

Doping Among African Athletes Across Competition Levels: Prevalence, Prohibited Substances, Detection Methods, and Evidence Gaps - A Systematic Review and Meta-analysis

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Abstract

Background

Doping threatens athlete health, fair competition, and confidence in sport, yet its prevalence and substance patterns among African athletes remain poorly quantified. Interpretation is complicated by heterogeneous athlete populations, limited representation of elite competitors, and studies that sometimes combine WADA-prohibited agents with permitted supplements, recreational substances, or herbal products.

Objective

To systematically review and meta-analyze the prevalence of prohibited doping among African athletes, characterize reported substances and methods, compare self-report with laboratory ascertainment, examine regional and competition-level patterns, and identify priorities for surveillance and sports-medicine practice.

Methods

This PRISMA 2020 systematic review and meta-analysis was prospectively registered in PROSPERO. PubMed/MEDLINE, Scopus, Web of Science, and African Index Medicus were searched without date restriction, supplemented by targeted grey-literature searches. Two independent reviewers screened records, with separate full-text reviewers and third-reviewer adjudication. Outcomes were harmonized against the applicable IOC/WADA framework. Cross-sectional studies were appraised using the JBI prevalence checklist, laboratory surveillance with an adapted JBI case-series framework, and mixed-method grey literature with MMAT. Random-effects meta-analysis used logit-transformed proportions with DerSimonian-Laird estimation and REML/Hartung-Knapp robustness analysis.

Results

Of 273 records identified, 55 duplicates were removed, 218 records were screened, 44 full texts were assessed, and 19 reports met eligibility criteria. Four independent peer-reviewed cohorts comprising 850 athletes and 64 cases contributed to the primary analysis. The pooled prevalence of ever/previous prohibited doping was 8.0% (95% CI 5.0–12.6%; $I^2=73.5\%$). REML/Hartung-Knapp analysis retained the 8.0% estimate with a wider 95% CI of 3.7–16.5%. Pooled anabolic-agent prevalence was 2.3% (95% CI 0.7–7.2%). Two South African laboratory series yielded pooled sample positivity of 3.8% (95% CI 1.2–11.0%; $I^2=98.0\%$). Adding the Kenyan WADA/ADAK report increased the pooled self-report estimate to 10.1%.

Conclusions

Prohibited doping in African sport appears meaningful but remains imprecisely quantified. The pooled estimate should not be interpreted as a continent-wide prevalence value. Elite athletes, sport-specific patterns, and endurance-related agents remain underrepresented. Self-report and laboratory positivity should remain

analytically distinct. Standardized WADA-compatible definitions, representative sampling, explicit recall periods, exact numerator/denominator reporting, and stronger biological surveillance are needed.

Registration:

PROSPERO CRD420261489442.

Key Points

- Across four directly comparable peer-reviewed cohorts, the pooled prevalence of ever/previous prohibited doping was 8.0%, but the small evidence base and substantial heterogeneity make this an estimate of the available studies rather than a definitive prevalence for Africa.
- Anabolic agents and stimulants were the most recurrent prohibited categories in prevalence studies, while cannabinoids, narcotics, growth hormone, diuretics and prohibited methods appeared in selected settings. Sport- and competition-level patterns could not be quantified reliably; elite endurance-athlete exposure to agents such as erythropoietin and nandrolone is better documented in enforcement/testing data than in representative prevalence studies.
- Self-report prevalence, laboratory sample positivity and anti-doping rule violations are not interchangeable outcomes. Future African surveillance should combine standardized epidemiological measurement with appropriately targeted biological testing and transparent reporting.

1. Background

Doping in African sport is a health, integrity and governance concern, but its epidemiology remains incompletely characterized. A further contextual challenge is that athletes in some African settings use plant extracts, traditional herbal preparations and nutritional supplements for cultural, health-maintenance or performance-preparation purposes. Such products are often perceived as natural and safe, yet composition may be poorly controlled and undeclared prohibited substances may occur through adulteration or contamination [37, 38]. The anti-doping relevance of these products lies primarily in exposure uncertainty and inadvertent rule-violation risk; they should not be treated as equivalent to intentional prohibited-substance use. Across the African literature, inconsistent terminology has sometimes grouped WADA-prohibited substances together with permitted supplements, herbal products and recreational drugs, limiting valid estimation of doping prevalence.

Doping in sport is both a health problem and a governance problem. Under the World Anti-Doping Code, anti-doping rule violations extend beyond a positive analytical test and include use or attempted use of prohibited substances or methods, possession, trafficking, administration, sample tampering and other conduct [1]. The Prohibited List is updated annually and distinguishes substances prohibited at all times, substances prohibited only in competition, prohibited methods, and substances whose status is sport-specific [1, 2]. This regulatory architecture is essential for fairness and athlete protection, but it complicates epidemiological measurement because the same compound can have different status according to dose, route, sport or timing.

Estimating the prevalence of doping is inherently difficult. Some of the contributing factors include shortcomings of the Athlete Biological Passport (ABP), direct and indirect testing protocols. Biological testing is

specific but time-bounded and can miss intermittent use, combined use of legally permitted methods, microdosing, substances with short detection windows and prohibited methods that do not leave conventional analytical signatures. Direct questionnaires are inexpensive and scalable but vulnerable to non-disclosure, social desirability and misunderstanding of what constitutes a prohibited substance or method. Indirect estimation models can improve privacy and disclosure, but require more complex designs and assumptions. These methodological differences explain why doping prevalence estimates often diverge sharply across studies and why adverse analytical findings cannot be interpreted as the population prevalence of doping [3–5].

A 2021 evidence synthesis by the WADA Working Group found wide variability in published doping prevalence and concluded that the quality and reporting of prevalence studies remained inconsistent [3]. A 2026 systematic review of indirect estimation models likewise demonstrated that prevalence estimates depend strongly on measurement approach [4]. Petróczi and colleagues revisited data from the 2011 World Championships in Athletics using a privacy-protecting single-sample-count model and estimated 12-month admitted doping at 21.2%, while emphasizing non-compliance and substantial uncertainty in indirect estimation [39]. Earlier reviews similarly showed that routine laboratory testing generally identifies a smaller fraction of doping than sensitive epidemiological approaches [5]. These findings underscore that ascertainment method matters as much as geography and that enforcement counts, analytical findings and prevalence estimates are not interchangeable.

Earlier reviews similarly suggested that laboratory testing typically identifies only a small fraction of the prevalence inferred from more sensitive survey or biological-model approaches [5]. These findings underscore that method matters as much as geography.

Africa represents an important evidence gap in global anti-doping epidemiology. The continent sustains internationally competitive athletics, football, rugby, combat sports, weightlifting and endurance sport, yet published surveillance and analytical capacity are unevenly distributed. Existing studies from Cameroon, Nigeria, South Africa, Uganda, Algeria, Ethiopia, Malawi, Ghana, Burkina Faso and other settings differ in athlete level, sport, questionnaire design, terminology, prohibited-list era and outcome definition. Some use “performance-enhancing substance” (PES) to include caffeine, vitamins, protein supplements or herbal preparations, whereas others report IOC/WADA-prohibited substances or methods specifically. Without careful harmonization, pooling these constructs can produce clinically and policy-relevant misclassification and inflate apparent doping prevalence.

The types of substances reported also matter for prevention and detection. Anabolic-androgenic steroids, stimulants, cocaine, growth hormone, cannabinoids, diuretics and masking agents, narcotics and blood-manipulation methods appear in African studies, but their regulatory status is not uniform across time or sport. The 2026 WADA Prohibited List continues to classify anabolic agents under S1, peptide hormones and growth factors under S2, diuretics and masking agents under S5, stimulants under S6, narcotics under S7 and cannabinoids under S8; beta-blockers remain prohibited only in specified sports [2]. The broader literature identifies anabolic-androgenic steroids as one of the most extensively studied performance- and image-enhancing drug classes, although prevalence varies considerably by population and ascertainment method [6], and the evidence for actual performance enhancement differs substantially across prohibited substance classes [7]. Thus, an epidemiologically valid review must distinguish any-PES use from prohibited doping and must use historical context when interpreting older studies.

