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Synergizing Electromedical and Biomedical Engineering for Health Technology Self-Reliance in Indonesia

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Abstract

Indonesia's envision to become a high-income, self-reliant nation in technology by 2045, as articulated in the Indonesia Emas 2045 vision, depends heavily on a resilient and innovative health technology ecosystem (Sadwika, 2026). Two similar but frequently conflated professions underpin this ecosystem: Electromedical Engineering (*Teknik Elektromedik*), a vocational discipline regulated under *Kepmenkes No. 371/2007* and represented by the *Ikatan Ahli Teknik Elektromedik Indonesia* (IKATEMI), and Biomedical Engineering (BME), an academic-research discipline oriented toward medical technology innovation and represented by the *Konsorsium Ilmu Biomedical Engineering Indonesia* (KIBI). Employing a narrative policy-analysis approach, this article synthesizes regulatory documents, institutional reports, and peer-reviewed studies published between 2007 and 2024, selected for their direct relevance to electromedical and biomedical engineering regulation, education, and workforce conditions in Indonesia. Evidence was thematically coded and triangulated across regulatory, academic, and institutional sources to clarify professional boundaries, competencies, and regulatory status, and to examine the persistent role confusion, workforce shortages, and fragmented governance hindering Indonesia's medical technology sector. We argue that Electromedical Engineering constitutes the operational basis of clinical safety and equipment reliability, while Biomedical Engineering drives domestic innovation, import substitution, and policy advocacy. Rather than competing jurisdictions, these professions represent complementary links in a single value chain, from device conception to bedside maintenance. Guided by this synthesis, the article proposes an integrated strategic agenda spanning regulatory harmonization, curriculum strengthening, research funding expansion, and international collaboration, concluding that deliberate synergy between these two professions is indispensable to achieving Indonesia's health technology sovereignty by 2045.

INTRODUCTION

In 2045, Indonesia will mark a century of independence, and the government has set an ambitious national vision, termed as *Indonesia Emas 2045* (Golden Indonesia 2045)(Sadwika, 2026). It projects the nation among the world's five largest economies, underpinned by a highly skilled workforce, advanced technological capacity, and equitable, high-quality public services (Muhyiddin, 2019). Health system resilience and technological self-reliance are explicit pillars of this vision, particularly following the COVID-19 pandemic, which frankly exposed Indonesia's dependence on imported medical devices basic needs, such as ventilators, diagnostic reagents, and personal protective equipment (Kementerian Kesehatan RI, 2020; Mahendradhata et al., 2021). At the peak of the pandemic, more than 90% of Indonesia's medical devices and pharmaceutical raw materials were imported, a vulnerability that triggered renewed policy attention toward domestic health-industry capacity under the banner of health self-reliance (Kementerian Kesehatan RI, 2021)(Sadwika, 2025).

Central to this self-reliance agenda is the health technology workforce, such as biomedical engineers, electromedical technicians, and biomedical scientists who advocate, design, manufacture, install, calibrate, and maintain the devices on which modern clinical care depends. Yet Indonesia's health technology human-resource landscape is characterized by a persistent and under-examined duality: two distinct but often fused professions; Electromedical Engineering (*Teknik Elektromedik*) and Biomedical Engineering (*Teknik Biomedis*), which operate under different regulatory frameworks, educational pathways, and professional associations. Yet, these professions are frequently treated as interchangeable by hospital administrators, policymakers, and even prospective students (Kusumawati et al., 2022; Susanto & Wijaya, 2020).

This duality reflects a genuine gap in the literature. Existing Indonesian scholarship has largely examined the two professions in isolation: workforce studies of electromedical technicians (Susanto & Wijaya, 2020; Ramadhani & Kurniawan, 2023) rarely engage with the curriculum and innovation-capacity literature on biomedical engineering graduates (Kusumawati et al., 2022; Nasution et al., 2021), and comparative or policy-integrative treatments that place both professions within a single analytical framework remain scarce. Consequently, the practical consequences of their conflation for workforce planning, professional recognition, and national research investment have not been systematically examined. Yet, prior work has not moved beyond descriptive comparison to a framework explaining how the two professions' distinct competencies interact across the innovation-to-maintenance continuity. This article addresses that gap. Accordingly, it aims to (a) clarify the professional boundaries, competencies, and regulatory status of Electromedical and Biomedical Engineering in Indonesia; (b) examine the workforce, curriculum, and governance consequences of their persistent conflation; and (c) propose an integrated strategic agenda aligning both professions with Indonesia's 2045 health-technology sovereignty goals.

