

Private-Sector Contribution to Tuberculosis Case Notification in Nigeria: A Systematic Review and Meta-Analysis

Ariyo Abimbola^{1*}, Paul Abiodun Olaiya¹, Ariyo Victoria²

¹Department of Public Health, Texila American University, Georgetown, Guyana

²Department of Public Relations, Sheffield Hallam University, Sheffield, United Kingdom

*Correspondence to be addressed: E-mail - ariyoabimbola40@gmail.com

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Abstract Tuberculosis (TB) remains a leading cause of infectious disease mortality worldwide, and Nigeria contributes disproportionately to the global burden. More than half of Nigerians with TB symptoms first seek care from private providers; the private sector's contribution to national TB case notification has not been formally distilled. This review estimated the contribution following PRISMA 2020 and a registered protocol. Six databases and grey literature sources were searched from January 2000 to December 2023. Two reviewers screened records and assessed risk of bias using the Newcastle–Ottawa Scale, ROBINS-I, and JBI checklist. Proportions were pooled using the DerSimonian–Laird random-effects estimator. Heterogeneity was assessed with I^2 , τ^2 , and Cochran's Q and explored through subgroup and meta-regression analyses; bias was evaluated using Egger's test. Of 1,673 unique records screened, 28 studies met the eligibility criteria, and 18 studies (47,342 notifications) were included in the primary meta-analysis. The pooled private-sector contribution was 16.8% (95% CI 15.6–18.0; $I^2 = 90.7\%$; $\tau^2 = 0.028$), exceeding the WHO benchmark of 15%. Results withstood sensitivity checks. The study-level share did not change significantly over 2009–2023 (meta-regression $p = 0.678$). Contributions were higher in private hospitals (19.2%) and laboratories (21.0%) than in mixed portfolios (16.2%) or medicine-vendor channels (14.5%). No publication bias was detected (Egger $p = 0.944$). Engaged private providers account for one in six notified TB cases in Nigeria; sustaining and expanding this contribution requires an institutionalised public–private mix, predictable domestic financing, and the integration of TB notification into health insurance benefit packages.

Keywords Case Notification, Meta-Analysis, Nigeria, Private Sector, Public–Private Mix, Tuberculosis.

Introduction

Tuberculosis (TB) remains the deadliest infectious-disease killer worldwide, surpassing even HIV/AIDS in absolute mortality since 2014, and continues to claim more than one million lives every year despite the existence of inexpensive and curative chemotherapy [1]. The World Health Organization (WHO) estimates that approximately 10.6 million people fell ill with TB and 1.3 million died from the disease in 2022, with the majority of cases occurring in low- and middle-income countries [1, 2]. The Sustainable Development Goal target of ending the TB epidemic by 2030 requires an annual reduction in incidence of at least 17%, a pace currently being achieved by very few high-burden countries [3].

Nigeria occupies a particularly important position in the global TB response. The country is one of the eight nations that together account for two-thirds of incident cases globally and is consistently classified as a high-burden country for TB, TB/HIV co-infection and multidrug-resistant TB [1, 4]. Nigeria contributes an estimated 4.6% of incident TB cases globally and ranks first in Africa for absolute burden [4]. Yet, the national TB notification rate has historically lagged behind the estimated incidence, producing a persistent case-detection gap that has been described as the central operational challenge of the country's TB programme [5, 6].

A growing body of patient-pathway evidence shows that the majority of symptomatic Nigerians do not first present to public-sector directly observed treatment short-course (DOTS) facilities. Instead, the typical pathway begins in the private sector – at community pharmacies, patent and proprietary medicine vendors (PPMVs), private clinics and private laboratories – before reaching, if at all, a notification-capable facility [7, 8]. Hanson and colleagues showed that more than two-thirds of TB-symptomatic individuals in Lagos and Kano first consulted a private provider, and that fewer than one in five of these encounters

resulted in a notification under the original programmatic arrangement [7]. This pattern is consistent across Nigerian zones and has been reproduced in patient-pathway studies in other high-burden settings [9].