Accordingly, this systematic review and meta-analysis aimed to: (1) quantitatively synthesize the prevalence of self-reported doping involving prohibited substances or methods among African athletes using harmonized athlete-level data; (2) describe the prohibited substances and methods reported; (3) compare self-report and laboratory ascertainment; (4) examine variation by region, sport and competition level where data permitted; (5) assess methodological quality and evidence gaps, including representation of elite national/international athletes; and (6) identify priorities for sports-medicine practice, anti-doping surveillance and future African research. Particular emphasis was placed on separating WADA-defined doping from broader PES use and on avoiding double-counting of overlapping cohorts.

2. Methods

This review was prepared and reported in accordance with the PRISMA 2020 statement [8]. The review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD420261489442).

2.1 Eligibility criteria

Population

Competitive amateur, collegiate/university, national, professional or elite athletes based, training or competing in an African country were eligible. Studies of general student populations, health professionals, non-athletes or mixed populations were excluded unless an athlete subgroup and its denominator could be extracted separately.

Exposure/outcome

Eligible quantitative outcomes required actual self-reported use or objective detection of at least one substance or method prohibited under the applicable IOC/WADA framework. Studies reporting only knowledge, attitudes, intentions, supplement use or hypothetical willingness were excluded from prevalence pooling. Broad PES outcomes were retained for narrative synthesis only when they mixed prohibited and non-prohibited products.

Study designs

Cross-sectional prevalence studies, observational surveys and laboratory surveillance/testing series were eligible. Qualitative studies, reviews, position statements and correspondence were excluded from the prevalence synthesis. Detection-method papers without a prevalence denominator were retained only when they directly informed the review objective concerning analytical detection.

Geography and language

No African country or language was intentionally excluded. French-language studies were retained where eligible. Grey literature from anti-doping agencies was considered separately for sensitivity analyses.

2.2 Information sources and search approach

Systematic searches were conducted in PubMed/MEDLINE, Scopus, Web of Science and African Index Medicus and were supplemented by targeted grey-literature searches of relevant anti-doping organizations, institutional

repositories and related sources. Search concepts combined terms for doping/performance-enhancing substances, athletes/sport, Africa and individual African country names. No date restriction was applied, and no African country was intentionally excluded. The searches identified 158 records from PubMed/MEDLINE, 62 from Scopus, 35 from Web of Science, 1 from African Index Medicus and 17 from grey literature, for 273 records before de-duplication. Database-specific syntax, interfaces and the final search date should be reproduced verbatim in the electronic supplementary material from the archived search logs. SPORTDiscus could not be accessed by the review team and was therefore not searched; this is addressed explicitly as a limitation.

The core search concept was: (doping OR performance-enhancing drug* OR performance-enhancing substance* OR prohibited substance* OR banned substance* OR anabolic steroid* OR stimulant* OR blood doping) AND (athlete* OR sport* OR player* OR football* OR runner* OR cyclist* OR boxer* OR weightlift*) AND (Africa OR African OR individual African country names). Database-specific adaptations accounted for controlled vocabulary, phrase searching and platform syntax.

2.3 Study selection and duplicate-cohort resolution

All retrieved records were imported into Rayyan for de-duplication and screening management. Fifty-five duplicates were removed, leaving 218 unique records for title and abstract screening. Two reviewers independently screened titles and abstracts while blinded to one another's decisions; disagreements were resolved by a third reviewer acting as adjudicator. Forty-four reports progressed to full-text assessment. Full texts were successfully retrieved for all 44 reports and were independently assessed against the eligibility criteria by a separate pair of reviewers. Differences in eligibility judgments were resolved by a third reviewer. Twenty-five reports were excluded at full-text review, leaving 19 reports that met the final eligibility criteria. Eligible reports contributed to quantitative synthesis only when outcome definitions, reference periods and denominators were sufficiently comparable. Potentially overlapping cohorts were examined using author lists, sample size, sex distribution, geography, institutions, competition level, sampling procedures and data-collection descriptions. The Nigerian tertiary-athlete publications by Akindutire et al. and Ajayi-Vincent and Olanipekun were treated as companion reports from the same underlying 510-athlete cohort; the cohort was counted once in quantitative synthesis, while the companion report contributed unique prohibited-method information [21, 22].

Reviewer workflow

Rayyan was used to preserve blinding during title/abstract screening and to document decisions. A second reviewer pair conducted a full-text eligibility assessment to reduce carry-over from first-stage screening. Third reviewers adjudicated unresolved disagreements. Designated members of the review team conducted methodological appraisal using the prespecified tools, and appraisal judgments were discussed within the team. Data extraction, verification and meta-analysis were undertaken collaboratively using standardized outcome definitions and a shared extraction framework.

2.4 Data extraction and harmonization

Data were extracted at the study/cohort and outcome levels using a standardized form. Variables included author/year, country, setting, sport, athlete level, sex, sample size, numerator, denominator, reference period, substance or method, ascertainment approach and applicability to the historical IOC/WADA prohibited framework. The team cross-checked extracted values before synthesis. Lifetime/ever use, current/recent use,

last-12-month use, pre-match/in-competition use and laboratory positivity were kept separate to avoid combining non-equivalent prevalence constructs.

No numerator was manufactured from a rounded percentage unless the integer event count was mathematically exact and explicitly flagged. Outcomes with ambiguous denominators, multiple-response denominators that exceeded the participant sample, or product groupings that mixed prohibited and permitted agents were classified as non-poolable. For example, the Kenyan WADA/ADAK report provided a valid ever-use estimate of 74/338 and an overall last-12-month estimate of 92/338, but its substance-specific multiple-response table used a total of 371 responses; those substance-specific denominators were therefore not pooled [26].

2.5 Methodological quality assessment

Methodological quality appraisal was performed by designated members of the review team using design-appropriate tools. Cross-sectional prevalence studies were assessed with the JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data, covering the sampling frame, sampling approach, sample-size adequacy, participant/setting description, coverage, validity and reliability of outcome identification, statistical analysis and response rate [9]. Appraisal judgments were reviewed within the team and disagreements were resolved by discussion. Because the JBI checklist does not prescribe a validated numerical cut-off, no arithmetic “quality score” was created; overall judgments reflected the pattern and likely consequence of domain-level limitations.

The South African laboratory surveillance studies were assessed using an adapted JBI case-series framework because their denominators were urine samples rather than sampled athlete populations. The Zimbabwe WADA-funded mixed-method report was assessed using MMAT mixed-method criteria. Detection-only analytical studies were not assigned a prevalence risk-of-bias rating.

2.6 Statistical analysis

The primary meta-analysis was restricted to independent, peer-reviewed, athlete-level self-report cohorts with defensible event counts and denominators forever/lifetime or previous prohibited doping. Proportions were transformed to the logit scale. For a study with e events among n athletes, the logit proportion was calculated as $\ln[e/(n-e)]$ and its standard error as $\sqrt{1/e + 1/(n-e)}$. The prespecified random-effects analysis used inverse-variance weighting with DerSimonian-Laird estimation of between-study variance (τ^2) [10], with heterogeneity summarized using Cochran’s Q and I^2 [11]. Results were back-transformed to proportions with 95% confidence intervals. Because only four studies contributed to the primary pool, a robustness analysis re-estimated τ^2 using restricted maximum likelihood (REML) and applied a Hartung-Knapp adjustment to the confidence interval. A 95% prediction interval was also calculated to illustrate the plausible range of prevalence in a new comparable setting. These analyses were undertaken collaboratively by members of the review team using the prespecified outcome definitions.

Laboratory sample positivity was synthesized separately from athlete-level prevalence. Substance-specific analyses were performed only where exact numerators and denominators were available. Leave-one-out analysis, risk-of-bias stratification and a grey-literature sensitivity analysis adding the Kenyan WADA/ADAK ever-use estimate were conducted. Formal funnel-plot asymmetry tests, including Egger’s regression and Begg’s rank correlation [12, 13], were not used for inferential conclusions because the primary meta-analysis contained only four studies and such tests are severely underpowered with very small k . Statistical calculations were performed

in Python 3.13.5 using NumPy 2.3.5 and SciPy 1.17.0; the complete R/Stata-ready dataset and formulas are provided as supplementary material.