Electromedical Engineering is a well-established vocational (Diploma III/IV) discipline in Indonesia, formally regulated since 2007 under Kepmenkes No. 371/MENKES/SK/III/2007, which defines the Electromedical Specialist/Engineer (*Ahli Teknik Elektromedik, ATEM*) as a health professional responsible for the planning, installation, calibration, maintenance, and repair of medical electronic equipment (Kementerian Kesehatan RI, 2007). Its professional association, IKATEMI (*Ikatan Teknik Elektromedis Indonesia*), has for decades represented practitioners embedded within hospital biomedical/electromedical engineering (*elektromedik*) units.

Biomedical Engineering, by contrast, is a comparatively younger academic discipline in Indonesia, typically offered as a four-year Sarjana (S1) or postgraduate program housed within engineering faculties (e.g., Institut Teknologi Bandung, Universitas Indonesia, Institut Teknologi Sepuluh Nopember, Universitas Gadjah Mada, and others), emphasizing device design, biomaterials, medical imaging, signal processing, tissue engineering, and translational research (Nasution et al., 2021). Its emerging professional and academic body, Indonesian Biomedical Consortium (*Konsorsium Ilmu Biomedical Engineering Indonesia,* KIBI), positions the discipline as a driver of innovation, research commercialization, and industrial partnership rather than clinical maintenance (Noviantari et al., 2025).

The absence of a harmonized national qualifications framework distinguishing these two fields has produced tangible consequences: overlapping job advertisements that conflate ATEM and BME competencies, hospitals hiring under-qualified staff for high-complexity R&D roles (or, conversely, over-qualified BME graduates performing routine maintenance work below their competency level), and a fragmented voice in national health-industry policy discourse (Prasetyo et al., 2020; Ramadhani & Kurniawan, 2023). The scale of this confusion is not merely trivial: workforce surveys of government hospitals indicate that roughly one in three electromedical-unit vacancies in Java is filled by staff whose formal qualifications do not match the position's technical demands (Susanto & Wijaya, 2020), while comparable maldistribution and skill mismatch have been documented in eastern Indonesia's more remote provinces (Ramadhani & Kurniawan, 2023). This role confusion is not merely semantic; it has direct implications for patient safety, workforce planning, curriculum design, and, eventually affecting Indonesia's capacity to determine self-reliance on medical technologies.

METHOD

This article employed a narrative, policy-oriented literature review for synthesizing heterogeneous sources such asstatutory regulations, ministerial decrees, professional association documents, government strategic plans, and peer-reviewed scholarship into a coherent policy argument (Grant & Booth, 2009). Sources were identified through: (a) systematic searching of Indonesian regulatory databases (Ministry of Health, Ministry of Education, Culture, Research, and Technology, and Agency for Health, Human Resources Development and Empowerment of Indonesia) for statutes and decrees on electromedical and biomedical engineering professions; (b) searches of Google Scholar, Scopus, PubMed, and Garuda (*Garba Rujukan Digital*) for Indonesian- and English-language scholarly articles published primarily between 2019 and 2024, using keyword combinations including "*teknik elektromedik*," "biomedical engineering Indonesia," "health technology workforce Indonesia," "*Indonesia Emas 2045 kesehatan*," and "medical device policy Indonesia"; and (c) review of institutional publications from IKATEMI, KIBI, Bappenas, and WHO regional offices. This search process yielded 76 candidate documents, of which 58 met the inclusion criteria and were retained for full review: 34 peer-reviewed articles, 15 statutory or regulatory instruments, and 9 institutional or organizational reports. Documents were included if they directly addressed the regulatory status, competencies, education, or workforce composition of Electromedical or Biomedical Engineering in Indonesia, or provided comparative international evidence on clinical/biomedical engineering workforce policy; documents were excluded if they addressed medical technology only tangentially, duplicated information already captured in a more recent or more authoritative source, or could not be verified against an official government or institutional repository. Inclusion otherwise prioritized Indonesia-specific sources and recent (within five years) international literature offering comparative or theoretical grounding. Given the rapidly evolving regulatory landscape (e.g., the enactment of Omnibus Law on Health (UU

