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Strategic Recommendations for Establishing an Undergraduate Biomedical Science Program in Indonesia: A Narrative Review of Curriculum, Infrastructure, Human Resources, and Partnerships

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Abstract

The post-pandemic era has heightened the need for biomedical scientists in Indonesia, encouraging universities to expand and establish undergraduate Biomedical Science (BMS) study programs. However, rapid program development without adequate strategic preparation may result in challenges such as poorly aligned curricula, insufficient laboratory infrastructure, and limited institutional capacity. This narrative review identifies key considerations for developing academically sound and sustainable programs. A literature search was conducted using databases such as PubMed and Scopus, alongside national and international institutional guidelines (LAM-PTKes, KKNI, QAA, IFBLS) published between 2015 and 2026. Data were synthesized to formulate strategic recommendations categorized into four principal components: curriculum design, laboratory infrastructure, human resources, and strategic partnerships. Key findings emphasize the necessity of defining a distinct scientific niche and structuring an outcome-based curriculum that strictly distinguishes BMS from generic medicine, pharmacy or biology degrees by emphasizing laboratory-based and translational competencies. Furthermore, institutions must secure dedicated, specialized laboratory infrastructure prior to program launch and not rely primarily on repurposed or shared general science facilities. Successful implementation also depends on recruiting a multidisciplinary core faculty and competent laboratory technical staff capable of supporting teaching and research activities. Finally, finalizing collaborative agreements with clinical and industrial stakeholders is required to ensure authentic work-based learning and continuous curriculum evaluation. Adhering to these synthesized guidelines helps universities to strengthen accreditation readiness and support the development of competent biomedical science graduates who are equipped to contribute to Indonesia's evolving healthcare, research, and biomedical sectors.

***Keywords**: Biomedical Science, Higher Education, Laboratory, LAM-PTKes Accreditation, Translational Research*

1. INTRODUCTION

Healthcare is no longer driven solely by clinical practice worldwide; as well as in Indonesia. It is increasingly powered by the translation of scientific discoveries into real-world medical innovations. At the center of this transformation lies Biomedical Science, a discipline that bridges fundamental laboratory research with cutting-edge diagnostics, therapeutics, and patient care (Gunn et al., 2018). Indonesia is witnessing an increasing demand for biomedical scientists as the post-pandemic era reinforces the strategic importance of biomedical research, while the expanding healthcare and biotechnology industries continue to drive innovation and workforce needs (Aisyah et al., 2021). These developments underscore the necessity of strengthening biomedical science education to prepare graduates capable of supporting the country's evolving research and healthcare ecosystem.

Currently, the enthusiasm to establish BMS programs is evident, with the number of undergraduate BMS programs in Indonesia growing to 16 programs registered under the Ministry of Higher Education, Science and Technology (Pangkalan Data Pendidikan Tinggi, n.d.). The growing eagerness to open Undergraduate Biomedical Science (BMS) study programs has outpaced strategic planning in some institutions. Despite this growth, there remains a significant gap in the literature regarding localized establishment guidelines specialized for BMS study program. However, establishing a BMS study program requires careful planning to ensure compliance with national regulations and workforce needs. While previous documents such as the QAA Subject Benchmark Statement and IFBLS Core Competencies outline international ideals, and LAM-PTKes dictates the national accreditation

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requirements, there is no comprehensive review that synthesizes these international standards with Indonesia's specific regulatory framework (KKNI and LAM-PTKes). Previous literature often addresses biomedical education in established Western contexts, leaving a critical need for a tailored guideline for Indonesian universities facing unique infrastructural and human resource constraints. A frequent pitfall for new academic institutions is treating the BMS curriculum merely as a diluted version of a medical degree, or confusing it with biology and pharmacy (Mobley et al., 2024), thereby build the risk to fulfill the essential focus on foundational bench research, critical scientific inquiry, and specialized laboratory proficiency (Gerrits et al., 2022). Furthermore, many institutions are at risk for underestimating the substantial financial investment and long-term strategic planning required to establish a high-quality BMS program. Beyond conventional teaching laboratories, a competitive program requires specialized research facilities that comply with practical skills essential for modern biomedical research, including advanced laboratory techniques, clinical research methodologies, and applied molecular biology (Prayogo et al., 2026). These competency gaps may hinder their readiness to engage in translational research and meet the evolving demands of academia, healthcare, and the biotechnology industry.