3. Results

3.1 Study selection and evidence structure

The searches identified 273 records: PubMed/MEDLINE (n = 158), Scopus (n = 62), Web of Science (n = 35), African Index Medicus (n = 1) and grey literature (n = 17). After removal of 55 duplicates in Rayyan, 218 unique records underwent blinded title and abstract screening by two independent reviewers, with third-reviewer adjudication of disagreements. A total of 174 records were excluded at this stage. Forty-four reports were sought and all were successfully retrieved for full-text assessment. A separate pair of reviewers independently assessed the 44 full texts, with a third reviewer resolving disagreements. Twenty-five reports were excluded at full-text review and 19 met the final eligibility criteria. These reports were retained in the systematic review and contributed to meta-analysis or other quantitative synthesis only when their outcome definitions and denominators met the prespecified comparability criteria. The selection pathway is shown in the PRISMA 2020 flow diagram (Fig. 1).

Figure 1. PRISMA 2020 study-selection flow diagram.

Full-text exclusions (n = 25) reflected ineligible populations or outcomes, absence of extractable prevalence/detection data, non-primary research, non-doping outcomes, and duplicate or overlapping reports. The detailed exclusion audit trail is provided in Additional File 4.

The retained evidence covered Nigeria, South Africa, Cameroon, Uganda, Ethiopia, Ghana, Algeria, Malawi, Burkina Faso, Kenya and Zimbabwe. Study populations ranged from school and university athletes to national/professional competitors and laboratory testing series. Survey sample sizes ranged from 43 elite footballers in Malawi to 1,431 Ghanaian athletes within an athlete subgroup, while laboratory series included 679 samples from 1983–1987 and 14,017 samples from 1995–2002 in South Africa [18, 27, 28].

3.2 Primary pooled prevalence of prohibited doping

Four independent peer-reviewed cohorts satisfied the strict criteria for the overall primary meta-analysis: Muwonge *et al.* in Uganda (14/360), Mohammed *et al.* in Ethiopia (15/152), Chebaiki *et al.* in Algeria (22/200) and Guessogo *et al.* in Cameroon (13/138) [14–16, 25]. Together, these studies included 850 athletes and 64 reported cases of prohibited doping or prohibited-substance use.

The DerSimonian-Laird random-effects pooled prevalence was 8.04% (95% CI 5.02–12.64%). Heterogeneity was substantial ($I^2=73.53\%$, $\tau^2=0.193$, $Q = 11.33$, $df = 3$, $p = 0.010$). Because only four studies contributed to the primary pool, a REML/Hartung-Knapp robustness analysis was emphasized in interpretation; it produced the same pooled point estimate (8.04%) but a wider 95% CI of 3.72–16.54%, with an approximate 95% prediction interval of 1.70–30.71%. These wider intervals underscore the uncertainty generated by sparse, heterogeneous evidence. Study-level prevalence ranged from 3.9% in Ugandan professional athletes to 11.0% in the Algerian recreational/professional sample; the Ethiopian estimate was 9.9% for lifetime/ever use and the Cameroonian university-athlete estimate was 9.4% for previous/ever use.

3.3 Substance-specific findings

Substance-specific evidence was more extensive than the strict overall-prevalence pool, but it was highly heterogeneous in definition and time frame. Anabolic agents were the most consistently quantifiable class. Ohaeri et al. reported lifetime anabolic-steroid use of 3/250 (1.2%) among Nigerian professional sportspeople, while Gradidge et al. reported anabolic-androgenic steroid use of 4/100 (4.0%) among competitive South African male high-school athletes [17, 24]. Pooling these two exact-denominator estimates yielded an anabolic-agent prevalence of 2.27% (95% CI 0.69–7.20%; $I^2=60.7\%$).

Stimulants appeared repeatedly across the African evidence base. Ohaeri et al. reported amphetamine use of 0.8% and cocaine use of 0.4% [17]. Ama et al. found that 8% of 1,116 Cameroonian amateur footballers reported cocaine use in general and 7% reported use before matches; exact event counts were not printed in the retrieved source and were therefore not included in the primary quantitative pool [20]. Afolayan/Adegboyega reported current ephedrine use of 8.1% in Nigerian national-level elite athletes, but only rounded percentages were available [23]. Akindutire et al. reported use/trial of several prohibited agents, including cocaine, stanozolol and nandrolone, within the Nigerian tertiary-athlete cohort [21].

Growth hormone was reported by 5/100 South African high-school athletes in the Gradidge study [24]. The Zimbabwe WADA-funded report also recorded last-12-month use of anabolic steroids, cocaine, growth hormone, diuretics and cannabinoids, but these data were retained for grey-literature sensitivity/narrative synthesis rather than the primary peer-reviewed pool [29].

A recurring methodological problem was the conflation of prohibited doping with broad PES use. Chisati et al. reported that 91% of Malawian elite footballers used at least one PES, but the dominant products were caffeine, herbal products and energy bars, while cocaine was reported by only 2% [18]. Similarly, Mekacher et al. reported “doping conduct” in 65/397 (16.4%) Algerian sports-school respondents, but the authors explicitly noted that some products considered “doping” by participants were proteins, vitamins or other non-prohibited products [19]. These headline estimates were therefore excluded from the WADA-defined prevalence pool.

3.4 Prohibited methods

Prohibited methods were less frequently quantified than substances. The companion Nigerian tertiary-athlete report recorded blood doping in 96/510 (18.8%) and chemical manipulation in 109/510 (21.4%), although the exact correspondence between the questionnaire wording and current WADA method categories was imperfect [22]. Injection as a route of administration was also reported, but injection per se cannot be considered a prohibited method without knowing the injected substance and route restrictions. The Kenyan report included blood doping among last-12-month prohibited methods/substances, while the Zimbabwe report included a small aggregate proportion reporting prohibited methods [26, 29].

3.5 Detection and ascertainment methods

Most athlete-level prevalence studies relied on direct self-report questionnaires, ranging from researcher-developed instruments to modified WADA social-science tools. Direct questioning provided low-cost access to large athlete samples but was vulnerable to stigma, under-reporting and inconsistent comprehension of prohibited-list rules.

Two South African studies provided historical laboratory surveillance. van der Merwe et al. reported 45 positive urine samples among 679 analysed between 1983 and 1987 (6.6%) using gas chromatography for stimulants and GC-MS for anabolic steroids [27]. van der Merwe later reported 300 positive samples among 14,017 analysed between 1995 and 2002 (2.14%), with anabolic agents and stimulants dominating the positive findings [28]. When these two non-overlapping sample series were synthesized, pooled laboratory sample positivity was 3.76% (95% CI 1.22–11.02%), with extreme heterogeneity ($I^2=98.0\%$). This estimate should not be interpreted as the proportion of unique athletes who doped because athletes may have been tested repeatedly and some samples were from foreign competitors.

Strahm et al. evaluated carbon-isotope-ratio profiling of endogenous steroids in international professional soccer reference populations, including African players, illustrating the role of gas chromatography-combustion-isotope ratio mass spectrometry in detecting exogenous testosterone administration [30]. This paper contributed to the detection-method narrative but not to prevalence estimation.

3.6 Regional, sport and competition-level patterns

Within the primary exact-denominator pool, East Africa was represented by the Ugandan and Ethiopian studies, both involving professional/competitive adult athletes. Their two-study pooled estimate was 6.24% (95% CI 2.45–15.01%), with high heterogeneity ($I^2=85.0\%$). Because the regional and athlete-level subgroup are the same pair of studies, they should be interpreted together rather than as independent lines of evidence. The result is descriptive and does not constitute a stable East African prevalence estimate.

The remaining primary cohorts represented different athlete populations: the Algerian sample was predominantly bodybuilding-oriented recreational/professional athletes, whereas the Cameroonian sample comprised university athletes competing at national level. Elite national and international competitors, particularly high-performance endurance athletes, were not represented sufficiently to support a dedicated pooled estimate. More broadly, most African regions contained too few high-quality, representative studies for credible country-level meta-regression, sport-specific meta-analysis or robust comparisons between recreational, collegiate, national and international athletes. This scarcity is itself a major evidence gap and likely contributes to the apparent inconsistency of regional patterns.

3.7 Methodological quality

Quality varied materially across studies. The Ghanaian AAS study was judged low concern because it used a large school-based sample, random selection and high response. Several primary studies, including Uganda, Cameroon and the Kenyan grey-literature survey, were rated low-to-some concern. Other studies were judged to have some concern because of incomplete sampling-frame information, restricted athlete populations or unclear response handling. Small convenience samples, broad PES constructs and poorly defined prevalence denominators produced high concern in the Malawian, Burkina Faso and Akintayo studies. The laboratory surveillance series were judged to have some concern for prevalence inference because analytical methods were strong but unique-athlete denominators and demographic coverage were unavailable.