No. 17, 2023), particular attention was paid to post-2023 regulatory developments and their implications for both professions. This review approach, while not a systematic review in the PRISMA sense, follows established conventions for policy-analytic narrative synthesis in health workforce literature (Debie et al., 2022).

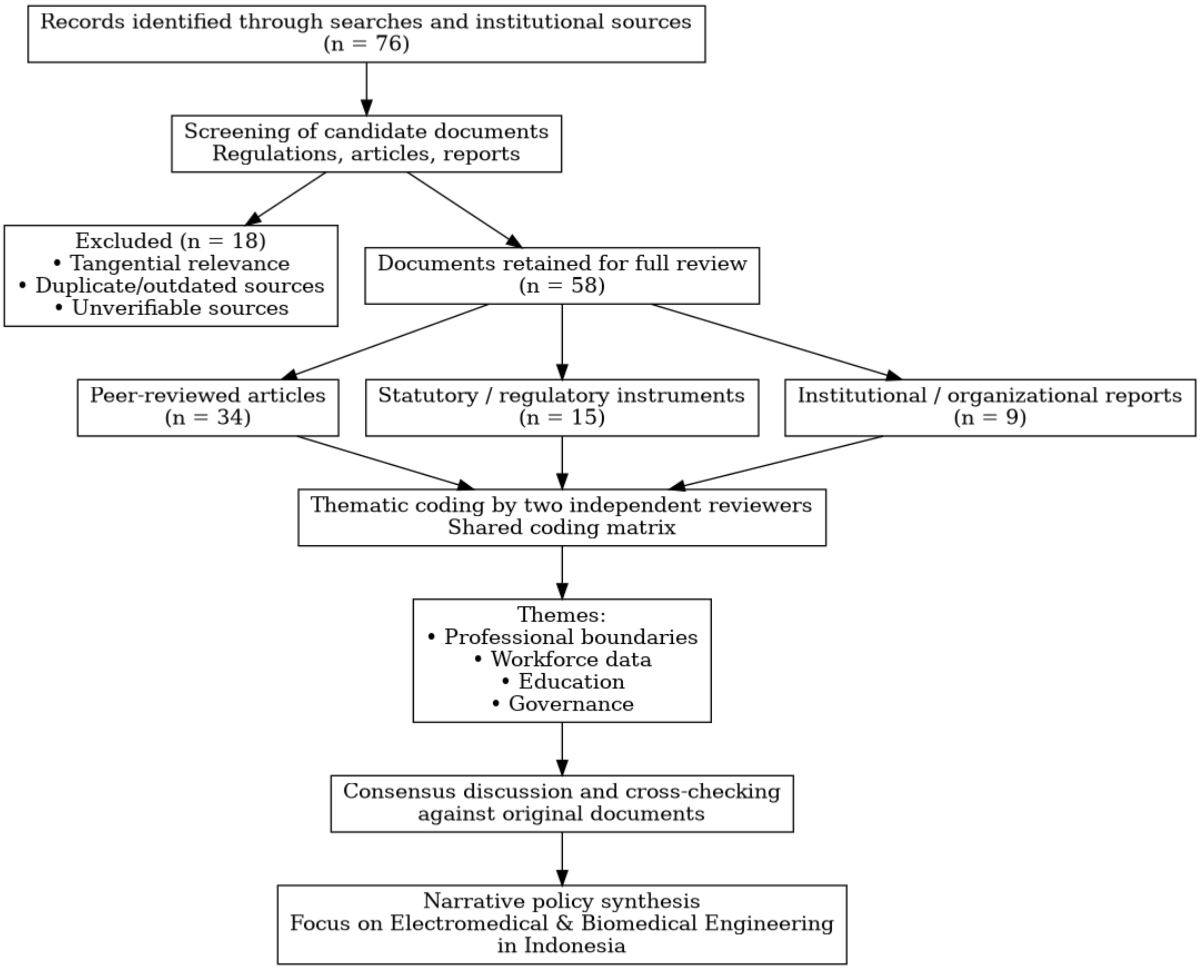

Figure 1. Narrative policy review process used in this study

A total of 76 candidate documents were identified through searches of regulatory databases, academic databases, and institutional publications. After screening, 58 documents met the inclusion criteria and were subjected to independent thematic coding and narrative policy synthesis.

RESULTS AND DISCUSSIONS

The preceding sections signify that Electromedical Engineering and Biomedical Engineering are best complimentary professional conceptions. They are not a rival, rather it is a sequential that mutually relates to establish a single national health-technology cooperation. We propose a simplified conceptual model, the "Advocate-Innovate-Deploy-Sustain" (AIDS) chain, that redefines BME as an integrated national innovation system rather than a profession limited to technical support. The framework emphasizes that sustainable healthcare technology development depends on continuous interactions among policy, engineering innovation, clinical implementation, and lifecycle management.

Advocate. As BME remains an emerging discipline in Indonesia, its first goal extends beyond technical expertise to strategic advocacy. Biomedical engineers should actively participate in shaping public policy, regulatory frameworks, and national healthcare technology strategies. This includes contributing to the formulation of a long-term national BME roadmap, advising policymakers on medical technology priorities, promoting domestic innovation through supportive procurement and industrial policies, and advocating for stronger investment in research and manufacturing capacity. Effective advocacy also requires engagement with professional organizations, healthcare institutions, industry, and legislative bodies to overcome bureaucratic fragmentation and elevate BME from a supporting technical service to a strategic national capability. Without sustained political commitment and regulatory support, even technically excellent innovations are unlikely to achieve widespread clinical adoption. Therefore, BME curricula should be expanded to cover socio-political-related subjects.

