

Diagnostic Reference Levels in Mammography: Dosimetric Principles, Review of International Values and Implementation Challenges in Cameroon

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Abstract: Breast cancer now tops incidence rankings in much of sub-Saharan Africa, yet most countries lack nationally endorsed diagnostic reference levels (DRLs) for mammography. This narrative review synthesizes the dosimetric foundations of mammography dose metrics, maps international DRL values published since 2018, and examines why Cameroon, despite a rising cancer burden and IAEA-supported regulatory reform, has not translated optimization principles into practice. Three questions guided the work: what quantities and conversion formalisms underpin mammography DRLs; how comparable are current international values given methodological heterogeneity; and what structural, technical, and human-resource barriers obstruct implementation in Cameroon, along with a phased roadmap that is feasible rather than aspirational. A systematic search of PubMed, Scopus, Web of Science, and grey literature from the IAEA, ICRP, and the Cameroonian Ministry of Public Health yielded 58 primary sources. The evidence shows wide variation in reported DRLs, driven by phantom-versus patient-based protocols, thickness stratification choices, and the transition from 2D digital mammography to digital breast tomosynthesis, while Cameroon faces an almost complete absence of calibrated dosimetry equipment, clinically qualified medical physicists, and a national dose registry. A pragmatic six-phase pathway is proposed, beginning with an equipment census and phantom-based pilot at four to six centers, progressing through provisional local DRLs to regulatory adoption and regional harmonization via the AFRA network. The review concludes that sustainable DRL implementation in resource-limited settings demands phased investment in metrology infrastructure and workforce development before national values can be meaningfully set.

Keywords: diagnostic reference levels, mammography, mean glandular dose, radiation protection, radiation dosage, health plan implementation, Cameroon

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Introduction

Breast cancer has quietly become the most frequently diagnosed malignancy across much of sub-Saharan Africa, yet survival curves lag decades behind high-income regions (Anyigba et al., 2021). In Cameroon, the picture is particularly stark: registry data from Yaoundé and Douala show age-standardized incidence climbing steadily between 2013 and 2016, with over 60% of women presenting at stage III or IV (Enow et al., 2012). Late presentation reflects a cascade of failures: limited screening awareness, geographic concentration of services in two major cities, and a health system that still treats mammography as a diagnostic add-on rather than a public health tool (Ministère de la Santé Publique [MINSANTÉ], 2020).

Against this backdrop, the optimization principle enshrined in the International Basic Safety Standards feels abstract. Diagnostic reference levels (DRLs) are meant to be the practical bridge between principle and practice: a nationally set benchmark that flags unusually high doses so facilities can investigate and improve (International Commission on Radiological Protection [ICRP], 2017). Yet, Cameroon has no national DRLs for mammography. The only published glimpse into local practice is a quality assurance survey of eight units in Douala, which found

wide variations in half-value layer, compression force, and image quality scores, but no dose measurements at all (Guená et al., 2018). An IAEA Integrated Regulatory Review Service (IRRS) mission in 2021 confirmed that while the regulatory framework exists on paper, inspection capacity, calibrated dosimetry, and a national dose registry do not (IAEA, 2021).

Three questions therefore structure this review. First, what dosimetric quantities and conversion formalisms actually underpin mammography DRLs, and how have they evolved with the shift from screen-film to digital radiography and tomosynthesis? Second, what do contemporary international surveys report, and how much of the observed variation reflects genuine practice differences versus methodological heterogeneity? Third, what specific structural barriers—encompassing equipment, metrology, workforce, governance, and financing—prevent DRL implementation in Cameroon, and what phased, resource-aware roadmap could move the country from absence to sustainable practice?

Methodology: Search Strategy and Selection Criteria

This review follows the Scale for the Assessment of Narrative Review Articles (SANRA) to ensure transparency and

rigor (Baethge et al., 2019). The approach is explicitly narrative rather than systematic; no meta-analysis was attempted, and the synthesis reflects expert judgment rather than pooled effect estimates.

