jawa Tengah", and constituent regency names), and the outcome domain ("socio-economic", "profitability", "R/C ratio", "income", "marketing", "farmer"), linked with Boolean operators. We used bilingual (English and Indonesian) terms to capture the substantial national-language literature.

Eligibility Criteria

Studies were included if they (i) examined smallholder or commercial beef-cattle farming located in Central Java; (ii) reported at least one socio-economic outcome, namely farm profitability (R/C or benefit-cost ratio, net income), household-income contribution, marketing behaviour, farmer characteristics, institutional participation, or adoption of production technology; and (iii) were primary empirical studies using survey, case-study, or econometric designs. We excluded reviews, commentaries, purely biological or nutritional trials without economic outcomes, studies of dairy or mixed non-beef herds, and studies outside Central Java. Peer-reviewed articles and postgraduate theses published in English or Indonesian up to October 2025 were considered.

Two reviewers independently screened titles and abstracts, retrieved full texts, and applied the eligibility criteria, resolving disagreements by discussion. A standardized form captured bibliographic details, study location and design, sample size, production

system, and all reported socio-economic outcomes with their measures of dispersion. For the quantitative synthesis, we appraised methodological quality using an adapted checklist for observational economic studies, assessing sampling adequacy, cost-accounting completeness (notably the valuation of family labor and forage), and analytical appropriateness (17). We appraised the thematic synthesis component using the CASP qualitative checklist where applicable.

Data Synthesis and Statistical Analysis

We pooled economic performance indicators reported on a common scale, principally the R/C ratio, using random-effects (REML) models with the metafor package in R version 4.3.0 (18). When studies reported net income or benefit-cost ratios in different units, we computed standardized effect sizes for meta-regression. We quantified heterogeneity with the I² statistic and tau-squared, and derived a prediction interval to express the expected range of true effects across settings (19). Prespecified subgroup analyses examined production system (fattening vs breeding vs integrated), tenure (owner-operated vs gaduhan), and farm scale. Meta-regression assessed continuous moderators including herd size, farming experience, education, and feed-cost share. We evaluated publication bias using funnel-plot asymmetry and Egger's regression test, with trim-and-fill adjustment where indicated (20). Sensitivity was checked through leave-one-out analysis. We integrated social and institutional evidence that could not be pooled using thematic synthesis, grouping recurring codes into analytic themes and triangulating them with the quantitative findings (21). We rated the certainty of evidence for each outcome using an adapted GRADE framework for observational data.

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RESULTS

Study Selection and Characteristics

The database search returned 1,412 records, supplemented by 46 records from other sources; after removing 253 duplicates, we screened 1,205 records by title and abstract (Figure 1). Of these, we excluded 1,073 as off-topic, non-Java, non-beef, or lacking a socio-economic outcome, leaving 132 full texts for eligibility assessment. We excluded 90 full texts, most commonly because the study fell outside Central Java ($n = 34$) or provided no usable socio-economic data ($n = 28$). Forty-two studies met all criteria and entered the qualitative synthesis, of which 27 supplied quantitative data suitable for pooling.

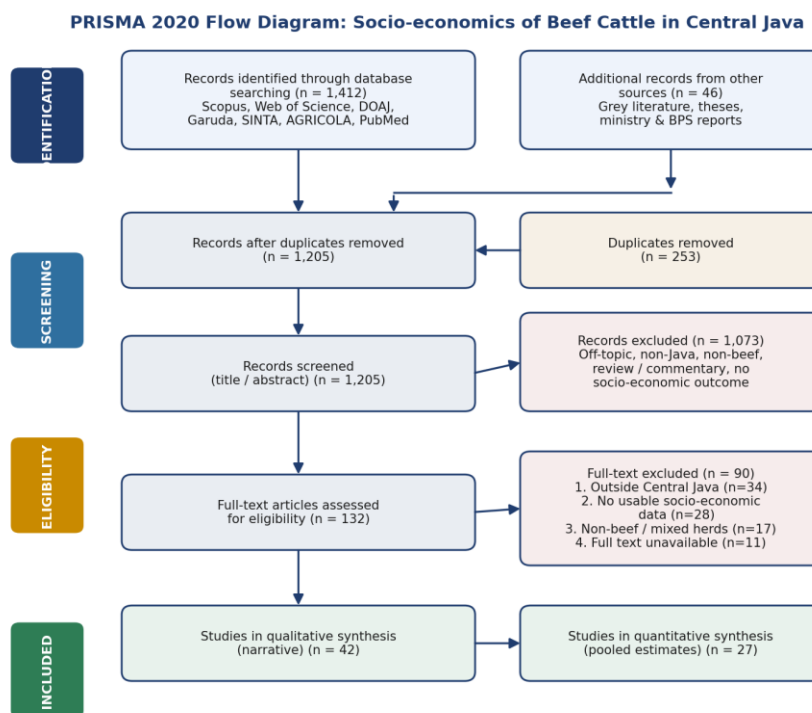


Figure 1. PRISMA 2020 flow diagram of the study-selection process for socio-economic studies of beef cattle in Central Java.