Innovate. Supported by policies related to the biomedical development, Biomedical Engineers within universities, BRIN research institutes, start-ups, and industrial R&D centers should drive the conception, design, prototyping, and clinical validation of medical technologies that directly address Indonesia's unique healthcare challenges. Innovation should be guided by unmet clinical needs to find technological solutions (Nasution et al., 2021; Prasetyo et al., 2020). This stage transforms BME from an equipment-oriented discipline into a problem-solving engineering profession capable of strengthening national technological sovereignty.

Deploy. Once validated and manufactured, either through domestic production or strategic technology transfer, innovations must be effectively translated into clinical practice. Electromedical Engineers play a crucial role by installing, commissioning, testing, and integrating medical devices into healthcare facilities while ensuring compliance with national and international safety standards, interoperability with existing hospital infrastructure, and effective user training (Kementerian Kesehatan RI, 2007; Wibowo et al., 2021). Successful deployment ensures that engineering innovation generates tangible improvements in healthcare delivery rather than remaining confined to laboratories.

Sustain. The final stage focuses on ensuring long-term reliability, safety, and continuous improvement. Electromedical technicians (ATEM) perform preventive maintenance, calibration, troubleshooting, and repairs throughout the operational life of medical equipment. More importantly, field observations, including equipment failures, maintenance records, user feedback, and performance under diverse local conditions, should be systematically collected as a feed-back to BME researchers and manufacturers. This loop transforms maintenance activities into a valuable source of real-world engineering evidence, generating iterative product refinement, improved reliability, and the development of next-generation technologies (Iadanza et al., 2019).