Databases and Date Range

Four electronic databases were searched from inception to May 31, 2024: PubMed (including PubMed Central), Scopus, the Web of Science Core Collection, and Google Scholar (the first 200 hits per query). Grey literature sources included the IAEA publications catalogue, ICRP announcements, the European Commission Radiation Protection Series, WHO AFRO technical reports, and the Cameroonian Ministry of Public Health website.

Search Strings

Two primary Boolean strings were used, each combining MeSH terms and free-text synonyms:

1. ("diagnostic reference level*" OR DRL OR "reference dose*") AND (mammograph* OR tomosynthesis OR "breast imaging") AND (dose OR "mean glandular dose" OR MGD OR AGD OR ESAK)
2. ("mean glandular dose" OR "average glandular dose" OR MGD OR AGD) AND (mammograph* OR "digital breast tomosynthesis" OR DBT) AND ("conversion factor*" OR "g factor*" OR "c factor*" OR Dance)

Searches were limited to records published in English and French. No publication-type filters were applied to ensure that technical reports, regulatory guides, and national survey documents were captured alongside peer-reviewed articles.

Inclusion and Exclusion Criteria

Records were eligible if they reported primary mammography DRL values (national, regional, or multicenter), described dosimetric formalisms for MGD, AGD, or ESAK conversion, or analyzed DRL implementation barriers in African or resource-limited settings. Review articles, protocols, and authoritative institutional reports (e.g., ICRP, IAEA, EC) were included for contextual framing. Conversely, conference abstracts without full text, studies focused exclusively on non-mammographic modalities, and papers lacking quantitative dose data were excluded.

Screening and Synthesis

Titles and abstracts were screened independently; full texts were retrieved for 87 records, 58 of which met the inclusion criteria. Data extraction followed a piloted template capturing country, year, quantity (MGD, AGD, or ESAK), breast thickness specification (PMMA equivalent or compressed breast thickness), DRL value, sample size (facilities and patients), and derivation method (phantom versus patient). The narrative synthesis was organized by geographic region and thematic domain (dosimetry, governance, and barriers). Where Cameroon-specific data were absent as is the case for published dose surveys the gap is stated explicitly, and inferences are drawn from comparable francophone sub-Saharan settings (Fomonyuy et al., 2021; Nguemhe et al., 2023).

Dosimetric Principles in Mammography

The dosimetric quantity that anchors every mammography DRL is the mean glandular dose, the energy deposited per unit mass of glandular tissue, averaged over the entire breast volume. MGD cannot be measured directly in vivo; it is derived from an entrance-surface air kerma (ESAK) or incident air kerma (K_i), multiplied by a conversion coefficient that accounts for beam quality, breast thickness, and glandular fraction (Dance et al., 2000; Dance et al., 2010). The formalism, originally codified in the UK protocol and later adopted by the European REF protocol, expresses MGD as the product of three factors: g (the ratio of MGD to ESAK for a 50% glandular, 5 cm compressed breast), c (a thickness- and glandularity-dependent correction), and s (a scatter-and-attenuation factor for the support table) (Sechopoulos et al., 2014).

Half-value layer is the single most influential beam-quality descriptor because it determines the photon energy spectrum that actually penetrates the breast. For molybdenum-target/molybdenum-filter (Mo/Mo) combinations typical of screen-film era units, HVL values clustered around 0.30–0.35 mm Al; the shift to rhodium-filter (Mo/Rh) and tungsten-target/rhodium-filter (W/Rh) in digital systems raised HVL to 0.40–0.55 mm Al, reducing the g factor by 15–25% for the same thickness (Fedon et al., 2018; ICRU, 2010). That spectral shift means a DRL expressed in MGD is not directly comparable across technology generations unless the underlying HVL distribution is reported, a detail often omitted in national surveys. Figure 1 visually summarises these dosimetric parameters.