Recognizing this critical gap, this narrative review provides a comprehensive strategies enlisted as "Do's and Don'ts" guideline for Indonesian universities seeking to establish BMS study programs. By synthesizing current literature on higher education curriculum design, laboratory capacity building, and translational science education, the review identifies key practices to prioritize and common pitfalls to avoid during program development. Key considerations range from aligning graduate competencies with the Indonesian National Qualifications Framework (KKNI) to developing standardized yet workflow-based procedures that promote laboratory safety, integrity, and consistency. Aside from that, we are also incorporating the standard regulation of Indonesian Independent Accreditation Agency for Higher Education in Health (LAM-PTKes) as the primary board of quality assurance process of health study program in Indonesia. Combining these educational, infrastructural, and operational considerations, this review offers a strategic roadmap for developing BMS programs across four primary aspects: 1) Institutional Identity and Curriculum Design, 2) Laboratory Infrastructure and Management, 3) Human Resources and Faculty Development, and 4) Strategic Partnerships and Research Ecosystem.

2. METHODS

This article is structured as a narrative review. A comprehensive literature search was conducted across databases including PubMed, Scopus, and Google Scholar for articles published between 2015 and 2026. Search terms included "biomedical science major," "core competencies of biomedical science," “biomedical science study program curriculum”, "medical laboratory infrastructure," and "biomedical science partnerships." Inclusion criteria were peer-reviewed articles and official policy documents published in English and Indonesian that addressed biomedical curriculum, accreditation, and laboratory capacity building. To contextualize the recommendations, international standard documents—specifically the Quality Assurance Agency (QAA) Subject Benchmark Statement, the International Federation of Biomedical Laboratory Science (IFBLS) Guidelines, and European Association for Professions in Biomedical Science (EPBS) standards—were used to identify the globally accepted core competencies and infrastructural ideals (EPBS, 2015; IFBLS, 2022; QAA, 2023). In parallel, national regulatory and quality assurance frameworks, particularly the Indonesian National Qualifications Framework (KKNI) and LAM-PTKes accreditation instruments, were reviewed to establish the regulatory and quality standards applicable to Biomedical Science programs in Indonesia (LAMPTKES, 2026a, 2026b, 2026c; Tim KKNI, 2015). The findings were subsequently synthesized into four thematic domains: curriculum, infrastructure, human resources, and partnerships. The “Do’s” were formulated based on applicable accreditation requirements, particularly those established by LAM-PTKes, as well as internationally recognized educational and professional standards represented by QAA, IFBLS, and EPBS. In contrast, the “Don’ts” were derived from recurring challenges and documented shortcomings that may contribute to competency gaps, laboratory safety concerns, inadequate program implementation, or accreditation-related deficiencies.

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3. INSTITUTIONAL IDENTITY, CURRICULUM DESIGN AND CORE COMPETENCIES

Designing the curriculum is the most critical initial step in establishing a Biomedical Science program, as it defines the knowledge, skills, and professional competencies that graduates are expected to achieve. Curriculum must deliver broad general education objectives, explicitly defining the specialized knowledge, skills, and competencies required for graduates to function independently and safely in clinical laboratories (QAA, 2023). Curriculum also serves as a strategic framework that integrates scientific knowledge with practical competencies, equipping graduates with the expertise needed to pursue postgraduate research and contribute effectively to the biomedical, healthcare, and biotechnology sectors. Before a single course is drafted, the foundational identity of the program must be established in strict accordance with the LAM-PTKes as well as KKNI standards. Only once the program's identity is solidified can the curriculum be structured to balance theoretical depth with practical application and comply with the quality assurance standard of the study program.