3.8 Sensitivity analyses

Leave-one-out analysis showed that the pooled prevalence was most sensitive to removal of the Ugandan study. Excluding Muwonge et al. increased the pooled prevalence from 8.04% to 10.22% (95% CI 7.83–13.24%) and reduced I^2 to 0%, indicating that the lower Ugandan estimate was the principal driver of heterogeneity. Excluding

the Ethiopian, Algerian or Cameroonian studies yielded pooled estimates of 7.49%, 7.15% and 7.63%, respectively, with I^2 remaining above 75%.

The two studies classified as low-to-some concern yielded a pooled prevalence of 6.06% (95% CI 2.49–13.99%; $I^2=82.1\%$), whereas the two studies classified as some concern yielded 10.52% (95% CI 7.72–14.19%; $I^2=0\%$). These comparisons are exploratory because each stratum contained only two studies.

Adding the Kenyan ADAK ever-use estimate of 74/338 (21.9%) increased the pooled prevalence to 10.06% (95% CI 5.30-18.28%) and increased heterogeneity to $I^2=91.8\%$, demonstrating the impact of grey literature and population/method differences on the summary estimate [26].

3.9 Small-study effects and publication bias

With only four studies in the primary pool, formal statistical assessment of funnel-plot asymmetry was not considered reliable. Egger's regression and Begg's rank-correlation procedures [12, 13] were therefore not used to infer the presence or absence of publication bias, and trim-and-fill was not performed. The more consequential threat is likely evidence-availability bias, including non-publication, weak indexing and geographic under-representation of African sports-science studies.

Table 1
Core characteristics of the retained African evidence base

Country	Study	N	Population	Ascertainment	Key finding
Uganda	Muwonge et al., 2015	360	Professional; 6 sports	Direct self-report	3.9% lifetime; 3.3% recent
Ethiopia	Mohammed et al., 2022	152	Competitive athletics	Direct self-report	9.9% lifetime/ever; 4.6% current
Nigeria	Ohaeri et al., 1993	250	Professional multi-sport	Direct self-report	AAS 1.2%; amphetamine 0.8%; cocaine 0.4%
Ghana	Sagoe et al., 2015	1,431 athlete subgroup	High-school athletes	Direct self-report	AAS 4.6% in athlete subgroup
Cameroon	Ama et al., 2003	1,116	Amateur/elite/local football	Direct self-report	Cocaine 8% general; 7% before matches
Algeria	Mekacher et al., 2019	397 responding to use item	Sports high-school	Direct self-report	16.4% broad doping conduct; not WADA-specific
Malawi	Chisati et al., 2022	43	Elite football	Direct self-report	91% any PES; cocaine 2%
Algeria	Chebaiki et al., 2020	200	Recreational/professional; bodybuilding dominant	Direct self-report	22/200 (11%) prohibited substances
Cameroon	Guessogo et al., 2021	138	University national-level athletes	Direct self-report	9.4% previous/ever doping product use
South Africa	Nolte et al., 2014	346	Competitive high-school/TuksSport	Direct self-report	3.9% current prohibited PED use
South Africa	Gradidge et al., 2011	100	Competitive male high-school	Direct self-report	GH 5%; AAS 4%
South Africa	van der Merwe et al., 1988	679 samples	Multi-sport competitors	Urine GC/GC-MS	45/679 positive (6.6%)
South Africa	van der Merwe, 2004	14,017 samples	54 sporting codes	Urine GC/GC-MSD	300/14,017 positive (2.14%)
Kenya	Yauma et al., 2024	338	Athletics, rugby, boxing, weightlifting	Direct self-report; grey literature	74/338 ever use; 92/338 last 12 months

Country	Study	N	Population	Ascertainment	Key finding
Zimbabwe	Charumbira et al., 2024	361	Elite athletes; 11 sports	Mixed methods; grey literature	Substance-specific last-12-month self-use
Nigeria	Akindutire et al., 2012	510	Elite tertiary-institution athletes; multi-sport	Direct self-report	Use/trial of named prohibited agents including cocaine, stanozolol and nandrolone
Nigeria	Ajayi-Vincent & Olanipekun, 2013	510	Companion report from same tertiary-athlete cohort	Direct self-report	Blood doping 18.8%; chemical manipulation 21.4%
Nigeria	Afolayan & Adegboyega, 2012	220	Elite athletes from 11 sports	Direct self-report	Current ephedrine 8.1%; anabolic steroids 3.6%; dianabol 2.7%
Burkina Faso	Ouédraogo et al., 2011	63	Professional football, cycling and athletics	Self-administered questionnaire	Pharmaceutical products and local plants reported as doping products; construct not fully WADA-specific

Table 2
Primary overall meta-analysis

Study	Events	Total	Prevalence	Country	Reference period
Muwonge et al., 2015	14	360	3.89%	Uganda	Lifetime/ever
Mohammed et al., 2022	15	152	9.87%	Ethiopia	Lifetime/ever
Chebaiki et al., 2020	22	200	11.00%	Algeria	Ever/consumed
Guessogo et al., 2021	13	138	9.42%	Cameroon	Previous/ever
Pooled Random effects (DerSimonian-Laird); REML/Hartung-Knapp robustness analysis	64	850	8.04% (95% CI 5.02–12.64%)	—	Primary CI 5.02–12.64%; HK robustness CI 3.72–16.54%; I ² =73.5%

Table 3
Summary of methodological quality judgments

Judgment	Studies/examples	Main reasons
Low concern	Sagoe et al., 2015 (Ghana)	Large, well-described school sample; high response; athlete subgroup extractable
Low-to-some concern	Muwonge 2015; Yauma 2024; Guessogo 2021; Afolayan 2012	Generally adequate reporting with some limits in sampling frame, coverage or outcome detail
Some concern	Mohammed 2022; Mekacher 2019; Ama 2003; Akindutire/companion; Chebaiki 2020; van der Merwe laboratory series	Restricted frames, incomplete response information, broad constructs or non-person laboratory denominators
Some-to-high/high concern	Ohaeri 1993; Chisati 2022; Ouédraogo 2011; Gradidge 2011	Small/convenience samples, low response, ambiguous denominators or weak representativeness

Table 4
Main quantitative syntheses and sensitivity analyses

Analysis	k	Pooled estimate	95% CI	I ² (%)	τ ²	Q	p
Overall peer-reviewed self-report	4	8.04%	5.02–12.64	73.5	0.193	11.33	0.010
Anabolic agents	2	2.27%	0.69–7.20	60.7	0.461	2.54	0.111
Laboratory sample positivity	2	3.76%	1.22–11.02	98.0	0.679	50.94	< 0.001
East Africa primary subset	2	6.24%	2.45–15.01	85.0	0.421	6.68	0.010
Leave-one-out: omit Uganda	3	10.22%	7.83–13.24	0	0	0.25	0.883
Primary + Kenya grey literature	5	10.06%	5.30–18.28	91.8	0.565	49.02	< 0.001
Primary robustness: REML + Hartung-Knapp	4	8.04%	3.72–16.54	73.5	0.194	11.33	0.010

4. Discussion

4.1 Principal findings

This review provides an Africa-specific synthesis of doping prevalence, substance patterns and detection methods while explicitly separating WADA-prohibited doping from the broader and less specific construct of performance-enhancing substance use. The principal quantitative finding was a pooled ever/previous prohibited-doping prevalence of approximately 8% across four directly comparable peer-reviewed African athlete cohorts. The conventional random-effects confidence interval was 5.0–12.6%, but a REML/Hartung-Knapp robustness analysis widened the interval to 3.7–16.5%, with a prediction interval extending from approximately 1.7% to

30.7%. The key message is therefore not a single continental prevalence value, but the combination of a non-trivial signal, substantial heterogeneity and marked uncertainty. The pooled estimate is higher than routine laboratory adverse-analytical-finding rates and lower than estimates derived from privacy-protecting indirect-estimation studies, reinforcing that different ascertainment methods do not provide directly interchangeable measures [3–5].

The result should therefore be interpreted neither as “the true prevalence of doping in Africa” nor as evidence that African athletes dope less or more than athletes elsewhere. It is a summary of a small, methodologically heterogeneous subset of available African direct self-report studies with sufficiently clear event counts, denominators and prohibited-doping definitions. The evidence remains geographically sparse, concentrated in a limited set of sports and countries, and vulnerable to non-disclosure and evidence-availability bias.