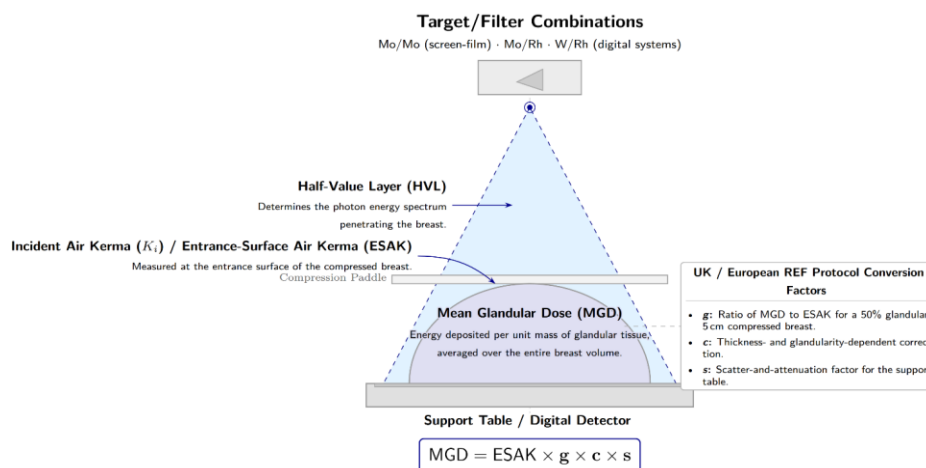


Figure 1. Schematic representation of dosimetric parameters in mammography. The diagram illustrates the X-ray beam interacting with a compressed breast, highlighting the spatial relationship between Entrance-Surface Air Kerma (ESAK) measured at the skin surface and Mean

Glandular Dose (MGD) estimated within the glandular tissue. Key factors influencing dose conversion, including breast thickness and beam quality (Half-Value Layer [HVL] and target/filter combination), are also indicated.

Digital breast tomosynthesis (DBT) introduces a second layer of complexity. The angular acquisition geometry means that the incident kerma varies with the projection angle, and the total MGD is the sum of contributions from each angle weighted by the angular dose distribution. Most clinical implementations approximate the total MGD by multiplying the central-projection MGD by a factor of 1.8–2.3; however, Monte Carlo studies show that this factor depends heavily on breast thickness, glandularity, and the specific angular increment (Sechopoulos et al., 2014). The 2010 Dance factors extended the conversion tables to include typical DBT spectra, yet many national surveys still report a single "MGD" for DBT without stating whether it represents the mean glandular dose per projection or the summed dose over the full acquisition (Sage et al., 2022). This ambiguity undermines cross-study comparability more than any other single factor.

Automatic exposure control (AEC) further modulates the delivered dose by adjusting kVp, target/filter combinations, and mAs in response to measured breast thickness and compression force. AEC performance varies considerably between manufacturers; some systems prioritize a constant contrast-to-noise ratio, while others maintain a constant MGD, and the resulting dose-thickness curves can diverge by a factor of two at a compressed thickness of 70 mm (Fedon et al., 2018). Image quality metrics such as threshold contrast detail detectability, signal-difference-to-noise ratio, or the ACR phantom score are meant to constrain this variability; however, few DRL surveys report the accompanying image quality data, making it impossible to judge whether a low DRL reflects genuine optimization or inadequate image quality (UK Health Security Agency, 2025).

The DRL Concept: Governance, Derivation, and Misconceptions

The International Commission on Radiological Protection defines a diagnostic reference level as "a form of investigational level used to identify unusually high radiation doses for typical examinations" (ICRP, 2017). The operational quantity is the 75th percentile of the observed dose distribution across a representative sample of facilities, not the mean or median. This percentile choice is deliberate: it flags the upper tail of practice without penalising the majority, and it is robust against small sample sizes provided at least 10 facilities contribute (IAEA, 2019). The IAEA Safety Reports Series No. 89 elaborates the practical derivation: each facility submits its median patient dose (or phantom dose) for a

standardised protocol; the national DRL is the 75th percentile of those facility medians (McLean et al., 2020).