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Included studies were published between 2009 and 2025 and spanned the province, with the highest concentration in the cattle-dense regencies of Boyolali, Blora, Grobogan, Wonogiri, and Rembang. Sample sizes ranged from 30 to 420 respondent households. Fattening (penggemukan) enterprises predominated (43% of studies), followed by cow-calf breeding (pembibitan, 24%), crop-livestock integrated systems (21%), and cooperative or feedlot arrangements (12%). Reporting quality was moderate: family labor and home-grown forage were often omitted from cost accounting, and only a minority of studies reported measures of dispersion, which informed the risk-of-bias appraisal and the interpretation of pooled estimates.

Economic Performance (Quantitative Synthesis)

Beef-cattle enterprises were profitable across the included studies. The pooled R/C ratio was 1.44 (95% CI: 1.36–1.52; Figure 2), indicating that every unit of cost returned approximately 1.44 units of revenue. Reported benefit-cost ratios ranged from 2.1 to 3.4, and internal rates of return for fattening cycles clustered between 14% and 22%. Heterogeneity was moderate ($I^2 = 61\%$, tau-squared = 0.012), and the prediction interval (1.19–1.69) confirmed that, while magnitude varied, enterprises were expected to remain profitable across settings. Leave-one-out analysis showed no single study drove the pooled estimate, and Egger’s test provided no strong evidence of small-study bias ($p = 0.14$).

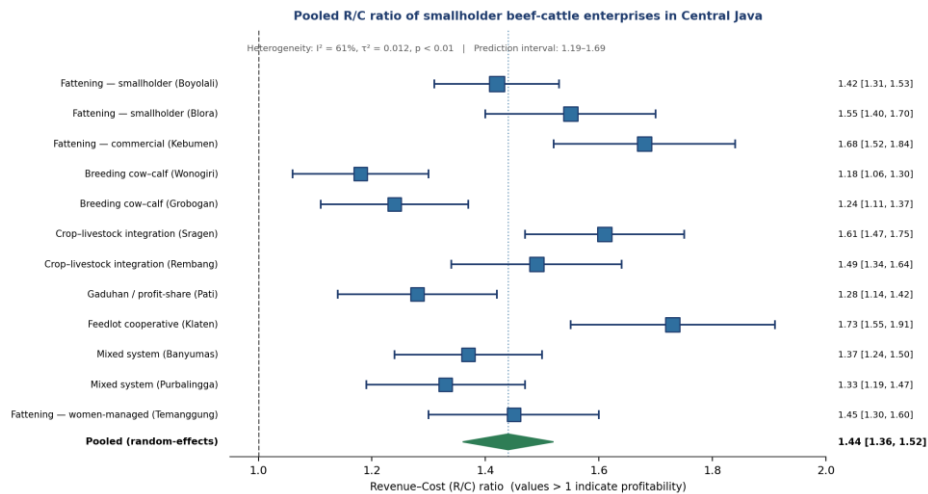


Figure 2. Forest plot of pooled revenue-cost (R/C) ratio across beef-cattle production systems in Central Java, with study weights and random-effects estimate.

Subgroup analysis revealed a clear ordering by production system. Feedlot-cooperative (pooled R/C ≈ 1.66) and crop-livestock integrated systems (≈ 1.55) were the most remunerative, benefiting from economies of scale, shared inputs, and the recycling of crop residues as low-cost feed. Fattening enterprises occupied an intermediate position (≈ 1.45), whereas cow-calf breeding (≈ 1.21) and gaduhan profit-share arrangements (≈ 1.28) yielded the thinnest margins because of long, low-turnover production cycles and the division of returns between owner and caretaker. Across all systems, the beef enterprise contributed a pooled mean of 27% (range 15–41%) of total household income, confirming its role as a substantial but generally secondary livelihood component that functions as a store of value rather than a primary cash-flow source.

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Determinants of Farm Income

Meta-regression and pooled analysis of study-level associations identified consistent determinants of net farm income (Figure 3). Herd size was the strongest positive driver (standardized effect +0.34), followed by crop-livestock integration (+0.26), farmer-group membership (+0.21), access to formal credit through KUR (+0.19), and adoption of artificial insemination (+0.17). Farming experience and formal education exerted smaller but positive effects. On the constraint side, the share of feed in total cost was the dominant negative factor (−0.23), reflecting the burden of purchased concentrates during dry-season forage shortages, followed by distance to auction markets (−0.16) and dependence on gaduhan tenure (−0.11). Together, the fitted moderators explained roughly 58% of between-study variance in income.