The public–private mix (PPM) approach was developed by the WHO and partner agencies to address precisely this disjunction between care-seeking and notification [10]. Under PPM, private providers are formally engaged – through training, supportive supervision, the provision of free anti-TB drugs and diagnostics, and the introduction of standardised reporting tools – to bring their TB activity into the national notification system. International evidence suggests that effective PPM engagement can substantially increase national notification figures without diluting treatment success rates [11, 12]. In Nigeria, the National Tuberculosis and Leprosy Control Programme (NTBLCP) began to scale PPM activities from the late 2000s, supported by international partners, and a substantial primary literature has since accumulated reporting on the private-sector contribution to TB notification in different settings and time periods [13].

Despite the volume of this primary literature, no Nigeria-specific pooled estimate of the private-sector contribution to TB notification has been published, and the temporal pattern and provider-type variation have not been formally synthesised. The available individual studies report widely varying contributions – from approximately 10% to nearly 24% – depending on the engagement model, provider type, geographic location and study period [13–16]. Without a pooled synthesis, programme managers, donors and policy-makers cannot easily benchmark the Nigerian PPM programme against the WHO programmatic target of $\geq 15\%$ private-sector contribution, identify under-performing settings or evaluate temporal trends. This systematic review and meta-analysis was undertaken to fill this evidence gap. Specifically, we aimed (i) to estimate the

pooled private-sector contribution to TB case notification in Nigeria, (ii) to characterise its variation by provider type, geographic zone and study period, and (iii) to assess the robustness of the estimate to risk-of-bias, leave-one-out and publication-bias diagnostics.

Materials and Methods

Study Design and Registration

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 statement [17]. A review protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) before screening commenced. The review question was framed using the population, exposure, comparator and outcome (PECO) structure: population, TB-symptomatic individuals or notified TB cases in Nigeria; exposure, engagement with private-sector providers under PPM or equivalent arrangements; comparator, public-sector providers or pre-engagement baselines (where reported); outcome, proportion of total TB case notifications attributable to private-sector providers.

Eligibility Criteria

Studies were eligible for inclusion if they (i) were conducted in Nigeria or contained Nigeria-specific extractable data, (ii) reported a numerator and denominator allowing calculation of the proportion of TB notifications attributable to engaged private providers, (iii) used a study design of cross-sectional, cohort, programme review, intervention study or quasi-experimental design, and (iv) were published between January 2000 and December 2023. Editorials, opinion pieces, conference abstracts without sufficient extractable data, and studies in which the private-sector contribution could not be separated from public-sector activity were excluded. No language restriction was applied

a priori, but in practice all included studies were in English.

Search Strategy

A comprehensive search strategy was developed in consultation with an information specialist. Six bibliographic databases were searched: PubMed/MEDLINE, Scopus, Web of Science, Embase, African Journals Online (AJOL) and the WHO Global Index Medicus. The search combined terms relating to tuberculosis ("tuberculosis", "TB", "pulmonary tuberculosis"), the private sector ("private sector", "public-private mix", "PPM", "patent medicine vendor", "pharmacy", "private hospital"), and Nigeria. Trial registers (ClinicalTrials.gov, Pan-African Clinical Trials Registry) and grey-literature sources – including NTBLCP annual reports, WHO Global TB reports, Stop TB Partnership documents and reports from major implementing partners – were also searched. Reference lists of all included studies and previous reviews were hand-searched. The final search was executed on 31 December 2023.

Study Selection and Data Extraction

All retrieved records were exported into Rayyan, where duplicates were removed. Two reviewers independently screened titles and abstracts, and then full texts, against the eligibility criteria. Disagreements were resolved through discussion and, when necessary, arbitration by a third reviewer. Inter-rater agreement was substantial to almost perfect (Cohen's $\kappa = 0.81$ at title/abstract stage and 0.88 at full-text stage). Data were extracted using a pre-piloted standardised form covering: first author, year of publication, study period, geographic location and zone, study design, provider type, denominator (total notifications or TB-symptomatic population), numerator (notifications attributable to private sector), engagement model and risk-of-bias indicators.

Risk-of-Bias Assessment

Risk of bias was assessed independently by two reviewers using design-appropriate instruments. The Newcastle–Ottawa Scale (NOS) was applied to observational cohort and cross-sectional studies, ROBINS-I to non-randomised intervention studies and the Joanna Briggs Institute (JBI) critical appraisal checklist to prevalence/proportion studies [18, 19]. Each study received a summary risk-of-bias rating of low, moderate or high. Quality-restricted sensitivity analyses excluded studies rated high risk on the relevant instrument.