4.2 Why the pooled estimate is lower than indirect-estimation estimates

This review provides an Africa-focused synthesis of doping prevalence, prohibited substance patterns and detection methods while explicitly separating WADA-prohibited doping from broader PES use. The principal quantitative signal was an 8% pooled prevalence of ever/previous prohibited doping across four directly comparable peer-reviewed athlete cohorts. That point estimate should be read alongside the substantial heterogeneity and the wider REML/Hartung-Knapp interval (3.7–16.5%) and prediction interval (approximately 1.7–30.7%). The clinically and policy-relevant message is therefore not a single “African prevalence” number, but evidence of non-trivial doping coupled with major uncertainty and between-setting variation. The estimate is higher than routine laboratory positivity reported in the included surveillance series and lower than values derived from privacy-protecting indirect-estimation studies, reinforcing that the ascertainment method fundamentally shapes observed prevalence [3–5].

The pooled result should not be interpreted as evidence that African athletes dope more or less than athletes elsewhere. It summarizes a small subset of African studies with sufficiently clear numerators, denominators, reference periods and prohibited-doping definitions. Geographic coverage remains sparse, several sports are represented by single studies, and direct questioning is vulnerable to under-disclosure. These features constrain both external validity and causal interpretation of subgroup differences.

4.3 Substance pattern and implications for prevention

Anabolic agents and stimulants were the most recurrent prohibited categories in the prevalence literature. The pooled anabolic-agent estimate of 2.3% was based on only two exact-denominator studies and should be treated as provisional. Anabolic agents appeared in Nigeria, South Africa, Algeria, Ghana and Kenya, while stimulants including cocaine, amphetamine and ephedrine were reported across several settings [17, 20, 23, 24, 26, 31]. This pattern is consistent with the wider literature identifying anabolic-androgenic steroid use across sporting populations [6]. However, the included studies did not provide enough representative, sport-specific data to determine whether substance patterns differ systematically between recreational, collegiate, national and international athletes. This is particularly important for endurance sport, where erythropoietin (EPO) and blood manipulation are physiologically relevant but were inadequately captured by the prevalence studies in this review.

External anti-doping intelligence helps illustrate this evidence gap but should not be mistaken for prevalence data. WADA's Kenya stakeholder investigation documented recurrent adverse analytical findings involving nandrolone and EPO among Kenyan athletes and suggested that the pattern differed by athlete career profile; EPO appeared more prominent among higher-earning athletes, whereas nandrolone featured more often among lower-earning athletes [41]. The Kenyan WADA/ADAK social-science report included EPO among last-12-month prohibited-substance responses, but its substance-specific multiple-response denominator was internally inconsistent and therefore was not pooled [26]. Comparable representative prevalence data for EPO among Ethiopian elite endurance athletes were not available in the included evidence. Thus, EPO and nandrolone should be highlighted as important surveillance targets rather than assigned region-wide prevalence estimates from insufficient data.

Cannabinoids, narcotics and substances of abuse require especially careful interpretation. The current WADA framework identifies cocaine, diamorphine/heroin, MDMA and THC as substances of abuse because their use frequently occurs outside sport [1, 2]. A positive history of use therefore does not automatically establish performance-motivated doping. The Zimbabwe report explicitly asked about use "for whatever reason" [29], while African studies from Nigeria and Cameroon also reported psychoactive or recreational substances within broader substance-use or doping questionnaires [17, 20]. Such outcomes are useful for athlete-health surveillance but should not be silently re-labelled as intentional doping.

The supplement-doping interface is a particularly important prevention target. African studies from Malawi and Algeria showed frequent use of legal supplements alongside limited certainty about product safety or prohibited-list status [16, 18], while South African high-school data demonstrated anti-doping knowledge gaps in a population where prohibited-PED use was also reported [32]. In Kenya, Chebet's study of elite middle- and long-distance runners examined doping knowledge, attitudes, practices and information sources, reinforcing the need for athlete education and context-sensitive prevention among endurance athletes [40].

International evidence further shows that sports supplements may contain undeclared prohibited substances and can create a genuine risk of inadvertent anti-doping rule violations [34, 35]. For sports-medicine teams, prevention therefore extends beyond discouraging deliberate doping: medication reconciliation, supplement-risk counselling, therapeutic-use-exemption awareness, route- and threshold-specific restrictions, and referral to qualified sports-pharmacy or anti-doping expertise are all relevant safeguards.

4.4 Detection methods: what each method can and cannot tell us

The evidence clearly demonstrates that self-report and biological detection answer different questions. Direct surveys estimate admitted use over a specified period, whereas urine testing detects analytical evidence within substance-dependent windows [3–5]. The historical South African laboratory series provide valuable evidence of testing activity, detected classes and analytical technology, but their denominators are samples rather than unique athletes [27, 28]. Repeated testing, targeted testing and inclusion of foreign competitors mean that a 2% or 7% sample-positivity rate cannot be equated with a 2% or 7% athlete prevalence.

Modern anti-doping detection extends beyond conventional GC-MS screening to isotope-ratio mass spectrometry, LC-MS/MS, and the Athlete Biological Passport (longitudinal evaluation of steroids, hormones and blood profiles). The Strahm et al. study illustrates the value of carbon-isotope-ratio profiling for detecting

exogenous testosterone in international professional football populations that included African players [30]. The Athlete Biological Passport adds a complementary longitudinal strategy by identifying atypical biomarker profiles rather than relying solely on direct identification of a prohibited substance [36]. The African evidence set, however, contained few population-level studies linking these technologies to prevalence estimation. This reflects a structural gap: analytical capacity may exist in regional centres, but published surveillance denominators and athlete-level linkage are limited. Future research should distinguish routine testing statistics, adverse analytical findings, anti-doping rule violations and independently estimated prevalence.

4.5 Implications for athlete health, sports medicine and anti-doping practice

For sports medicine clinicians, team physicians, physiologists, coaches and anti-doping organizations, the findings support a risk-management approach rather than reliance on a single prevalence estimate. Clinical encounters should include careful medication and supplement histories, recognition that inadvertent exposure can occur through contaminated products, and referral to appropriately qualified anti-doping or sports-pharmacy expertise where uncertainty exists [1, 2, 34, 35]. At system level, surveillance should pair confidential epidemiological methods with biological testing, while preserving the distinction between admitted use, analytical positivity and formal anti-doping rule violations. The wide prediction interval in the primary meta-analysis further suggests that prevention and testing strategies should be locally risk-informed rather than extrapolated from a continental average.

4.6 Geographic gaps and African anti-doping capacity

A major finding is the geographic and competition-level thinness of the evidence. The retained literature represents only a minority of African countries and is clustered in particular sports, institutions and research-active settings. High-level national and international athletes are underrepresented in representative prevalence studies, while some of the most visible anti-doping concerns in African sport arise in elite endurance athletics. Consequently, apparent regional or athlete-level differences may reflect where investigators, anti-doping organizations and testing infrastructure are present rather than genuine differences in doping burden. Countries and competition levels with little published evidence should therefore be treated as data-poor, not as low-risk.

This imbalance has policy consequences. Anti-doping resource allocation should ideally respond to risk, but risk cannot be measured reliably without surveillance. Countries without accredited laboratories or mature national anti-doping research systems may have the least data, not necessarily the least doping. WADA-funded social-science projects in Kenya and Zimbabwe demonstrate the value of targeted regional research, but they also reveal the need for denominator discipline, standardized instruments and transparent distinction between perceived prevalence, personal use and rule violations [26, 29]. Earlier work in Burkina Faso similarly highlighted limited knowledge and the accessibility of products perceived as doping agents, underscoring that prevention and surveillance gaps are not confined to countries with larger published evidence bases [33].

4.7 Methodological quality and reporting priorities

Methodological quality was mixed and directly affected the interpretability of prevalence estimates. Stronger studies clearly defined athlete populations, used defensible sampling approaches, achieved adequate participation and reported extractable numerators and denominators. Weaker studies relied on convenience samples, poorly specified sampling frames, broad PES constructs or multiple-response tables that could not

support athlete-level prevalence inference [18, 19, 21–24, 33]. Several reports presented percentages without exact event counts. For future prevalence research, reporting n/N together with percentage, recall period and prohibited-list context should be considered essential rather than optional.