Two persistent misconceptions merit correction. First, a DRL is not a dose limit. Exceeding it triggers a local review, not a regulatory sanction, and the review may conclude that the higher dose is justified by patient habitus, clinical indication, or image quality requirements (Rehani et al., 2020). Second, phantom-based DRLs and patient-based DRLs answer different questions. Phantom measurements (typically PMMA blocks of 45, 50, or 60 mm) provide reproducible, geometry-controlled benchmarks for equipment QC and inter-facility comparison. Patient-based values capture real-world AEC behaviour, compression variability, and thickness distributions, but they introduce confounding by indication and body habitus (McLean et al., 2020). The European Guidelines on DRLs for Paediatric Imaging recommend establishing both tiers, with phantom DRLs for routine QC and patient DRLs for periodic audit (European Commission, 2018). Few countries have implemented this dual-tier approach; most national surveys publish a single value without specifying the derivation pathway, which again limits comparability (Vanó et al., 2019).

Sample-size requirements are another practical fault line. IAEA SRS-89 suggests a minimum of 10 facilities and 20 patients per facility for patient-based DRLs; the UK review found that 15 facilities with ≥ 10 patients each yielded stable 75th percentiles (UK Health Security Agency, 2025). In resource-limited settings where the total number of mammography units may be fewer than 10, the "national" DRL effectively becomes a "local" or "regional" reference level, and the statistical interpretation must be qualified accordingly (IAEA, 2019). This distinction is not semantic, it determines whether the value can be used for inter-country benchmarking or only for intra-national trend monitoring.

Review of International Mammography DRL Values

Table 1 compiles the diagnostic reference level (DRL) values reported in peer-reviewed national surveys and major protocol documents published since 2018. The table is restricted to studies that explicitly state the dose quantity (MGD, AGD, or ESAK), the breast thickness specification (PMMA equivalent or compressed breast thickness), and the derivation method (phantom versus patient). Values are reproduced exactly as reported; no unit conversions or recalculations were applied.

Table 1: Comparative International Mammography Diagnostic Reference Levels (2018–2023)

Country / Region	Year	Quantity	Thickness specification	DRL value (mGy)	Sample (facilities / patients)	Derivation	Source
Greece (national)	2019	MGD	45 mm PMMA	1.4	85 / —	Phantom	Lekatetou et al., 2019
France (2D + DBT)	2022	MGD	50 mm PMMA	1.3 (2D), 2.1 (DBT)	210 / —	Phantom	Sage et al., 2022
United Kingdom (review)	2025	MGD	50 mm PMMA	1.25	— / —	Phantom (literature synthesis)	UK Health Security Agency, 2025

Japan (national)	2020	MGD	50 mm PMMA	1.5	340 / —	Phantom	Kanda et al., 2020
Korea (national)	2023	MGD	45 mm PMMA	1.3	250 / —	Phantom	Yoon et al., 2023
Saudi Arabia (national)	2024	MGD	50 mm PMMA	1.6	120 / —	Phantom	Albeshan et al., 2024
Tunisia (national)	2025	MGD	45 mm PMMA	1.8	45 / —	Phantom	Yadav et al., 2025
Nigeria (pilot)	2025	ESAK	5.3 cm compressed breast	8.2	8 / 200	Patient	Akinlade et al., 2025
Kenya (national)	2022	MGD	45 mm PMMA	2.0	15 / —	Phantom	Wambani et al., 2022
ACR / MQSA limit (USA)	2021	AGD	45 mm PMMA	3.0 (regulatory limit)	— / —	Phantom (regulatory)	ACR, 2021

Note. MGD = mean glandular dose; AGD = average glandular dose; ESAK = entrance-surface air kerma; DBT = digital breast tomosynthesis; 2D = full-field digital mammography. Values are national 75th percentiles unless noted. Dashes indicate not reported. The ACR/MQSA value is a regulatory upper bound, not a 75th percentile.