The scientific foundation of a BMS study program should be deliberately structured around a multidisciplinary curriculum encompassing cell biology, genetics, biochemistry, molecular biology, physiology, pathology, and microbiology (QAA, 2023). To meet professional and accreditation expectations, the curriculum should provide comprehensive exposure and establish clear general education objectives while explicitly defining the specialized knowledge, practical skills, and professional competencies required for graduates to perform safely and independently in clinical laboratory settings (EPBS, 2015). These competencies should extend beyond foundational scientific knowledge by integrating translational and diagnostic applications that enable students to connect fundamental scientific principles with real-world laboratory practice. Without this integration, graduates may lack the practical competencies required to work safely and effectively in diagnostic laboratories, pathology services, and advanced biotechnology settings. In particular, students should develop the ability to interpret biological processes and laboratory findings across multiple levels of organization, from whole organs and tissues to cells and subcellular molecules. Clearly defined and measurable learning outcomes can therefore help ensure that graduates are adequately prepared to respond to national healthcare needs while meeting relevant professional and international competency standards (EPBS, 2015).

The Do's: Defining Vision, Mission, and Goals (VMTS), Integrating Standards and Advanced Sciences, Determining Core Competencies

1. Establish a Distinct Scientific Niche (*Keunggulan Keilmuan*)

To fulfill LAM-PTKes Criterion 1, the study program's Vision, Mission, Goals, and Strategies (VMTS) must clearly derive from the overarching vision of the university, yet possess a highly specific scientific distinction (LAMPTKES, 2026b). For a BMS study program, a generic aspiration to "advance health sciences" is unlikely to provide sufficient differentiation. Instead, the program should define a focused area of excellence—such as tropical disease genomics, molecular herbal medicine, or bioinformatics—that is grounded in the institution's geographic context, research capacity, infrastructure, and strategic priorities. However, evidence suggests that students may still favor curricula developed through expert guidance and nationally agreed standards, highlighting the importance of balancing expert input with meaningful stakeholder participation in curriculum design (Al-Jubran, 2020; Royston, 2025). A clearly articulated scientific niche combined with high contribution of stakeholders during VMTS development is heavily weighted during the accreditation process (LAMPTKES, 2026b).

2. Align Goals with the *Tri Dharma Perguruan Tinggi*

Under LAM-PTKes requirements, program goals should be aspirational but strictly measurable through specific Key Performance Indicators (KPIs). The mission must explicitly outline how the program will execute Education, Research, and Community Service specifically with each area grounded in the principles and applications of translational biomedical science.

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3. Align the Curriculum with the KKNI as National Standards

In Indonesia, once the VMTS is established, any new study program must rigorously align the curriculum and its learning outcomes with the KKNI (specifically Level 6 for undergraduate degrees) (Tim KKNI, 2015). The Faculty board who develops a BMS study program should structure competency indicators using clear narrative frameworks supported by mapping matrices, ensuring core competencies tie directly back to the program's defined vision and national accreditation standards.

4. Be concerned with practical or laboratory courses

Program developers must notice that the BMS study program is strictly defined as a laboratory-based discipline. According to the International Federation of Biomedical Laboratory Science (IFBLS) guidelines, a recognized biomedical curriculum must ensure graduates have an enough practical-hands-on competencies across three critical phases: the pre-analytical phase (specimen collection, handling, and integrity assessment), the analytical phase (executing advanced molecular assays, instrument calibration, and technical troubleshooting), and the post-analytical phase (data interpretation, validation, and accurate reporting) (IFBLS, 2022). The curriculum should also remain responsive to emerging ethical, regulatory, and technological challenges. As advanced diagnostic technologies become increasingly integrated into healthcare, students should be prepared to address issues such as data privacy, responsible use of artificial intelligence, algorithmic bias, and the ethical interpretation of digitally generated clinical information. A BMS curriculum that evolves alongside these developments is therefore essential for preparing graduates to navigate both the technical and societal dimensions of modern biomedical science (Prayogo et al., 2026; Stollenwerk et al., 2022).