This AIDS framework is expectedly able to strengthen collaboration between the professions of electromedical and biomedical engineering to meet the BME goals of Indonesia. A robust, well-resourced ATEM workforce is a *precondition* for successful domestic device innovation: without reliable field-deployment and maintenance infrastructure, even the most innovative BME-designed device will fail to achieve sustained clinical adoption, undermining investor and clinician confidence in *"Buatan Indonesia"* (Made in Indonesia) medical technology (Kementerian Perindustrian RI, 2021). Conversely, without a continuous pipeline of BME-driven innovation, Indonesia's electromedical workforce is posit to perpetual dependency on maintaining imported technology, diminishing the possibility of self-reliance of health technology.

The Significance Roles of Electromedical Engineering and Biomedical Engineers in Medical Field

We contend that Electromedical Engineering's contribution to *Indonesia Emas 2045*, though less visible in innovation-centric policy discourse, is foundational rather than peripheral. Patient safety outcomes are directly and measurably linked to equipment maintenance quality; international clinical engineering literature consistently associates robust biomedical/clinical engineering maintenance programs with reduced equipment-related adverse events and extended device operational lifespan, translating into significant cost avoidance for health systems operating under resource constraints (Iadanza et al., 2019; International Federation for Medical and Biological Engineering, 2021). For Indonesia specifically, where capital budgets for medical equipment are finite and replacement cycles often extended beyond manufacturer-recommended intervals due to fiscal constraints, the marginal value of skilled preventive maintenance, extending functional equipment life, avoiding costly emergency repairs or premature replacement, is arguably even higher than in higher-income health systems (Wibowo et al., 2021; World Bank, 2022). A 2045 vision of health technology sovereignty that neglects this maintenance and reliability infrastructure risks building an innovation ecosystem atop an unstable operational foundation.

Simultaneously, Biomedical Engineering represents Indonesia's most direct disciplinary pathway toward reducing medical device import dependency and building indigenous intellectual property in the health-technology sector an explicit strategic objective under both the National Medical Device Development Master Plan and broader industrial policy targeting "high-technology" sectors for 2045 competitiveness (Kementerian Kesehatan RI, 2021; Muhyiddin, 2019). Comparative international experience for instance, South Korea's and India's respective trajectories in building domestic medical device industries through sustained university-industry R&D investment illustrates that biomedical engineering talent pipelines, when adequately funded and connected to manufacturing capacity, supported by a strategic national policy and a competent regulatory body, can meaningfully shift a nation from import-dependent to export-capable status within a generation (International Federation for Medical and Biological Engineering, 2021; World Bank, 2022). Indonesia's BME programs, though still maturing, represent precisely this kind of long-horizon strategic investment: their graduates are the human-capital foundation for future domestically designed diagnostic kits, point-of-care devices suited to Indonesia's decentralized health infrastructure, digital health/AI diagnostic tools, and eventually (Sadwika, 2026), higher-complexity devices such as imaging systems and implantables (Nasution et al., 2021; Rahardjo et al., 2022).

Regional comparators within ASEAN offer additional, more directly transferable lessons. Malaysia's statutory registration of clinical engineers under its allied health professions framework and Thailand's designation of biomedical engineering as a licensed profession under its Medical Device Act have both been associated with clearer hospital staffing structures and stronger industry confidence in locally regulated device-support services (Widodo et al., 2023). By comparison, Indonesia's roughly 6,000 registered ATEM practitioners and a still-modest annual output of approximately 800–1,000 BME graduates nationwide (Konsorsium Ilmu Biomedical Engineering Indonesia (KIBI), 2023) leave the domestic talent pipeline considerably thinner than that of peer ASEAN economies, reinforcing the urgency of the workforce and curriculum measures proposed in the Strengthening the Educational Pathway recommendations below. On the institutional-collaboration side, pilot arrangements such as joint device-development partnerships between university biomedical engineering faculties and regional hospital electromedical units, in which BME-designed prototypes were iteratively refined using ATEM-reported field-performance data before regulatory submission, illustrate at small scale precisely the kind of Innovate-Deploy-Sustain feedback loop this article recommends be institutionalized nationally (Konsorsium Ilmu Biomedical Engineering Indonesia (KIBI), 2023).