The Nigerian companion-publication problem also illustrates why cohort identifiers matter. Without explicit attention to institutions, geography, sample size and sex distribution, the same 510 athletes could have been counted twice. Future systematic reviews should map publications to cohorts before pooling, and primary studies should report data-collection dates and prior publications from the same sample.

For African studies specifically, we recommend a minimum reporting set: exact WADA-compatible doping question; exact recall period; athlete eligibility criteria; sport and competition level; sampling frame and sampling method; response rate; sex and age distribution; exact numerator and denominator for every prevalence estimate; prohibited-list year; distinction between therapeutic, recreational and performance-motivated use; and explicit description of whether products were prohibited, monitored or permitted at the relevant time. When feasible, indirect response techniques should be considered for sensitive questions, accompanied by clear assessment of instruction compliance [3, 4].

4.8 Interpretation of sensitivity and small-study-effect analyses

The leave-one-out analysis is informative because the primary pool is small. Removing the Ugandan study eliminated statistical heterogeneity and increased the pooled estimate to approximately 10%. This suggests that the principal between-study contrast is not a diffuse random phenomenon but largely reflects the lower Ugandan estimate relative to the Ethiopian, Algerian and Cameroonian primary studies [14–16, 25]. Differences in sport composition, question wording, population and disclosure culture may all contribute.

The grey-literature sensitivity analysis moved the pooled estimate upward and markedly increased heterogeneity after inclusion of the Kenyan ADAK estimate [26]. This does not mean that grey literature is inferior. Rather, it shows that adding a national WADA-funded survey with a substantially higher estimate changes the underlying population and method mix. The appropriate approach is therefore transparent stratification, not automatic exclusion or uncritical pooling.

Formal publication-bias inference is not justified with four primary studies. Funnel-plot asymmetry tests such as Egger's and Begg's procedures have little power in such a small evidence base [12, 13], so their non-significance would not be informative. The more important concern is evidence-availability bias: countries with no published or indexed research are invisible to the meta-analysis, and this geographic and infrastructure-related missingness cannot be diagnosed by a funnel plot.

4.9 Strengths and limitations

This review has several strengths. It used a transparent two-stage blinded screening process, incorporated an Africa-specific bibliographic source and grey literature, extracted outcomes at study/cohort level, resolved overlapping cohorts, separated lifetime/current/in-competition/laboratory outcomes, distinguished WADA-prohibited doping from broad PES use, and applied design-appropriate methodological appraisal. It also separated athlete-level self-report prevalence from laboratory sample positivity and used a small-sample robustness analysis, reducing the risk of presenting methodologically different outcomes as if they were interchangeable.

Several limitations warrant emphasis. First, only four directly comparable cohorts informed the primary pooled prevalence estimate; heterogeneity was substantial and the prediction interval was wide. Second, direct self-report can underestimate stigmatized and sanctionable behaviour [3–5]. Third, athlete representation was uneven: elite national/international athletes, high-performance endurance specialists and several major African sporting regions were inadequately represented. Consequently, competition-level and sport-specific substance patterns could not be estimated reliably. This was especially important for EPO, blood-manipulation methods and nandrolone, which are prominent in some endurance-sport testing and enforcement records but were insufficiently captured by exact-denominator prevalence studies [41]. Fourth, several potentially relevant studies used broad or historically inconsistent definitions, did not report exact numerators, or had denominators unsuitable for pooling. Fifth, laboratory surveillance used samples rather than unique-athlete denominators [27, 28]. Sixth, older studies were conducted under earlier IOC/WADA prohibited lists, so contemporary class labels are interpretive rather than retroactive legal classifications. Seventh, the review team was unable to access SPORTDiscus, a sports-specific database, which may have reduced retrieval sensitivity. Although PubMed/MEDLINE, Scopus, Web of Science, African Index Medicus and targeted grey literature provided substantial complementary coverage, complete retrieval cannot be guaranteed. Finally, the evidence remains concentrated in a limited number of countries, sports and competition levels. The pooled estimate should therefore be interpreted as a synthesis of the available comparable evidence rather than a definitive prevalence for Africa.

5. Conclusions

The available African literature indicates that doping involving prohibited substances or methods is neither negligible nor adequately characterized. Across the four most directly comparable peer-reviewed self-report cohorts, the pooled prevalence of ever/previous prohibited doping was approximately 8%; however, substantial heterogeneity and the wide small-sample-adjusted interval show that this is not a stable continent-wide prevalence estimate. Anabolic agents and stimulants were repeatedly reported, while cannabinoids, narcotics, diuretics, growth hormone and prohibited methods appeared in selected settings. Laboratory surveillance confirmed prohibited-agent detection but produced sample-positivity rates that should not be interpreted as athlete-level prevalence.

The central implication is methodological and practical: African anti-doping systems need harmonized epidemiological surveillance that can be linked, without conflation, to biological testing. Future studies should use WADA-compatible definitions, explicit recall periods, representative sampling across recreational, collegiate, national and international competition levels, confidential or indirect response approaches where appropriate, exact numerator/denominator reporting and clear prohibited-list context. High-performance endurance cohorts should be sampled explicitly so that the prevalence of EPO, blood manipulation and other endurance-relevant prohibited practices can be estimated rather than inferred from enforcement data. Strengthening athlete education, supplement and medication risk management, coordinated testing, longitudinal biological monitoring and regional analytical capacity would improve both athlete protection and the evidence base needed for proportionate anti-doping policy.

Abbreviations

Abbreviation	Full Meaning
AAS	Anabolic-Androgenic Steroids
ABP	Athlete Biological Passport
ADAK	Anti-Doping Agency of Kenya
CI	Confidence Interval
DL	DerSimonian-Laird
GC	Gas Chromatography
GC-MS	Gas Chromatography-Mass Spectrometry
GC-MSD	Gas Chromatography-Mass Selective Detection
GC-C-IRMS	Gas Chromatography-Combustion-Isotope Ratio Mass Spectrometry
GH	Growth Hormone
IOC	International Olympic Committee
I ²	I-squared Statistic, a measure of statistical heterogeneity
JBI	Joanna Briggs Institute
LC-MS/MS	Liquid Chromatography-Tandem Mass Spectrometry
MMAT	Mixed Methods Appraisal Tool
PED	Performance-Enhancing Drug
PES	Performance-Enhancing Substance
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
REML	Restricted Maximum Likelihood
WADA	World Anti-Doping Agency
τ^2	Tau-squared, estimate of between-study variance in a random-effects meta-analysis

Declarations

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Consent for publication

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Clinical Trial Number

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Competing interests

The authors DCI, AN, IMU, PEA, SS, TNU, MH, LKA, UM, AMY, OA, BMW, MJA, OO, EDE, AUI, NS, VA, BFO, AN, HO, DHW, AIA, and EJA, all declare that they have no competing interests.

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Authors' contributions

DCI, IMU, PEA, EDE, DHW, and AN conceptualized and designed the study. BMU, SS, VA, UM, and AMY conducted the literature search; OA, MH, AUI, NS, TNU, and OO conducted title/abstract and full-text screening; DCI, LKA, IMU, AN, HO, EJA, BO, and MJA conducted data extraction and contributed to manuscript drafting. DHW, SS, AMY, MJA, AN, OO, BO, VA, AIA, and the remaining co-authors contributed to data verification, evidence synthesis, interpretation of findings, manuscript review and intellectual revision. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

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Availability of data and materials

All data generated or analysed during this review are included in this manuscript. Additional details may be made available from the corresponding author upon reasonable request.