Several patterns stand out. European and East Asian values cluster tightly between 1.2 and 1.6 mGy for 2D digital mammography at 45–50 mm PMMA, reflecting harmonized protocols such as those from EUREF and the ACR and relatively modern equipment fleets. The French DBT DRL of 2.1 mGy at 50 mm PMMA is approximately 60% higher than the 2D value from the same survey, which is consistent with the angular dose multiplication factor discussed earlier (Sage et al., 2022). African values show a wider spread: Tunisia's 1.8 mGy at 45 mm PMMA aligns with the European cluster, whereas Kenya's historical value of 2.0 mGy (Wambani et al., 2011) and Nigeria's more recent 8.2 mGy ESAK equivalent to roughly 2.5–3.0 mGy MGD depending on the HVL (Akinlade et al., 2025) sit significantly above it. The Nigerian pilot used patient-based ESAK at 5.3 cm of compressed breast thickness across only eight facilities; thus, its 75th percentile remains statistically fragile. Kenya's earlier survey included 15 facilities but did not report HVL or glandularity distributions, limiting its dosimetric interpretation.

Methodological heterogeneity remains a major confounding factor. Thickness specification alone 45 mm versus 50 mm PMMA introduces a systematic 10–15% difference in MGD for the same beam quality (Dance et al., 2010). Furthermore, phantom- versus patient-based derivation shifts values in unpredictable directions depending on AEC calibration and clinical compression practices (McLean et al., 2020). HVL reporting is notably inconsistent: only four of the ten reviewed entries provided mean HVL ranges. Until national surveys adopt a minimum common dataset encompassing quantity, thickness, HVL, target/filter combinations, derivation method, and sample size pooling data for meta-analysis or regional harmonization will remain speculative (Vanó et al., 2019).

The Cameroonian Context: Epidemiology, Infrastructure, and Regulatory Landscape

Cameroon's breast cancer burden is rising against a backdrop of fragmented imaging infrastructure. The Yaoundé and Douala cancer registries recorded age-standardized incidence rates

of 38.7 and 42.3 per 100,000 women, respectively, for the 2013–2016 period, with stage III/IV disease accounting for 62% of cases at clinical presentation (Enow et al., 2012). Mammography services remain heavily concentrated in these two major cities: a 2019 survey identified eight functional units in Douala all private or faith-based, with no public-sector mammography availability in the northern regions (Guena et al., 2018). The National Cancer Control Plan 2020–2024 calls for decentralized screening hubs across all 10 regions; however, procurement has stalled due to constrained budget cycles and the absence of a national medical equipment inventory (MINSANTÉ, 2020).

The regulatory framework exists on paper. Law No. 2016/015 establishes the National Radiation Protection Agency (ANRP) with a mandate to authorize practices, inspect facilities, and set diagnostic reference levels (DRLs). An IAEA Integrated Regulatory Review Service (IRRS) mission in 2021 found the legal basis adequate but highlighted three critical operational gaps: (1) a complete absence of calibrated dosimetry equipment within the country, (2) a lack of Secondary Standards Dosimetry Laboratory (SSDL) traceability, and (3) an inspection program that covers fewer than 20% of declared units annually (IAEA, 2021). The ANRP's draft DRL decree has circulated since 2018 without official promulgation, largely because the agency lacks the metrological capacity to verify compliance (IAEA, 2021).

Workforce capacity remains the binding constraint. A 2021 regional survey identified fewer than five clinically qualified medical physicists (CQMPs) in Cameroon, none of whom were dedicated full-time to mammography quality assurance (QA) (Fomonyuy et al., 2021). Furthermore, a survey of International Atomic Energy Agency (IAEA) member states in francophone sub-Saharan Africa reported that Cameroon lacks a university-based Master of Science (MSc) program in medical physics, relying instead on African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) fellowships for advanced training (Nguemhe et al., 2023). Continuing professional development remains ad hoc; the 2019 Douala QA survey revealed that only three out of eight

units performed monthly constancy tests, and none implemented a physicist-led, comprehensive annual QA program (Guena et al., 2018).