Operationalizing the AIDS framework requires more than a conceptual reframing; it requires concrete institutional mechanisms through which field-performance data generated by electromedical practitioners can systematically reach BME researchers and device manufacturers. International experience with clinical engineering departments, particularly in health systems that have institutionalized computerized maintenance management systems (CMMS) linked to national medical-device incident-reporting databases. It demonstrates that structured data capture at the point of maintenance can meaningfully inform both regulatory post-market surveillance and next-generation device design (Iadanza et al., 2019).

Indonesia's existing hospital equipment-inventory reporting requirements under SNARS accreditation standards provide a partial foundation for such a system, but currently function primarily as compliance documentation rather than as an active innovation-feedback resource (Sutoto, 2018). We suggest that a national clinical engineering data standard, potentially administered jointly by Kemenkes, BPOM, and BRIN, could transform routine technical maintenance logs into a structured, anonymized dataset accessible to registered BME research consortia, closing the AIDS loop in a manner that benefits both professions: electromedical practitioners gain enhanced professional recognition as generators of nationally significant data, while BME researchers gain access to real-world, Indonesia-specific device performance evidence that is often difficult to obtain through conventional literature or manufacturer data alone.

Absent deliberate policy intervention, the current trajectory of role confusion and regulatory fragmentation carries material opportunity costs. Talented BME graduates who cannot find R&D-appropriate employment either exit the health-technology sector entirely or emigrate, representing a direct loss to the national innovation capacity that *Indonesia Emas 2045* depends upon (Kusumawati et al., 2022). Simultaneously, under-resourced electromedical workforce distribution perpetuates safety risks and equipment downtime in precisely the peripheral and underserved regions where health equity gains are most needed (Ramadhani & Kurniawan, 2023). Perhaps most consequentially, the lack of a unified, clearly differentiated professional narrative weakens both IKATEMI's and KIBI's collective capacity to advocate for the policy instruments, dedicated licensure pathways, R&D tax incentives, clinical-engineering staffing mandates, structured industry placements that would benefit each profession individually and the health-technology ecosystem collectively (Prasetyo et al., 2020; Widodo et al., 2023).

Strategic Recommendations

Building on the synergy thesis articulated above, we propose four interlocking strategic recommendation clusters, directed at government regulators, higher-education institutions, professional associations (IKATEMI and KIBI), and industry stakeholders.

Regulatory Harmonization. Issue implementing regulations under UU No. 17/2023 that explicitly differentiate and formally recognize both professions. The transitional period following the 2023 Health Law presents a time-bound opportunity to replace the now-dated Kepmenkes 371/2007 with a modernized professional standard for electromedical technologists, while simultaneously introducing, for the first time, explicit statutory recognition of Biomedical/Clinical Engineers as a distinct professional category, potentially as a sub-classification within *tenaga teknik biomedika*, with clearly defined scope-of-practice boundaries relative to technicians (Republik Indonesia, 2023; Widodo et al., 2023). This would resolve the job-market conflation at its regulatory source.

Update Indonesia's national occupational classification (KBJI) to disaggregate electromedical and biomedical engineering job categories, enabling accurate labor-market data collection, evidence-based workforce planning by *Kemenkes and BPS* (*Badan Pusat Statistik*), and clearer signaling to employers regarding appropriate role titling and compensation benchmarking (Kementerian Kesehatan RI, 2021). Moreover, establish a joint IKATEMI–KIBI regulatory liaison council to ensure both professional voices are systematically consulted in future health-workforce and medical-device policy development, preventing unilateral regulatory decisions that inadvertently disadvantage either profession.

Strengthening the Educational Pathway. Develop formal articulation pathways between D-III/D-IV Electromedical Engineering programs and S1/S2 Biomedical Engineering programs, enabling high-performing ATEM graduates a structured route into BME academic and research careers, analogous to "2+2" or credit-transfer models used in other technical fields, thereby strengthening the talent pipeline connecting both professions rather than treating them as terminal, disconnected tracks (Puspitasari & Handayani, 2020; Yulianto et al., 2020).