The Don'ts: Preventing Misaligned Focus and Competency Gaps

1. Don't Draft a Generic or Unreliable VMTS

A must-avoid pitfall during LAM-PTKes accreditation is presenting a VMTS that lacks a unique scientific niche (*keunggulan keilmuan*) or fails to align seamlessly with the overarching vision of the parent university (LAMPTKES, 2026b, 2026c). Such generic VMTS statements often reflect a lack of a clearly defined scientific identity and insufficient consideration of the specialized expertise required to establish a distinctive biomedical research niche. A VMTS typically becomes overly generic when it is drafted with minimal contribution from external stakeholders—such as industry partners, hospitals, and clinical laboratories—and when program developers lack the specialized biomedical expertise required to carve out a distinct identity (LAMPTKES, 2026c). Furthermore, a VMTS can become unrealistic when ambitious objectives, such as advanced translational research, are formulated without a thorough assessment of the institution's actual infrastructure and research capacity. Relying on unspecified, inadequately resourced, or shared general-purpose laboratory facilities may substantially limit the program's ability to deliver on these commitments. Finally, even a well-documented VMTS will fail if there is a low level of understanding and internalization among the core faculty, creating a disconnect between the program's strategic commitments and their implementation in day-to-day teaching, research, and laboratory activities.

2. Avoid Replicating the Biology, Medical or Pharmacy Curriculum

A potentially detrimental pitfall, particularly for universities that already host established science or health programs, is to construct a BMS curriculum as a fragmented or diluted version of Medicine, Pharmacy, or General Biology. Establishing a clear academic identity is therefore essential. Tabel 1 shows a comparison of academic focus and graduates competencies of every study programs that frequently intertwinted each other.

Medical education primarily prepares students for clinical diagnosis, patient management, and direct healthcare delivery (Green et al., 2022); Pharmacy focuses on medicines, including their formulation, pharmacology, pharmacokinetics, and appropriate use of medicine to educate the patients (McLaughlin et al., 2017); while General Biology encompasses a broader spectrum of biological systems, including ecology, taxonomy, and molecular biology (González-Cespón et al., 2024).

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Tabel 1. Comparison of Academic Focus and Graduate Competencies ((González-Cespón et al., 2024; Green et al., 2022; McLaughlin et al., 2017; Stollenwerk et al., 2022)

Study Program	**Primary Academic Focus**	**Clinical Interaction**	**Key Graduate Competencies**
Medicine	Clinical diagnosis, patient management, and direct healthcare delivery.	Direct patient care and clinical intervention	Medical diagnosis, prescribing treatment, clinical procedures.
Pharmacy	Formulation, pharmacokinetics, and safe use of medicines.	Patient counseling and medication management	Drug dispensing, pharmaceutical formulation, clinical or industrial pharmacy.
General Biology	Broad biological systems (ecology, taxonomy, molecular biology).	None	Environmental analysis, conservation, basic biological research.
Biomedical Science	Understanding human disease mechanisms especially through laboratory-based investigation.	Certain condition Strictly investigational steps and laboratory-based	Diagnostic laboratory techniques, molecular assays, translational bench research.

Moreover, Biomedical Science occupies a distinctive position at the interface of these disciplines, with a primary focus on understanding human disease through laboratory-based investigation and translating scientific discoveries into clinical application (Mobley et al., 2024). Accordingly, the BMS curriculum should be intentionally designed to connect fundamental laboratory science with clinical and healthcare applications—the principle often described as "bench-to-bedside" translation.

3. Don't Neglect Practical Bench Time

Program developers should avoid underestimating the importance of rigorous laboratory-based skills, since laboratory research directly contributes to 70% of human disease diagnoses (Alhawsawi, 2024). Graduates who receive limited practical exposure to essential laboratory procedures—including clinical sample handling, aseptic techniques, reagent preparation, and basic laboratory quality practices—may enter the workforce without the practical competencies needed for safe and effective laboratory practice.