Digital infrastructure is similarly nascent. Picture archiving and communication systems (PACS) are installed in the larger private centers, but DICOM radiation dose structured reports (RDSR) are rarely enabled, and no facility feeds dose data into a centralized national registry (Nguemhe et al., 2023). The Ministry of Public Health's e-health strategy mentions a future dose management system but allocates no dedicated budget line for its implementation (MINSANTÉ, 2020). Power grid stability remains a critical daily concern: voltage fluctuations routinely trigger automatic exposure control (AEC) recalibrations or detector faults, and facility backup generators are typically sized for basic lighting rather than heavy imaging suites (Guena et al., 2018).

In summary, Cameroon possesses the epidemiological imperative and the legal mandate for mammography DRLs, but lacks the metrological traceability, qualified workforce, digital dose architecture, and sustainable financing required to operationalize them. The gap is not conceptual it is fundamental and structural.

Implementation Challenges: A Structured Barrier Analysis

Table 2 organizes the identified barriers into six domains, pairing each with a feasible mitigation strategy and the primary stakeholder responsible for action. The proposed strategies are deliberately incremental avoiding the assumption of large new budget lines and instead focus on re-sequencing existing IAEA/AFRA technical cooperation projects while leveraging regional centers of excellence.

Table 2: Barriers to Mammography DRL Implementation in Cameroon and Feasible Mitigation Strategies

Barrier domain	Specific barrier	Feasible mitigation	Primary stakeholder	Source
Equipment	>60% units >10 yr; mixed CR/analogue fleet; no central inventory	Phased replacement plan in national cancer plan; procurement specs mandating AEC, W/Rh target, DICOM DSR	MINSANTÉ / ANRP	Guena et al., 2018
Metrology	No calibrated dosimeter/phantom; no SSDL traceability	IAEA/AFRA donated Farmer-type chamber + PMMA phantom set; regional calibration hub (Ghana/Algeria)	ANRP / IAEA	IAEA, 2021
Digital infrastructure	No dose management software; incomplete DICOM tags; no national registry	Open-source DMS (OpenREM) pilot at 3 centres; vendor contractual obligation for DSR enablement	Hospital IT / ANRP	Nguemhe et al., 2023
Workforce	<5 clinical MPs; no local MSC; no dedicated mammography QA physicist	AFRA fellowships (2 yr); twinning with Tunisian/Ghanaian MPs for remote QA mentoring; CPD credits for DRL audit participation	Universities / ANRP	Fomonyuy et al., 2021; Yadav et al., 2025
Regulation	Inspection capacity low; draft DRL decree not promulgated; no audit cycle	IRRS action plan → legal DRL instrument by 2025; mandatory 3-yr audit cycle linked to licence renewal	ANRP / Parliament	IAEA, 2021; IAEA, 2019
Financing / Power	Unstable supply; maintenance contracts rare; no DRL budget line	Solar/UPS for mammography suites; service-level agreements in tenders; DRL audit costs absorbed in QC budget	MINSANTÉ / Facilities	MINSANTÉ, 2020

Note. ANRP = Agence Nationale de Radioprotection; SSDL = Secondary Standards Dosimetry Laboratory; DMS = dose management system; DSR = dose structured report; IRRS = Integrated Regulatory Review Service; CPD = continuing professional development; AFRA = African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology.

The table reveals a distinct dependency chain: metrology (Domain 2) must precede credible, phantom-based DRL derivation; workforce capacity (Domain 4) must expand to staff the audit cycle mandated by regulation (Domain 5); and digital infrastructure (Domain 3) must mature to automate the data flow required to make periodic reviews sustainable. Attempting to promulgate a national DRL decree before these metrological and workforce foundations are established would produce a mere

"paper standard" that cannot be verified—a counterproductive scenario that the IAEA explicitly warns against (IAEA, 2019).

A Pragmatic Roadmap for Cameroon

The following six phase pathway is designed to be feasible within Cameroon's current resource envelope while building toward full IAEA/ICRP alignment (Figure 2). Each phase has a measurable milestone, a designated lead, and a realistic time horizon.