Integrate translational-research and industry-collaboration modules into BME curricula, ensuring graduates possess practical device-development, regulatory-affairs, and manufacturing-liaison competencies alongside theoretical design skills, addressing the labor-market absorption challenge identified (Nasution et al., 2021). Modernize electromedical curricula to incorporate digital health, networked-device cybersecurity, and software-troubleshooting competencies, reflecting the convergence trends discussed below, ensuring the vocational workforce remains capable of servicing increasingly software-embedded medical technology (Iadanza et al., 2019; Rahardjo et al., 2022). Expand geographic distribution of both program types, particularly Poltekkes electromedical programs and satellite BME tracks, into underserved provinces (e.g., through partnerships with regional Poltekkes Kemenkes campuses in Sumatra, Kalimantan, Sulawesi, and eastern Indonesia), directly addressing the distributional inequity (Susanto & Wijaya, 2020).

Research and Development Funding Expansion. Establish a dedicated national medical-device innovation fund, administered jointly by BRIN and Kemenkes, with ring-fenced allocations for university–hospital–industry consortium grants explicitly requiring collaboration between BME research teams and electromedical/clinical-engineering field-implementation partners, operationalizing the "Advocate-Innovate-Deploy-Sustain" feedback loop (Badan Riset dan Inovasi Nasional (BRIN), 2022).

Introduce R&D tax incentives and streamlined regulatory-approval pathways (via BPOM) for domestically designed medical devices, reducing time-to-market friction that currently discourages private-sector investment in BME-driven product development (Kementerian Perindustrian RI, 2021). Furthermore, mandate structured field-performance data collection by hospital electromedical units, feeding standardized equipment failure-mode and usage data back to national repositories accessible to BME researchers, transforming routine ATEM maintenance records into a strategic innovation asset (Iadanza et al., 2019).

International Collaboration. Pursue ASEAN and broader international mutual-recognition arrangements for both electromedical and biomedical engineering qualifications, facilitating knowledge exchange, joint training programs, and eventual regional market access for Indonesian-designed devices (IFMBE, 2021).

Expand bilateral research partnerships and scholarship pipelines (e.g., with Japan, South Korea, Germany, Australia, and the Netherlands) targeting advanced biomedical engineering postgraduate training, with structured return-service or industry-placement obligations to mitigate brain-drain risk identified (Kusumawati et al., 2022; World Bank, 2022).

Facilitate IKATEMI's continued engagement with international clinical/biomedical engineering bodies (e.g., IFMBE's Clinical Engineering Division) to benchmark Indonesian professional standards against global best practice and access technical-training resources unavailable domestically (Widodo et al., 2023).