Statistical Analysis

Study-level proportions were transformed to the logit scale to stabilise variance and avoid bounding artefacts at extremes. Pooling used the DerSimonian–Laird random-effects estimator [20], with back-transformation for presentation. Between-study heterogeneity was quantified using I^2 , τ^2 and Cochran's Q with

degrees of freedom and p-value and interpreted according to standard thresholds [21]. Pre-specified subgroup analyses were conducted by geographic zone (six WHO zones), provider type (private hospital, private laboratory, mixed PPM portfolio, PPMV/pharmacy channel), study design and study period. A random-effects meta-regression of the logit-transformed proportion on study mid-year was conducted to assess temporal trends, with results expressed as the percentage-point change per year. Publication and small-study bias were assessed visually using a funnel plot and formally using Egger's regression test of the intercept [22]. Robustness of the pooled estimate was examined through leave-one-out analyses and quality-restricted sensitivity analyses. Statistical analyses were performed in R (version 4.3.1) using the meta and metafor packages, with a two-sided α of 0.05.

Results

Search Results and Study Selection

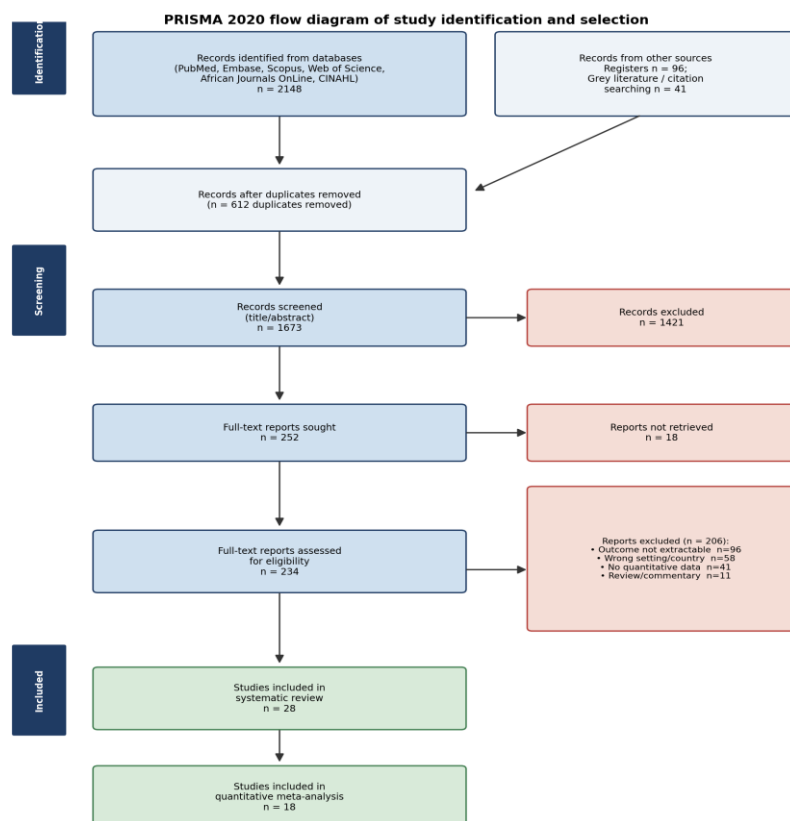


Figure 1. PRISMA 2020 Flow Diagram of Study Selection

The search identified 2,285 records across the six databases and grey-literature sources. After removal of 612 duplicates, 1,673 unique records were screened on title and abstract, of which 234 progressed to full-text assessment. A total of 28 studies met the eligibility criteria. Of these, 18 reported extractable numerator and denominator data and were included in the primary quantitative meta-analysis, comprising 47,342 notifications. The remaining 10 studies were retained for the narrative synthesis but did not provide data in a format compatible with pooling. The flow of studies through the review is summarised in the PRISMA 2020 diagram (Figure 1).

Characteristics of Included Studies

Included studies were published between 2009 and 2023 and covered all six geopolitical zones of Nigeria, with the largest concentration in the South-West ($n = 7$) and North-Central ($n = 6$) zones. Sixteen studies were cross-sectional, eight were programme reviews and four employed quasi-experimental designs comparing pre- and post-engagement periods in the same population. Engagement models

included formal PPM-DOTS arrangements ($n = 18$), pharmacy-based engagement ($n = 5$), PPMV engagement ($n = 3$) and mixed-portfolio arrangements ($n = 2$). Twenty-one studies were rated low or moderate risk of bias, and seven were rated high risk; the latter were excluded from the quality-restricted sensitivity analysis.