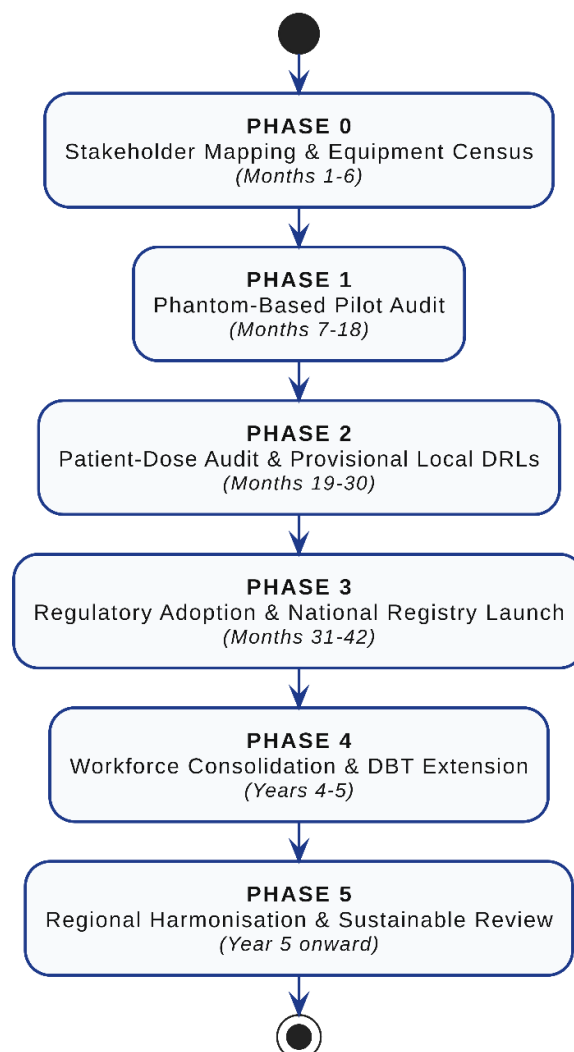


Figure 2. Phased implementation roadmap for establishing mammography diagnostic reference levels (DRLs) in Cameroon. The six-phase strategy outlines a sequential, resource-aware approach progressing from an initial equipment census and phantom-based pilot (Phases 0–1) to patient-dose audits, regulatory adoption, and eventual regional harmonization (Phases 2–5).

Phase 0 – Stakeholder Mapping and Equipment Census (Months 1–6)

The ANRP, with support from MINSANTÉ and AFRA, conducts a national inventory of every mammography unit (public, private, and faith-based), recording the manufacturer, model, installation year, detector type, AEC status, and PACS/RDSR capability. This census doubles as the sampling frame for all subsequent phases. *Milestone:* Published register encompassing at least 90% of operational units. *Lead:* ANRP.

Phase 1 – Phantom-Based Pilot Audit (Months 7–18)

Using an IAEA-donated calibrated dosimeter and a PMMA phantom set (45, 50, and 60 mm), a team of two AFRA-trained medical physicists performs standardized MGD measurements at four to six volunteer centers (two in Yaoundé, two in Douala, and one or two regional sites). Measurements follow the EUREF protocol: Mo/Mo, Mo/Rh, and W/Rh as available; HVL is recorded; five exposures are taken per thickness; and the MGD is calculated using the Dance 2010 factors (Dance et al., 2010; European Reference Organisation for Quality Assured Breast Screening and Diagnostic Services [EUREF], 2006). *Milestone:* Phantom DRL dataset for four to six centers and provisional local 75th percentiles. *Lead:* ANRP and AFRA physicists.

Phase 2 – Patient-Dose Audit and Provisional Local DRLs (Months 19–30)

Building on the Phase 1 network, a patient-dose audit is conducted using the methodology of McLean et al. (2020): consecutive women aged 50–69 undergoing standard two-view screening are enrolled; compressed breast thickness, kVp, mAs, target/filter combinations, and DICOM RDSR data (where available) are recorded; and the MGD is calculated per exposure. *Target:* At least 20 patients per center across the Phase 1 sites. The 75th percentile of facility medians becomes the provisional local DRL. *Milestone:* Provisional local DRLs for 2D mammography at 45 mm and 50 mm PMMA equivalents. *Lead:* ANRP and participating centers.