References

1. World Anti-Doping Agency. World Anti-Doping Code (2021) Montreal: World Anti-Doping Agency; 2021. Available from: 2021_wada_code.pdf Accessed 21 July 2026
2. World Anti-Doping Agency. The 2026 Prohibited List: World Anti-Doping Code. Montreal: World Anti-Doping Agency (2025) Effective 1 January 2026. Available from: 2026list_en_final_clean_september_2025.pdf. Accessed 21 July 2026

3. Gleaves J, Petróczi A, Folkerts D, de Hon O, Macedo E, Saugy M et al (2021) Doping prevalence in competitive sport: evidence synthesis with best practice recommendations and reporting guidelines from the WADA Working Group on Doping Prevalence. *Sports Med* 51(9):1909–1934. 10.1007/s40279-021-01477-y
4. Sagoe D, Cruyff M, Chegeni R, Soós S, de Hon O, van der Heijden P et al (2026) Doping prevalence in sport from indirect estimation models: a systematic review and meta-analysis. *Sports Med Open* 12:64. 10.1186/s40798-026-01014-z
5. de Hon O, Kuipers H, van Bottenburg M (2015) Prevalence of doping use in elite sports: a review of numbers and methods. *Sports Med* 45(1):57–69. 10.1007/s40279-014-0247-x
6. Sagoe D, Molde H, Andreassen CS, Torsheim T, Pallesen S (2014) The global epidemiology of anabolic-androgenic steroid use: a meta-analysis and meta-regression analysis. *Ann Epidemiol* 24(5):383–398. 10.1016/j.annepidem.2014.01.009
7. Heuberger JAAC, Cohen AF (2019) Review of WADA prohibited substances: limited evidence for performance-enhancing effects. *Sports Med* 49:525–539. 10.1007/s40279-018-1014-1
8. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372:n71. 10.1136/bmj.n71
9. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C (2015) Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. *Int J Evid Based Healthc* 13(3):147–153. 10.1097/XEB.0000000000000054
10. DerSimonian R, Laird N (1986) Meta-analysis in clinical trials. *Control Clin Trials* 7(3):177–188. 10.1016/0197-2456(86)90046-2
11. Higgins JPT, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. *BMJ* 327:557–560. 10.1136/bmj.327.7414.557
12. Egger M, Davey Smith G, Schneider M, Minder C (1997) Bias in meta-analysis detected by a simple, graphical test. *BMJ* 315:629–634. 10.1136/bmj.315.7109.629
13. Begg CB, Mazumdar M (1994) Operating characteristics of a rank correlation test for publication bias. *Biometrics* 50(4):1088–1101. 10.2307/2533446
14. Muwonge H, Zavuga R, Kabenge PA (2015) Doping knowledge, attitudes, and practices of Ugandan athletes: a cross-sectional study. *Subst Abuse Treat Prev Policy* 10:37. 10.1186/s13011-015-0033-2
15. Mohammed SA, Tessena T, Endiro KH, Wubishet B (2022) Knowledge, attitude and practice of doping among athletes of Amhara Region, Ethiopia: cross-sectional study. *J Drug Alcohol Res* 11(6):236184. 10.4303/jdar/236184
16. Chebaiki IJ, Bekadi A, Bechikh MY (2020) Sports supplements: use, knowledge, and risks for Algerian athletes. *North Afr J Food Nutr Res* 4(7):231–239. 10.51745/najfnr.4.7.231-239
17. Ohaeri JU, Ikpeme E, Ikwuagwu PU, Zamani A, Odejide OA (1993) Use and awareness of effects of anabolic steroids and psychoactive substances among a cohort of Nigerian professional sports men and women. *Hum Psychopharmacol Clin Exp* 8(6):429–432. 10.1002/hup.470080609
18. Chisati EM, Undi D, Ulili S, Nkhoma S, Mlongoti M (2022) Prevalence of performance enhancing substance use among elite football players in two super league teams in Blantyre, Malawi. *Malawi Med J* 34(3):157–161. 10.4314/mmj.v34i3.3

19. Mekacher LR, Toudeft F, Azzouz M (2019) Dopage sportif: connaissances et attitudes des athlètes des lycées sportifs algériens. *Sci Sports* 34(2):88–99. 10.1016/j.scispo.2018.10.013
20. Ama PFM, Betnga B, Ama Moor VJ, Kamga JP (2003) Football and doping: study of African amateur footballers. *Br J Sports Med* 37(4):307–310. 10.1136/bjism.37.4.307
21. Akindutire IO, Adegboyega JA, Olanipekun JA (2012) Doping knowledge and practice among elite athletes in tertiary institutions in Nigeria. *Eur Sci J* 8(4):152–163
22. Ajayi-Vincent OB, Olanipekun JA (2013) An assessment of prohibited methods of doping among athletes in tertiary institutions in Southwest, Nigeria. *Kuwait Chapter Arab J Bus Manag Rev* 2(9):53–58. 10.65453/ajbmr.v2i9.404
23. Afolayan J, Adegboyega JA (2012) Knowledge and use of performance enhancing drugs among Nigeria elite athletes. *IOSR J Appl Chem* 1(5):31–38. 10.9790/5736-0153138
24. Gradidge P, Coopoo Y, Constantinou D (2011) Prevalence of performance-enhancing substance use by Johannesburg male adolescents involved in competitive high school sports. *Arch Exerc Health Dis* 2(2):114–119. 10.5628/aeht.v2i2.102
25. Guessogo WR, Hamadou A, Bissou-Mahop J, Mban-Bian W et al (2021) Knowledge, attitudes and practices related to doping among Cameroonian university-level athletes: a cross-sectional study. *Eur J Phys Educ Sport* 9(1):13–24. 10.13187/ejpe.2021.1.13
26. Yauma RO, Rintaugu EG, Mundia MW (2024) Doping knowledge, prevalence, and predisposing factors among athletes in dominant Olympic sports in Kenya. *WADA Social Science Research Report*
27. van der Merwe PJ, Hundt HK, Müller FO, van Velden DP (1988) Drugs in sport: the first 5 years of testing in South Africa. *S Afr Med J* 74(4):161–162
28. van der Merwe PJ (2004) Drugs in sport: testing results from the South African Laboratory 1995–2002. *S Afr J Sports Med* 16(1):29–32. 10.17159/2078-516X/2004/v16i1a191
29. Charumbira LT, Mbayo V, Makaza D, Makoni P, Charumbira J, Matsungu TM (2024) Effectiveness of anti-doping systems: developing a strategic roadmap towards a doping-free sporting environment in Zimbabwe. *WADA Social Science Research Report*
30. Strahm E, Emery C, Saugy M, Dvorak J, Saudan C (2009) Detection of testosterone administration based on the carbon isotope ratio profiling of endogenous steroids: international reference populations of professional soccer players. *Br J Sports Med* 43(13):1041–1044. 10.1136/bjism.2009.058669
31. Sagoe D, Torsheim T, Molde H, Andreassen CS, Pallesen S (2015) Attitudes towards use of anabolic-androgenic steroids among Ghanaian high school students. *Int J Drug Policy* 26(2):169–174. 10.1016/j.drugpo.2014.10.004
32. Nolte K, Steyn BJM, Krüger PE, Fletcher L (2014) Doping in sport: attitudes, beliefs and knowledge of competitive high-school athletes in Gauteng Province. *S Afr J Sports Med* 26(3):81–86. 10.7196/SAJSM.542
33. Ouédraogo M, Goumbri WBF, Ouédraogo M, Liliou AF, Guissou IP (2011) Conduites dopantes dans le sport au Burkina Faso: connaissances, attitudes et pratiques. *Sci Sports* 26(1):25–31. 10.1016/j.scispo.2010.09.004
34. Outram S, Stewart B (2015) Doping through supplement use: a review of the available empirical data. *Int J Sport Nutr Exerc Metab* 25(1):54–59. 10.1123/ijsnem.2013-0174

35. Martínez-Sanz JM, Sospedra I, Mañas Ortiz C, Baladía E, Gil-Izquierdo A, Ortiz-Moncada R (2017) Intended or unintended doping? A review of the presence of doping substances in dietary supplements used in sports. *Nutrients* 9(10):1093. 10.3390/nu9101093
36. Sottas PE, Robinson N, Rabin O, Saugy M (2011) The Athlete Biological Passport. *Clin Chem* 57(7):969–976. 10.1373/clinchem.2011.162271
37. Sama H, Traoré M, Guenné S, Séré I, Hilou A, Dicko MH (2022) Ethnobotanical and phytochemical profiling of medicinal plants from Burkina Faso used to increase physical performance. *Med (Basel)* 9(2):10. 10.3390/medicines9020010
38. Muwonge H, Zavuga R, Kabenge PA, Makubuya T (2017) Nutritional supplement practices of professional Ugandan athletes: a cross-sectional study. *J Int Soc Sports Nutr* 14:41. 10.1186/s12970-017-0198-3
39. Petróczi A, Cruyff M, de Hon O, Sagoe D, Saugy M (2022) Hidden figures: revisiting doping prevalence estimates previously reported for two major international sport events in the context of further empirical evidence and the extant literature. *Front Sports Act Living.* ;4:1017329. 10.3389/fspor.2022.1017329. Corrigendum: *Front Sports Act Living.* 2023;5:1129320. doi:10.3389/fspor.2023.1129320
40. Chebet S (2014) Evaluation of knowledge, attitudes and practices of doping among elite middle and long distance runners in Kenya [doctoral thesis]. Nairobi: Kenyatta University; Kenyatta University Institutional Repository
41. World Anti-Doping Agency. Doping in Kenya: Stakeholder Project Report. Intelligence and Investigations Department. Montreal: World Anti-Doping Agency (2018) Available from: https://www.wada-ama.org/sites/default/files/final_public_report_on_kenya.pdf? Accessed 21 July 2026