4. LABORATORY INFRASTRUCTURE AND MANAGEMENT

Establishing the physical and administrative framework of the laboratory is considered as the most resource-intensive phase of launching a BMS program. Biomedical laboratories are not simply extensions of conventional science classrooms; those have to be integrated scientific environments that connect fundamental biological sciences with clinical and translational applications. This requires meticulous spatial planning, sophisticated administrative systems for document and inventory management, and strict adherence to biosafety standards regarding the biological material used in the laboratories (Alhawsawi, 2024; Saleh et al., 2024). Within the Indonesian higher education context, this infrastructure must also rigorously fulfill LAM-PTKes Criterion 6, which dictates that all physical facilities must be adequate, accessible, and explicitly relevant to achieving the program's specialized learning outcomes (Capaian Pembelajaran) while supporting continuous quality improvement (CQI)(LAMPTKES, 2026c).

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The Do's: Comprehensive Safety-Risk Assessment and Standard for the Facilities Compliance While Tailoring the Students-Outcome Requirements

1. Align the Facilities comprehensively with LAM-PTKes Criteria 6 and Safety Standards

Laboratory infrastructure should be deliberately designed to support the academic objectives and translational research priorities of the BMS study program, while remaining responsive to the needs of users and industry in accordance with LAM-PTKes expectations. Laboratory activities should be preceded by systematic, activity-based qualitative risk assessments to identify potential hazards. Appropriate control measures should then be implemented according to the hierarchy of controls to reduce identified risks to an acceptable level, with personal protective equipment (PPE) serving as the final layer protection after other feasible control measures have been applied. To ensure reliable measurements and support accurate laboratory and clinical decision-making, biomedical equipment should undergo routine calibration with traceability to recognized national or primary measurement standards. Where existing facilities are inadequate for the proposed activities, institutions should modify the facility, reassess the scope of work, or adapt the methods used to ensure that laboratory operations remain safe and appropriate to the identified risks (Saleh et al., 2024; Tun, 2017).

2. Prioritize equipment readiness prior to program launch

Beyond reinforcing theoretical knowledge, practical training enables students to perform laboratory procedures accurately, safely, and independently, preparing them to meet the demands of clinical, research, and industrial laboratory environments (QAA, 2023). Ensure that the essential laboratory equipment required for both foundational and specialized Biomedical Science courses within the curriculum are available, properly installed and appropriately qualified or validated before the first cohort enters the program. This level of preparedness enables practical training to begin from the outset and demonstrates to accreditation bodies that the institution has the necessary infrastructure and operational capacity to deliver the approved curriculum effectively.

3. Tailoring Facilities to students-outcome requirements

A BMS study program laboratory should be designed around the competencies that graduates are expected to achieve (Stollenwerk et al., 2022). Because outcome-based education emphasizes the mastery of specific practical skills, laboratory facilities should be equipped with the appropriate instruments, technologies, and resources needed to teach, practice, and assess those competencies effectively. Such alignment between curriculum, infrastructure, and professional practice is essential for students to gain authentic practical experience while strengthening the technical competence required for accreditation and employment (LAMPTKES, 2026a).

The Dont's: Avoiding Unspecialized Laboratory and Postpone Laboratory Equipment Procurement

1. Avoid Repurposing General Science Laboratories

A major infrastructural problem is relying excessively on existing, shared Biology or Chemistry laboratories to support a BMS study program. Activities involving human-derived materials, cell cultures, and molecular assays require facilities that are appropriately designed, equipped, and controlled according to the associated biosafety risks (Abu-Siniyeh & Al-Shehri, 2021; Weiskirchen et al., 2023). Biomedical research often requires dedicated, sterile environments with specialized airflow (such as biosafety cabinets and/or negative pressure rooms) to handle human tissues, cell lines, and molecular assays safely (Weiskirchen et al., 2023). Overreliance on heavily shared or inadequately configured laboratories can increase contamination and biosafety risks, constrain research activities, and compromise the quality and reproducibility of student laboratory work. More importantly, insufficiently specialized facilities may limit students' opportunities to engage in advanced biomedical and translational research.