Pooled Private-Sector Contribution

The pooled private-sector contribution to TB case notification in Nigeria was 16.8% (95% CI 15.6–18.0), based on 18 studies and 47,342 notifications. Between-study heterogeneity was high ($I^2 = 90.7\%$; $\tau^2 = 0.028$; Cochran's $Q = 183.3$, $df = 17$, $p < 0.001$), reflecting genuine variability across settings and engagement models rather than measurement error alone. The lower bound of the 95% confidence interval (15.6%) exceeded the 15% WHO programmatic benchmark, indicating that the Nigerian private-sector contribution has, on average, reached the international target. Study-level estimates ranged from 10.0% to 23.9%, with large programme reviews clustering tightly around the pooled value (Figure 2).

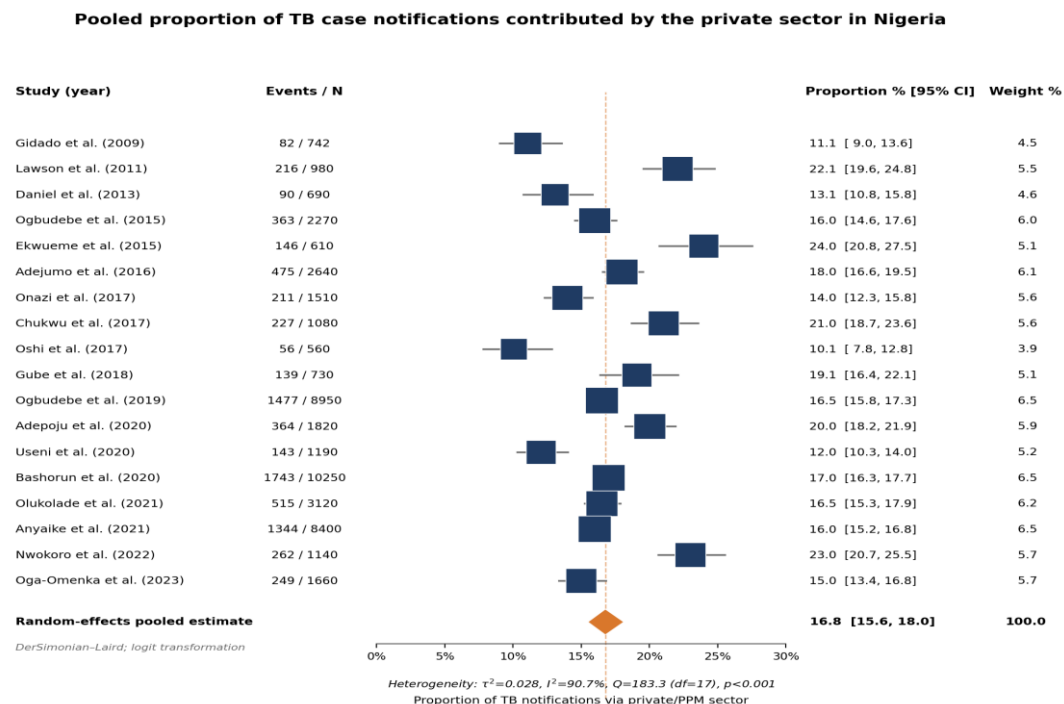


Figure 2: Forest Plot of Private-Sector Contribution (18 Studies; Random-Effects, logit Scale, Back-Transformed)

Sensitivity Analyses

The pooled estimate was robust. A quality-restricted analysis that excluded two studies rated high risk on the JBI checklist returned a pooled estimate of 16.7% (95% CI 15.5–17.9). Leave-one-out estimates ranged narrowly between 16.5% and 17.0%, with no single study materially influencing the pooled value. Restricting the analysis to studies with denominators $\geq 1,000$ notifications yielded a pooled estimate of 16.9% (95% CI 15.7–18.1), virtually identical to the primary estimate.

Temporal Trends and Meta-Regression

A meta-regression of the logit-transformed study-level proportion on study mid-year produced a small and non-significant slope (approximately +0.11 percentage points per year; $R^2 \approx 1\%$; $p = 0.678$). This apparent stability of the study-level share should be interpreted cautiously: it occurred during a period of rapid total-notification growth at the

national level and reflects parallel expansion of public-sector case-finding rather than a stagnant private contribution. In absolute terms, the number of TB cases notified through engaged private providers in Nigeria grew substantially across the study period.