Figures

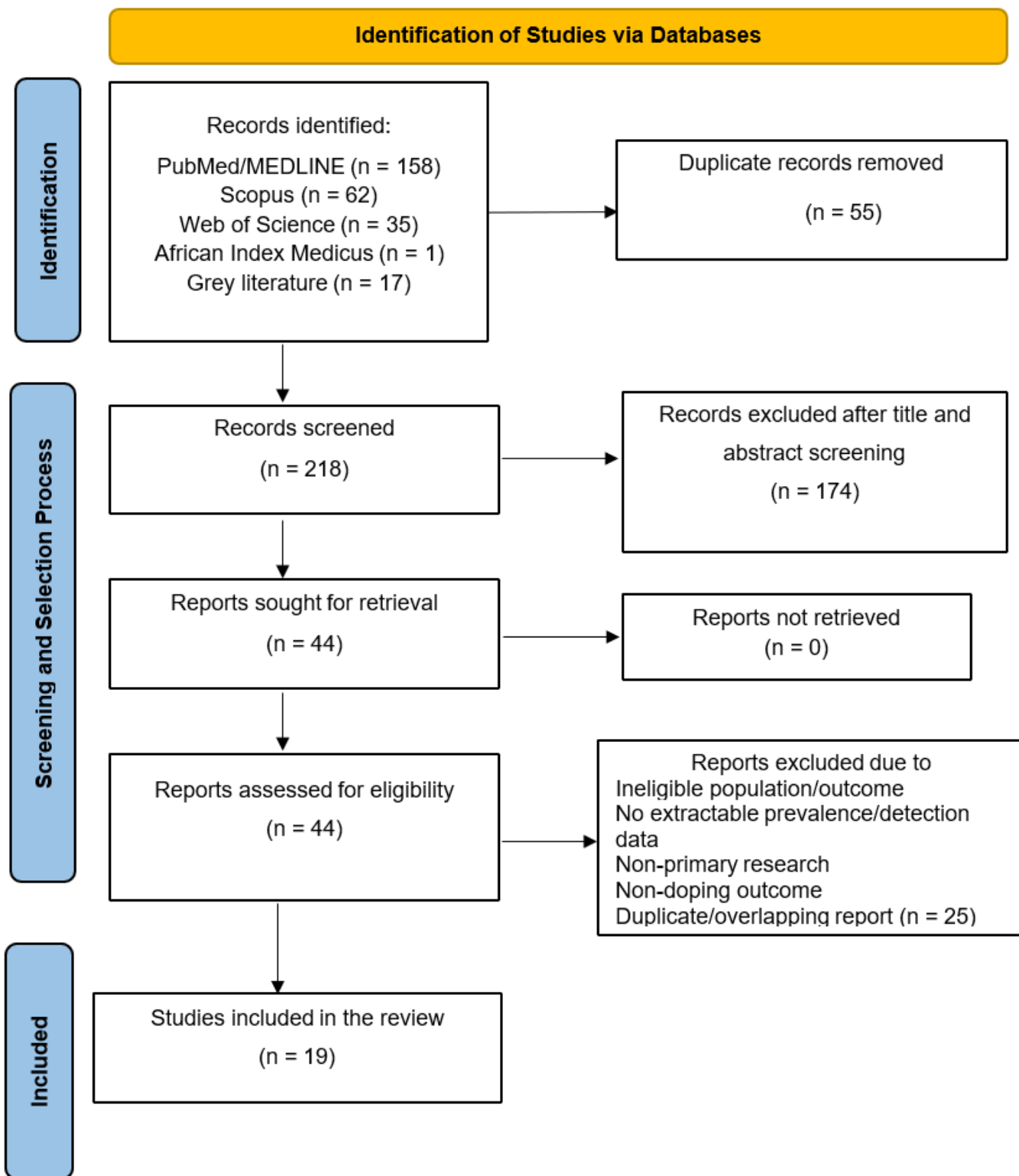


Figure 1

PRISMA 2020 study-selection flow diagram.

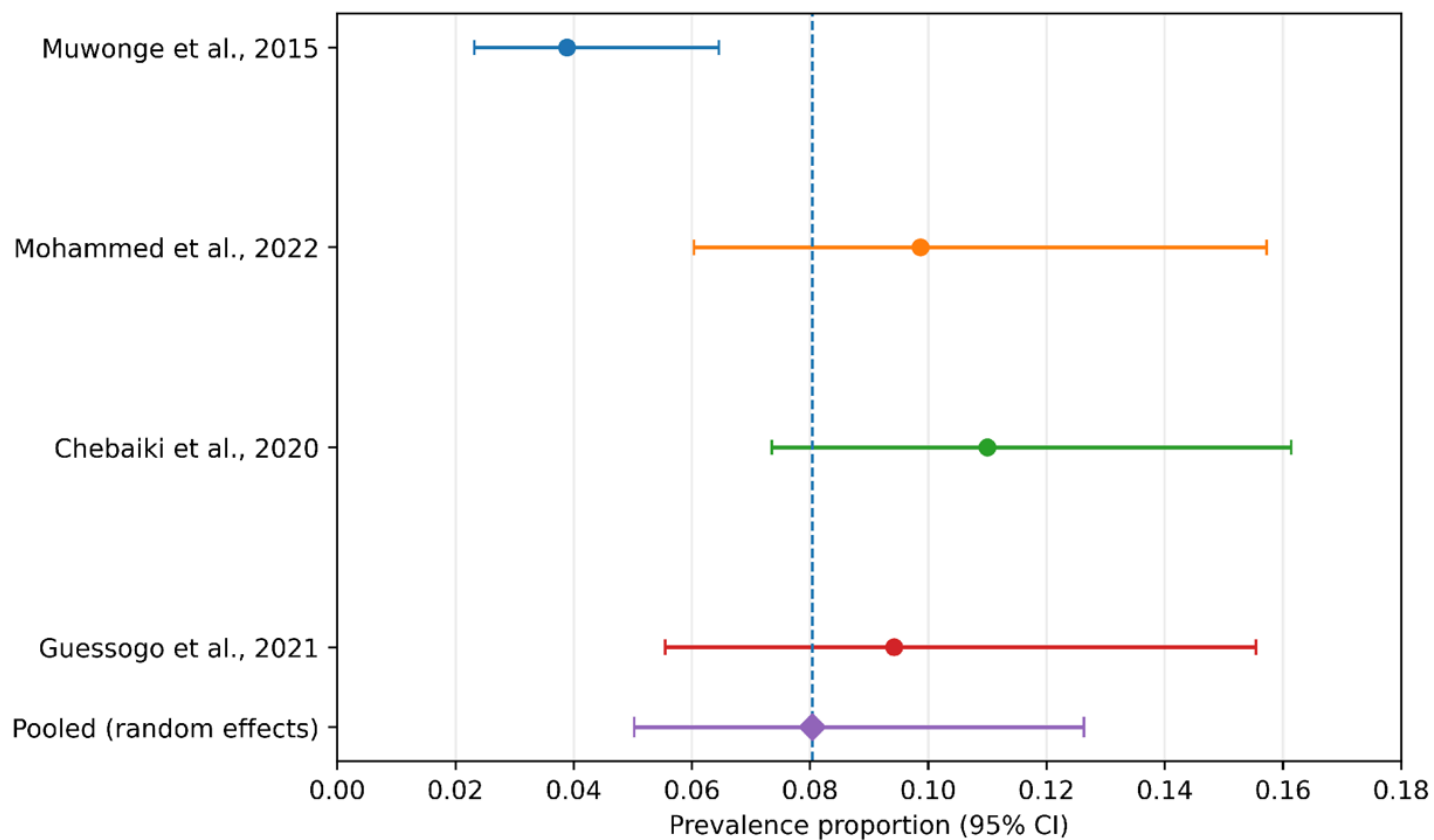


Figure 2

Random-effects forest plot of the primary pooled prevalence of ever/previous prohibited doping among African athletes.