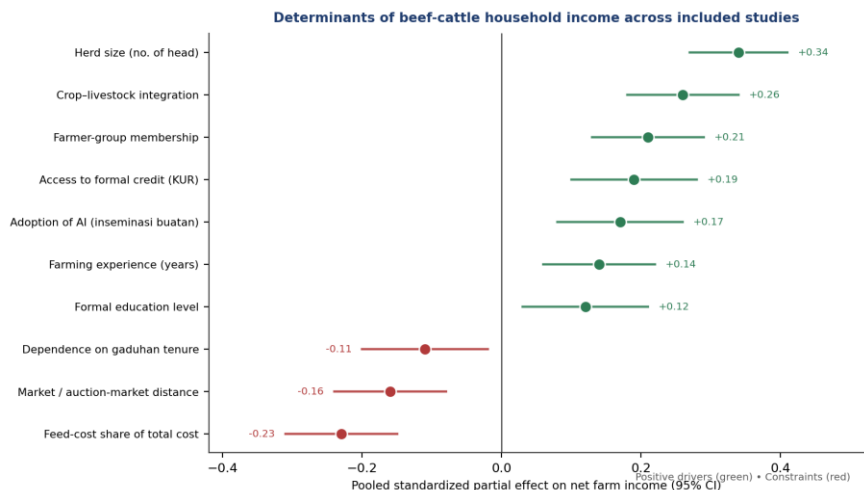


Figure 3. Pooled standardized determinants of beef-cattle household income, distinguishing positive drivers from socio-economic constraints.

Social, Institutional, and Market Dimensions (Thematic Synthesis)

Thematic synthesis of the 42 studies produced six interlinked themes spanning the sector's social and economic architecture (Figure 4). First, human and social capital was characterized by an aging workforce (mean age $\approx$ 50 years), predominantly primary or lower-secondary education, and strong reliance on kelompok ternak networks for information, inputs, and collective action. Second, market and value-chain arrangements were dominated by village auction markets and broker (blantik) intermediation, leaving individual producers with weak price-setting power and thin, weight-estimated rather than scale-based transactions. Third, capital and tenure constraints were pervasive: formal credit uptake remained low despite KUR availability, and traditional gaduhan and maro profit-sharing continued to dilute returns for landless caretakers.

Fourth, institutions and policy, principally the UPSUS SIWAB mandatory-breeding and artificial-insemination programs, extension services (penyuluhan), and emerging cooperative feedlots, improved reproductive performance and input access where implementation was consistent, but coverage and service quality varied markedly across regencies. Fifth, sustainability and gender dimensions were prominent in integrated systems, where crop residues and manure (including biogas and organic-fertilizer by-products) closed nutrient loops and diversified income, and where women contributed substantial, often under-recognized, labor to daily husbandry and household decision-making. Sixth, cutting across these themes, the cultural function of cattle as a liquid savings and social-status asset shaped disposal decisions, causing sales to be timed to household cash needs and ceremonial obligations rather than to optimal market conditions.

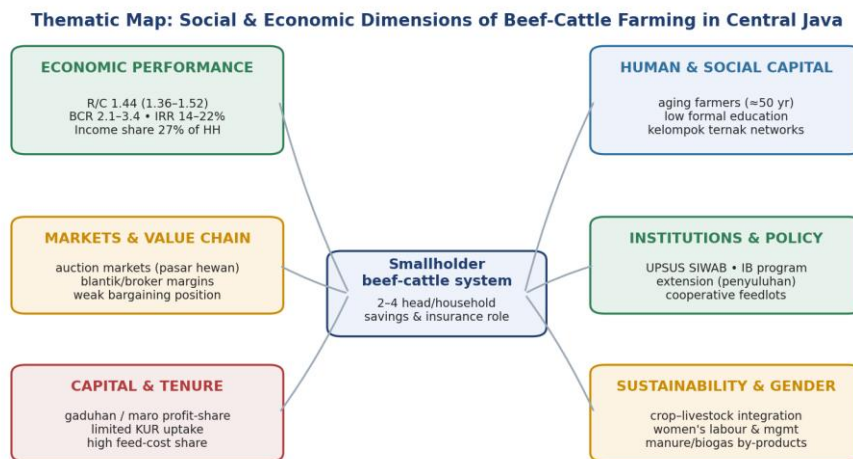


Figure 4. Thematic map linking the economic and social dimensions of smallholder beef-cattle farming in Central Java.