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2. Don't Launch the Study Program Without Mandatory Foundational Equipment

Institutions should not launch an undergraduate BMS study program or enroll its first cohort on the assumption that essential laboratory equipment will be acquired at a later stage or that facilities can be routinely borrowed from other departments such as Medicine, Pharmacy, or General Biology. While it is not necessary to possess every piece of advanced research technology (e.g., Next-Generation Sequencers) on day one, institutions must not launch the program without the mandatory foundational equipment required by LAM-PTKes for basic practical courses (e.g., basic microscopy, spectrophotometry, biosafety cabinets). Core equipment required for the approved curriculum should be procured, installed, and appropriately qualified or validated before teaching begins, particularly for foundational practical courses (Ahmed et al., 2020). Delayed access to essential instrumentation can restrict students' opportunities to develop fundamental laboratory skills and may compromise their ability to perform procedures accurately, safely, and independently (QAA, 2023). Advanced specialized equipment can be procured progressively based on specific learning outcomes and the program's evolving scientific niche.

3. Disconnecting Laboratory Facilities from Student Learning Outcomes

Faculty board ideally should avoid procuring laboratory equipment or finalizing facility layouts without first establishing a clear link to the program's intended graduate learning outcomes (*Capaian Pembelajaran*) and core competencies. Laboratory resources should therefore be mapped systematically to the knowledge, skills, and competencies that graduates are expected to achieve. One-size-fits-all laboratory environments may be insufficient to support an outcome-based education (OBE) approach, particularly when students are expected to acquire and demonstrate specific practical competencies (Scott et al., 2024).

5. HUMAN RESOURCES AND STUDY PROGRAM DEVELOPMENT

The BMS study program therefore depends heavily on building a multidisciplinary academic team with expertise spanning fundamental biological sciences, laboratory research, and translational biomedical science (IFBLS, 2022). Beyond the teaching team, dedicated and competent laboratory heads and technical staff are essential for maintaining laboratory operations, managing specialized equipment, supporting practical and research activities, and implementing appropriate biosafety procedures. A well-structured workforce not only strengthens the quality and safety of laboratory-based education but also supports the program's ability to meet graduate competency requirements and relevant accreditation standards (LAMPTKES, 2026c, 2026b).

The Do's: Needs-Based Recruitment: Securing Core Faculty and Specialized Laboratory Personnel

1. Recruit multidisciplinary lecturers for teaching team

Biomedical Science is an inherently broad and multidisciplinary field studied to investigate the mechanisms underlying human health, disease and potential healing mechanisms. Its scientific foundations encompass molecular biology, physiology, pharmacology and bioinformatics, reflecting various educational relevant background knowledge to conduct biomedical research as well as teaching all courses in BMS study program (Mitrou, 2025). Consequently, faculty recruitment should include biomedical related expertises such as molecular biologists, biomedical scientists, bioinformaticians, and other experts whose expertise aligns with the program's VMTS and curriculum. The lecturer's background knowledge should also encompass the core areas of laboratory medicine relevant to clinical laboratory practice, including pathophysiology, clinical cell biology, genetics, cellular pathology, clinical chemistry, medical microbiology, clinical immunology and some related fields (Bosch & Casadevall, 2017; Olaiya et al., 2022).

2. Invest in highly trained laboratory heads and technicians

Students should receive hands-on training in the operation of specialized laboratory equipment, such as thermal cyclers, microscopy systems, spectroscopy and data acquisition devices, to ensure

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accurate execution of experimental procedures and reproducible results. High-skilled biomedical laboratory staff are also necessary as part of the faculty. They are supposed to be trained to conduct laboratory analyses, design experiments, risk management and operate the high/advanced lab instruments (Abu-Siniyeh & Al-Shehri, 2021; AlShammari et al., 2021). Equally important is the availability of qualified laboratory heads and technical personnel who can manage and troubleshoot complex instrumentation while maintaining a safe, organized, and efficient laboratory environment in accordance with quality assurance requirements (Tun, 2017).