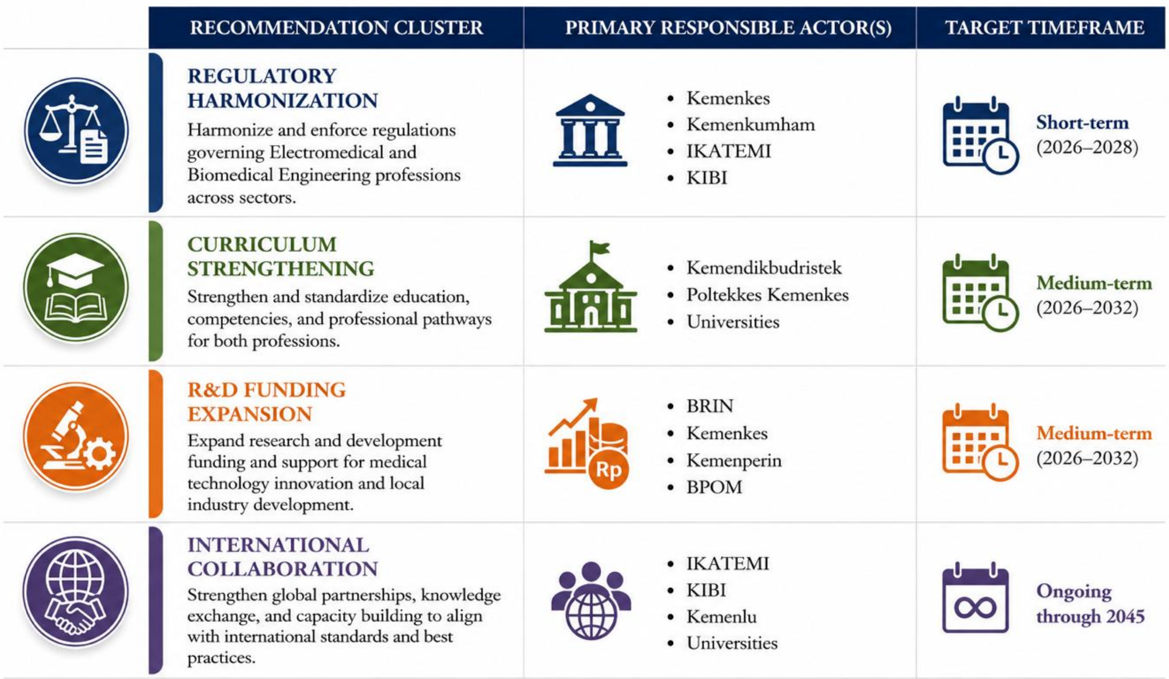

Figure 2. Strategic recommendation framework for strengthening the Electromedical and Biomedical Engineering workforce in Indonesia.

Note: Kemenkes = Ministry of Health of the Republic of Indonesia; Kemenkumham = Ministry of Law and Human Rights of the Republic of Indonesia; Kemendikbudristek = Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia;

BRIN = National Research and Innovation Agency; Kemenperin = Ministry of Industry of the Republic of Indonesia; BPOM = Indonesian Food and Drug Authority (National Agency of Drug and Food Control); Kemenlu = Ministry of Foreign Affairs of the Republic of Indonesia; IKATEMI = Indonesian Electromedical Engineering Association (Ikatan Ahli Teknik Elektromedik Indonesia); KIBI = Indonesian Biomedical Consortium; Poltekkes Kemenkes = Health Polytechnic of the Ministry of Health.

The framework identifies four priority policy domains: regulatory harmonization, curriculum strengthening, expansion of research and development (R&D) funding, and international collaboration.

CONCLUSION

Indonesia's pursuit of health technology sovereignty as a component of the broader *Indonesia Emas 2045* vision cannot succeed through the strength of a single profession alone. Electromedical Engineering and Biomedical Engineering, though distinct in regulatory status, educational pathway, and professional culture, are structurally interdependent: the former provides the operational reliability and patient-safety assurance without which no health technology, either it is domestic or imported, can be safely deployed at scale; the latter provides the innovative capacity without which Indonesia will remain permanently dependent on foreign-designed medical technology. The persistent conflation of these two professions in Indonesian labor markets and policy discourse, documented throughout this article, represents not merely a semantic inconvenience but a substantive barrier to coherent workforce planning, fair professional recognition, and effective national R&D investment. We have proposed a reframing the AIDS (Advocate-Innovate-Deploy-Sustain) concept that positions IKATEMI's electromedical technologists and KIBI's biomedical engineers as sequential, mutually reinforcing contributors to a single national objective, alongside feasible recommendations including regulatory harmonization, curriculum reform, R&D funding, and international collaboration. Realizing this synergy will require sustained, coordinated action from the Ministry of Health, higher-education authorities, BRIN, professional associations, and industry over the two decades remaining before 2045. The stakes are considerable: a health technology ecosystem that successfully integrates reliability and innovation stands to deliver not only improved patient safety and equitable equipment access across Indonesia's vast archipelago, but also a genuine, exportable national medical device industry, a tangible marker of the technological self-reliance at the heart of the Indonesia Emas 2045 vision. Future research should pursue empirical workforce mapping studies to quantify the scale of role confusion and geographic maldistribution identified qualitatively in this review, alongside longitudinal evaluation of pilot university-hospital-industry consortia as they are established under the recommended R&D funding mechanisms.

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