DISCUSSION

Principal Findings

This review provides the first pooled, province-specific evidence that smallholder beef-cattle farming in Central Java is reliably profitable, with a pooled R/C ratio of 1.44 and contributions of roughly one-quarter of household income. The finding is robust to sensitivity analysis and consistent with the wider Indonesian literature, yet moderate heterogeneity and a wide prediction interval underscore that profitability depends on the production system, feed economy, and institutional access rather than being uniform across households (22, 23). The clear performance gradient with integrated and cooperative systems outperforming breeding and profit-share arrangements identifies concrete levers for development policy.

The determinant analysis reframes profitability as a function of both scale and socio-institutional position. That herd size, credit access, group membership, and technology adoption raise income, while feed-cost share and market distance depress it, indicates that returns are shaped less by biology than by the household's capacity to mobilize capital, feed, and market linkages (24). The persistence of gaduhan tenure as a negative income moderator highlights an equity dimension: arrangements that enable landless households to enter cattle keeping simultaneously constrain the returns they can retain, a tension that any pro-poor livestock strategy must confront directly (25).

The thematic synthesis situates these economic patterns within a social system in which cattle are as much a financial and cultural institution as a production activity. The savings-and-insurance function explains why sales are frequently sub-optimal in timing, why fattening is favored over long-cycle breeding, and why productivity-focused programs alone may not translate into higher realized incomes unless market

institutions and price transparency also improve (26). The convergence of quantitative and qualitative evidence on the centrality of farmer groups and market access strengthens confidence in these mechanisms.

Strengths, Limitations, and Risk of Bias

The principal strengths of this review are its bilingual, seven-database search, which captured a large national-language literature typically missed by English-only syntheses; its combination of formal meta-analysis with structured thematic synthesis; and its adherence to PRISMA 2020. These features enhance both the comprehensiveness and the interpretive depth of the evidence base (27).

Several limitations temper the conclusions. Reporting quality in the primary studies was uneven: family labor and home-grown forage were frequently excluded from cost accounting, which tends to inflate observed R/C ratios, and few studies reported dispersion measures, limiting precision. Geographic clustering in cattle-dense regencies may reduce generalisability to marginal upland areas. Methodological heterogeneity ($I^2 = 61\%$) and the observational, cross-sectional nature of most studies preclude strong causal inference about determinants, and residual confounding cannot be excluded (28). Certainty of evidence was accordingly rated moderate for the pooled R/C estimate and low-to-moderate for individual determinants. Publication and language bias appear limited given the inclusion of grey literature and Indonesian sources, but cannot be ruled out entirely.

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Implications for Practice, Economics, and Policy

For producers and extension services, the evidence supports promoting crop-livestock integration and cooperative feedlot models, which combine higher margins with feed-cost efficiency and environmental co-benefits through manure recycling. Strengthening kelompok ternak as vehicles for collective input procurement, credit intermediation, and group marketing offers a practical route to counter broker-driven price compression and to raise the low observed uptake of KUR credit (29).

At the policy level, the results argue for coupling the productivity gains of UPSUS SIWAB and artificial-insemination services with market-side reforms – weight-based transparent pricing, improved auction-market infrastructure, and price information systems – so that reproductive and growth improvements are converted into realized household income. Attention to tenure equity, gender-responsive extension, and the cattle-as-savings function is essential if development gains are to reach the landless and women who supply much of the sector's labor (30). Future research should prioritize longitudinal, standardized farm-economic surveys with complete cost accounting, and rigorous impact evaluations of credit and market interventions, to convert the associational evidence synthesized here into causal guidance for sustainable and inclusive beef-cattle development in Central Java.

CONCLUSION

Smallholder beef-cattle farming in Central Java is a profitable and socially embedded livelihood, returning a pooled R/C ratio of 1.44 and about a quarter of household income while serving as a savings and insurance asset. Profitability is highest in crop-livestock integrated and cooperative systems and is driven by herd size, group membership, credit and technology access, and feed-cost efficiency, while constrained by market distance and profit-share tenure. Realizing the sector's potential requires an integrated strategy that pairs productivity programs with credit access, farmer-group strengthening, transparent market institutions, and equity-sensitive, gender-responsive support. Standardized longitudinal data and impact evaluations are needed to consolidate this evidence into robust, causally grounded policy for sustainable and inclusive beef-cattle development.

AUTHOR CONTRIBUTIONS

N.A.S. and Y.N.W. conceived and designed the review; N.A.S. performed the literature search, data extraction, and meta-analysis; Y.N.W. contributed to the thematic synthesis and interpretation of the social and institutional dimensions; N.A.S. drafted the manuscript, and Y.N.W. critically revised it for important intellectual content; both authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this review were extracted from the published studies listed in the References and are available from the corresponding author upon reasonable request.

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