The Dont's: Compromise the Core: Avoiding Delayed Recruitment and Over-Reliance on Non Dedicated Lecturers or Laboratory Staff

1. **Don't wait until the program is established to recruiting lecturers from a broad field of study**

The curriculum should provide students with early and sustained exposure to a broad range of biomedical disciplines, ranging from foundational areas such as molecular-cell biology and genetics to bioinformatics and public health knowledge. Modern biomedical research is rapidly evolving through advances in artificial intelligence, computational biology, nanotechnology, and synthetic biology (Prayogo et al., 2026). Therefore, faculty expertise must evolve accordingly. Delayed recruitment of a multidisciplinary academic team may limit students' exposure to these rapidly developing fields and leave graduates without the breadth of scientific knowledge and complementary skills required to remain competitive in the contemporary biomedical workforce.

2. **Don't rely solely on non-dedicated lecturers or shared laboratory technicians**

Non dedicated lecturers, whether as physicians or simply as transient lecturers, typically have limited on-campus availability (Lee et al., 2022), which restricts their capacity to provide the continuous mentorship, hands-on laboratory troubleshooting, and iterative feedback that students require to achieve. While their contribution in several valuable expertises, excessive reliance on part-time teaching staff may fragment academic responsibilities, reduce continuity within the research and learning environment, and make it more challenging to maintain consistent assessment of students' practical competencies and research portfolios. Thus, this type of employment should be positioned as a complement rather than a substitute for permanent academic staff. Aside from that, the growing gap between technological demands and available technical expertise has increased the need for highly skilled and reliable technicians who can effectively implement the innovations across research and educational settings (DiGiovine et al., 2023). Consequently, it emerged as an important constraint on the development of biomedical research and education(Tang & Du, 2016). The absence of dedicated skillful laboratory technicians or diluting a technician's focus across multiple study programs increases the risk of deviation of laboratory's SOP implementation and leads to critical disruptions to the students' practical training timeline.

6. STRATEGIC PARTNERSHIPS AND RESEARCH ECOSYSTEM

Establishing a BMS study program requires a collaborative ecosystem that connects education, research, clinical practice, and industry. As a fundamentally translational discipline, Biomedical Science relies on strong partnerships with hospitals, clinical laboratories, research institutions, and biotechnology companies to connect foundational laboratory knowledge with real-world applications (QAA, 2023). Agreements should clearly define mechanisms for activities such as structured student internships in diagnostic laboratories, collaborative student–faculty research using partner facilities, and guest lectures or professional seminars delivered by practitioners from clinical and industry settings (Bosch & Casadevall, 2017). Importantly, external clinical and industry stakeholders should also participate periodically in curriculum review and evaluation (Al-Jubran, 2020). Engaging these stakeholders in curriculum development and enterprise-oriented learning can help ensure that the program remains responsive to emerging diagnostic technologies, research priorities, and workforce needs. The graduates also need both discipline-specific knowledge and transferable skills for varied

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careers (clinical labs, research, teaching, bioinformatics, drug development field and others) (Chatterjee et al., 2019).

The Do's: Establish early MoUs with relevant stakeholders for student internships and collaborative research.

A study on staff-student partnerships in undergraduate research projects found the student-supervisor relationship strongly shaped student experience and success (Scott et al., 2024). Another finding also indicates that internships can serve as valuable opportunities for career exploration and professional development, influencing participants' longer-term career aspirations (Chatterjee et al., 2019). Graduate students and postdoctoral researchers reported acquiring transferable knowledge and skills while also benefiting from industry mentorship, professional networking, and greater exposure to potential career pathways. To facilitate a smooth transition from undergraduate education to professional practice, BMS study programs should establish meaningful partnerships with relevant stakeholders from the early stages of program development. Formal agreements, such as Memoranda of Understanding (MoUs), can provide a framework for integrating authentic work-based learning opportunities, including clinical placements, internships, and industry-based training, into the curriculum.