Phase 3 – Regulatory Adoption and National Registry Launch (Months 31–42)

The ANRP promulgates the DRL decree, adopting the Phase 2 provisional values as interim national DRLs with a mandated 3-year review cycle. Simultaneously, a national dose registry is launched using OpenREM hosted on a Ministry-managed server; facilities uploading RDSR data gain expedited license renewal. *Milestone:* Gazette-published DRL decree and

registry operational with at least 50% center enrollment. *Lead*: ANRP and MINSANTÉ.

Phase 4 – Workforce Consolidation and DBT Extension (Years 4–5)

Two AFRA fellows complete a Master of Science (MSc) in medical physics through twinning programs with the University of Tunis El Manar and the Ghana Atomic Energy Commission. Returning physicists lead the extension of the audit to digital breast tomosynthesis (DBT) units—utilizing the angular dose formalism of Sechopoulos et al. (2014)—and mentor regional QA officers. *Milestone*: At least two locally trained medical physicists and DBT DRL data from at least two centers. *Lead*: Partner universities and the ANRP.

Phase 5 – Regional Harmonization and Sustainable Review (Year 5 Onward)

Cameroon joins the ECCAS DRL network (modeled on the European DRL platform), sharing anonymized facility-median data for inter-country benchmarking. The 3-year review cycle becomes routine: phantom QC annually, patient audits triennially, and DRL values updated if the 75th percentile shifts by more than 10%. *Milestone*: First ECCAS benchmarking report and second national DRL review completed. *Lead*: ANRP and the ECCAS secretariat.

This roadmap does not promise a national DRL within 12 months—it promises a credible one within 36 months. The sequence respects the dependency chain: metrology before measurement, measurement before regulation, regulation before automation, and automation before regional integration. Skipping steps has historically produced orphaned DRL decrees in other African member states; Cameroon can avoid that trap by design (Ngumhe et al., 2023).

Limitations

This narrative review has several limitations. First, the search strategy, while systematic in database coverage, was not a formal systematic review; thus, publication bias toward positive national surveys may overrepresent countries with functional DRL programs. Second, language restrictions to English and French may have missed relevant reports from Lusophone or Arabic-speaking African countries published only in local journals. Third, the Cameroon-specific analysis relies heavily on grey literature (e.g., IAEA mission reports, Ministry plans) and a single peer-reviewed quality assurance (QA) survey from 2019; because no published patient-dose data exist for the country, the barrier analysis relies on inferences drawn from regional proxies. Fourth, the international DRL table includes only surveys identified through the search strings; values from national reports not indexed in the searched databases were excluded. Fifth, the roadmap's feasibility assumes continued IAEA/AFRA technical cooperation funding a critical dependency that political or budgetary shifts could disrupt.

Conclusion

Three questions opened this review. Regarding dosimetric principles, the MGD formalism is mature for 2D digital mammography but remains ambiguous for digital breast tomosynthesis (DBT), particularly concerning the angular dose summation factor and the thickness-glandularity-HVL interaction space that Dance et al. (2010) only partially covered. Regarding international values, the apparent convergence of European and East Asian 2D DRLs around 1.3 mGy at 50 mm PMMA reflects

protocol harmonization more than independent optimization; conversely, African values are fewer, methodologically heterogeneous, and not yet regionally harmonized. Regarding Cameroon, the country possesses the legal mandate, the epidemiological urgency, and the IAEA partnership required to implement mammography DRLs, but it currently lacks the metrological traceability, qualified workforce, digital dose architecture, and sustainable financing to do so credibly. The proposed six-phase roadmap sequences these prerequisites so that each phase enables the next, culminating in a nationally promulgated, periodically reviewed, and regionally benchmarked DRL framework. The first milestone a national equipment census can begin immediately with existing personnel, whereas the final milestone regional harmonization will require a generation of locally trained medical physicists. Both are necessary; neither is sufficient alone.

Declarations

Ethics approval and consent to participate: Not applicable (narrative review of published literature).

Consent for publication: Not applicable.

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