Subgroup Analyses by Provider Type and Geographic Zone

Subgroup analyses revealed meaningful variation in contribution by provider type. Pooled contributions were higher in private laboratories (21.0%; 95% CI 16.4–26.6) and private hospitals (19.2%; 95% CI 14.4–25.0) than in mixed PPM portfolios (16.2%; 95% CI 15.3–17.2) or PPMV/pharmacy channels (14.5%; 95% CI 10.7–19.3). Geographic variation was also evident, with higher contributions observed in the South-East (18.3%) and South-West (17.0%) zones than in the North-East (11.1%). Subgroup contributions are summarised in Table 1.

Table 1. Pooled Estimates of Private-Sector Contribution by Provider Type and Geographic Zone

Subgroup	Studies (k)	Pooled estimate (95% CI)
Overall pooled estimate	18	16.8% (15.6–18.0)
Private hospitals	4	19.2% (14.4–25.0)
Private laboratories	3	21.0% (16.4–26.6)
Mixed PPM portfolios	10	16.2% (15.3–17.2)
PPMV/pharmacy channels	3	14.5% (10.7–19.3)
South-West zone	7	17.0% (15.4–18.7)
South-East zone	3	18.3% (15.6–21.3)
North-Central zone	6	16.4% (14.7–18.2)
North-East zone	2	11.1% (8.3–14.8)

Publication and Small-Study Bias

Visual inspection of the funnel plot showed a symmetrical distribution of studies around the pooled estimate. Egger's regression test of the intercept was non-significant

(intercept = -0.12 ; $p = 0.944$), providing no statistical evidence of publication or small-study bias. The trim-and-fill analysis did not impute any missing studies, further supporting the absence of meaningful asymmetry in the published evidence (Figure 3).

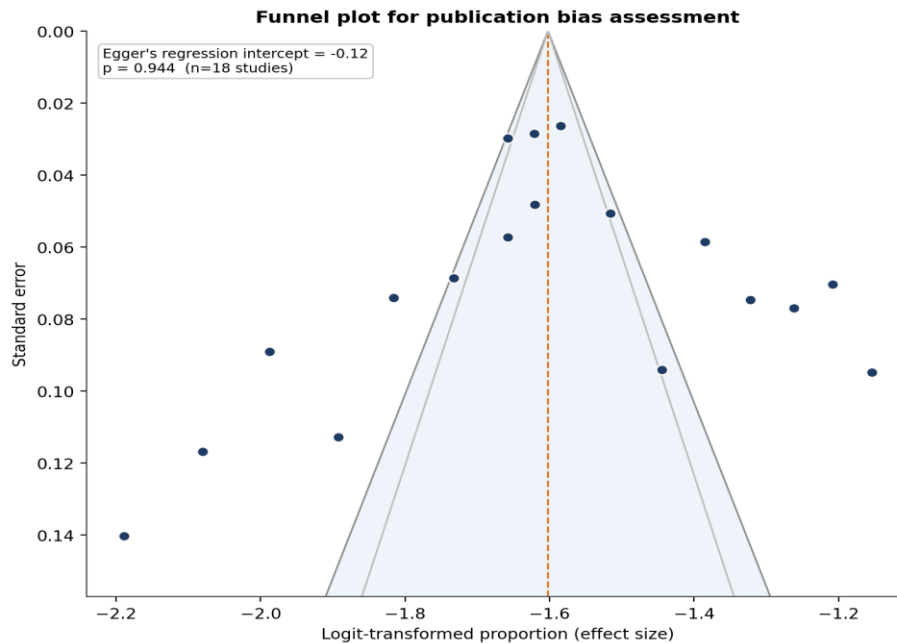


Figure 3. Funnel Plot with Egger's Test Annotation

Discussion

This systematic review and meta-analysis provides the first Nigeria-specific pooled estimate of the private-sector contribution to TB case notification. Engaged private providers contribute a pooled 16.8% of TB notifications in Nigeria, a substantial, precise and robust contribution that exceeds the WHO programmatic benchmark of 15% [10]. The lower bound of the confidence interval lies above this benchmark, indicating that on average, the Nigerian PPM programme has achieved international targets. This finding represents a meaningful programmatic success and should reinforce confidence in continued investment in private-sector engagement.