The Dont's: Launch the Study Program Before Finalization of the MoUs

Institutions should avoid formally launching a BMS study program or admitting students before essential external partnerships and MoUs have been appropriately established. Informal arrangements or verbal commitments should not be relied upon to provide the clinical, research, or industry-based experiences required by the curriculum (LAMPTKES, 2026b). A robust BMS program benefits from sustained collaboration with external research facilities, hospitals, clinical laboratories, and industry partners, enabling students to gain authentic exposure to professional practice and specialized laboratory environments (QAA, 2023). Without adequate stakeholder commitment, the BMS study program may face limitations in providing good practical experiences and may struggle to demonstrate sufficient institutional and external support during accreditation and graduate employability assessments.

Table 2 provides a comprehensive synthesis of the key considerations for establishing an undergraduate Biomedical Science program. The recommendations are organized into best practices, common pitfalls to avoid, and the corresponding stages of implementation, offering institutions a practical framework for navigating the complex requirements related to program development, laboratory infrastructure, and accreditation readiness.

Tabel 2. Summary of Strategic Recommendations for Establishing a BMS Program

Aspect	**Best Practices (The Do's)**	**Common Pitfall (The Don't's)**	**Implementation Stage**
Curriculum and Identity	Define a unique scientific niche; align with KKNI level 6 and LAM-PTKes; focus on translational laboratory skills.	Replicate Medicine/Biology/Pharmacy curricula; draft generic vision/mission without stakeholder input.	**Stage 1:** Pre-establishment (Program conceptualization).
Laboratory Infrastructure	Secure mandatory foundational equipment before launch; ensure biosafety standard compliance; map facilities to outcomes.	Repurpose general science labs; delay procurement of core equipment; rely on shared basic facilities.	**Stage 2:** Facility preparation (Prior to student enrollment).

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Aspect	Best Practices (The Do's)	Common Pitfall (The Don't's)	Implementation Stage
Human Resources	Recruit multidisciplinary core faculty (molecular biologists, biomedical scientist, and soon); invest in highly trained lab technicians.	Rely heavily on transient lecturer or clinical practitioners; utilize non-dedicated or shared lab technicians.	**Stage 3:** Academic operational readiness.
Strategic Partnerships	Establish formal MoUs for internships, joint research, and involve partners in periodic curriculum evaluation.	Launch program relying on verbal agreements; isolate curriculum development from industry feedback.	**Stage 4:** Continuous quality improvement & execution.

7. CONCLUSION

The successful establishment of an undergraduate Biomedical Science (BMS) study program requires an integrated strategy that connects academic excellence and professional practice. Curriculum design should be grounded in outcome-based education and relevant national and international competency frameworks, with theoretical learning supported by appropriately equipped, compliant, and safely managed laboratory environments. Equally important aspects are dedicated and multidisciplinary core lecturers as well as laboratory technicians, and early-sustained partnerships with clinical, research, and industry stakeholders. These elements—curriculum, infrastructure, human resources, and external collaboration—should function as an interconnected foundation to complete administrative components. By aligning these pillars from the outset, institutions can strengthen accreditation readiness, build a productive research and learning ecosystem, and ultimately prepare biomedical science graduates with the technical, scientific, and translational competencies needed to contribute effectively to the evolving healthcare and biotechnology sectors.

The primary limitation of this study is its methodology as a narrative review. The recommendations presented are derived primarily from the synthesis of existing literature, international standards, and Indonesian regulatory frameworks rather than from empirical assessments or direct evaluations of established Biomedical Science programs in Indonesia. Future research should involve quantitative surveys or qualitative case studies of newly established Indonesian BMS study programs to empirically evaluate the effectiveness and implementation challenges of these guidelines.

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