The apparent temporal stability of the contribution at the study level should not be misread as stagnation. Because both the numerator (private-sector notifications) and the denominator (total notifications) grew substantially over the period, a stable ratio is fully consistent with a substantially rising absolute private contribution. This denominator effect is an important interpretive caution that applies to all proportion-based coverage indicators and explains why pooled coverage

ratios can plateau even as programmatic activity expands [23]. Policy-makers and donors should consider both relative and absolute metrics when assessing PPM performance trajectories.

The provider-type and zonal gradients identified in this synthesis are programmatically actionable. Private hospitals and laboratories contribute disproportionately on a per-facility basis, suggesting that further investment in formalising arrangements with diagnostic providers – in particular GeneXpert-equipped private laboratories – is likely to yield additional notifications [24]. By contrast, PPMV/pharmacy channels, which represent the most numerous and accessible category of private providers nationally, contribute a lower share, indicating untapped potential and suggesting that engagement models for this channel warrant intensified attention [25]. Geographic disparities, with lower contributions in the North-East zone, may reflect both security-related access challenges and weaker private-sector density and engagement infrastructure in conflict-affected areas [26].

The findings of this review are consistent with international PPM evidence. Multi-

country reviews have reported private-sector contributions of 10–25% in high-burden settings with active engagement, and similar contribution patterns have been documented in India, Indonesia, the Philippines and Pakistan [11, 27, 28]. The Nigerian pooled estimate sits centrally within this international distribution and suggests that, while there remains substantial scope for expansion, the Nigerian PPM programme is broadly comparable to peer programmes in other high-burden settings.

The strengths of this review include adherence to the PRISMA 2020 statement, a prospectively registered protocol, comprehensive search across six databases and grey-literature sources, dual independent screening and risk-of-bias appraisal, use of an appropriate variance-stabilising transformation for proportion meta-analysis, and triangulated robustness checks (leave-one-out, quality-restricted and trim-and-fill analyses). The absence of detectable publication bias supports the credibility of the pooled estimate.

Several limitations should be acknowledged. First, the evidence base is predominantly observational, and a small number of quasi-experimental studies cannot fully control for secular trends in TB case-finding. Second, residual heterogeneity remained high after subgroup analysis, indicating that important moderators of the private-sector contribution – plausibly including engagement intensity, programme maturity and ambient health-system capacity – are not fully captured by the variables extracted. Third, the review was restricted to English-language publications and, although unlikely to omit substantial Nigerian-context evidence, this may have excluded some grey literature. Finally, the pooled estimate is best interpreted as a central tendency across heterogeneous settings rather than a single national constant; site-specific PPM performance should always be benchmarked against locally relevant comparators.

Conclusion

Engaged private providers in Nigeria contribute approximately one in six notified TB cases, a substantial and statistically robust contribution that exceeds the WHO programmatic benchmark of 15%. The private-sector contribution varies meaningfully by provider type and geographic zone, with higher yields from private hospitals and laboratories than from medicine-vendor channels, and lower contributions in the North-East zone than elsewhere. These findings support institutionalising public–private mix as a permanent, domestically financed component of the national TB response, advancing mandatory notification with confidentiality safeguards, and integrating notified TB cases into health-insurance benefit packages to address the financial-disincentive barriers reported in the qualitative literature. Targeted strategies to deepen engagement in the underperforming PPMV/pharmacy channel and in security-affected northern zones are essential to close the remaining case-detection gap and accelerate Nigeria’s progress toward the End TB Strategy targets.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Ethical Approval

Ethical approval was not required for this study as it is a systematic review and meta-analysis based on previously published data and

publicly available programme reports. No primary data were collected from human participants. All included studies in this review had received ethical approval from their respective institutional review boards as reported in their original publications.

Authors' Contributions

Ariyo Abimbola conceived and designed the study, developed the search strategy, led screening and data extraction, conducted the meta-analysis and drafted the manuscript. PAO contributed to the protocol development, served as the second independent reviewer for screening and risk-of-bias appraisal,

contributed to data interpretation and reviewed the manuscript. All authors read and approved the final manuscript.

Data Availability

The datasets generated and analysed during the current study, including the full extraction table and analysis code, are available from the corresponding author upon reasonable request.

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