



# An Interpretative Phenomenological Exploration of Ethical Experiences in Innovation among Early-Career Medical Biotechnology Researchers

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## ABSTRACT

Medical biotechnology is a rapidly evolving field that challenges conventional ethical and regulatory frameworks, particularly for early-career researchers. While technical advancements in this domain continue to accelerate, limited attention has been paid to how young scientists experience and make sense of ethical and institutional constraints during the innovation process. Despite existing policies and procedural guidelines, little is known about the subjective reflections of young researchers navigating these challenges—prompting the question: how do early-career scientists construct meaning within ethically ambiguous research environments? This study employs an interpretative phenomenological approach to explore the lived experiences of young biotechnology researchers facing regulatory and ethical uncertainty. Semi-structured interviews with eight participants were conducted at a major research-intensive university in Southeast Asia and analyzed thematically using IPA to uncover patterns of reflection and meaning-making. The analysis revealed four central themes: regulatory ambiguity, ethical tension, institutional limitation, and personal transformation. These themes highlight the emotional complexity and moral negotiations that shape how researchers perceive their roles in science and society. The findings suggest that beyond compliance, ethical identity formation is a dynamic and deeply personal process, influenced by institutional support and contextual uncertainty. This research expands our understanding of ethical experiences in scientific innovation and offers a foundation for future studies that seek to develop more human-centered regulatory and ethical frameworks.



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## INTRODUCTION

In the rapidly evolving landscape of medical biotechnology, young researchers are increasingly positioned at the forefront of scientific innovation. This field—encompassing the use of biological systems to develop health-related solutions for challenges such as genetic disorders and pandemics—presents not only transformative promise but also complex ethical terrain. However, the swift pace of innovation frequently outpaces the formulation and enforcement of robust ethical and regulatory guidelines, leading to tension between scientific advancement and institutional oversight.

For early-career scientists, this dissonance manifests in multifaceted uncertainty—extending beyond laboratory techniques to ethical ambiguities and inconsistent regulatory enforcement. In regions where policy infrastructures are underdeveloped or unevenly applied, these researchers often operate in liminal spaces, relying on personal judgment and informal mentorship in lieu of clear institutional directives. Thus, the pursuit of innovation in biotechnology is not merely a technical undertaking but a morally charged process shaped by institutional constraints, cultural values, and ongoing negotiations of professional accountability.

This phenomenon is not merely a procedural or institutional issue; it is fundamentally human. The subjective experiences of young researchers—marked by ethical dilemmas, emotional strain, and a constant need for self-reflection—have been largely overlooked in academic discourse. While previous studies have examined the structural challenges of biotechnology innovation, few have

explored how emerging scientists internalize and make sense of these challenges in their daily research practice.

There is, therefore, a critical need to understand the lived experiences of young biotechnology researchers within their socio-ethical environment. A phenomenological inquiry offers a suitable lens to explore how these individuals construct meaning from their involvement in a field marked by innovation, uncertainty, and ethical complexity. Such an exploration can contribute to a more human-centered understanding of biotechnology development, while also informing policies and institutional practices that support ethically responsible innovation.

Research into the lived experiences of individuals within ethically complex scientific fields has emerged as an important area of inquiry, particularly in the context of biotechnology innovation. As young researchers increasingly confront regulatory ambiguity and ethical uncertainty, there is growing recognition that their internal reflections and personal meaning-making processes are critical to understanding the broader challenges of responsible innovation. Exploring these experiences is essential not only for advancing ethical policy but also for shaping the moral and professional development of early-career scientists.

However, capturing the depth of such experiences presents notable methodological challenges. Conventional research approaches in biotechnology studies—often dominated by quantitative assessments or policy-level evaluations—tend to prioritize measurable outcomes over subjective understanding. These methods frequently overlook the emotional and cognitive dimensions of ethical decision-making, leaving a gap in how the scientific community comprehends the human cost and internal negotiations behind innovation under constraint.

This limitation renders many existing studies inadequate for fully understanding the essence of what it means to be a young researcher navigating conflicting demands of innovation, responsibility, and institutional pressure. A phenomenological approach, with its emphasis on individual perception, embodied experience, and contextual meaning, offers a more suitable pathway for accessing these underexplored dimensions. It allows for a richer and more authentic account of how researchers construct personal and ethical identities within environments marked by uncertainty and systemic limitation.

Existing efforts to address ethical and regulatory challenges in biotechnology development have largely relied on procedural, institutional, or policy-based approaches. These practical frameworks—such as compliance checklists, risk-benefit assessments, and standard ethical reviews—serve as the default mechanisms for guiding researchers through innovation processes. While useful, such approaches often assume uniformity in researcher understanding and overlook the nuanced, internal struggles that arise in real-world practice, especially among early-career scientists.

Moreover, studies that investigate the ethical dimensions of biotechnology innovation tend to adopt external or evaluative perspectives, using surveys or structured interviews to assess attitudes, knowledge, or behavior. Although these methods provide valuable baseline data, they fall short in capturing the emotional complexity, reflective thought, and personal dilemmas that shape how researchers make meaning of their ethical roles. As a result, current research presents an incomplete picture—one that neglects the internal realities of those directly involved in ethically sensitive scientific innovation.

This gap calls for a more immersive and reflective methodological approach. Phenomenology offers a compelling alternative by enabling the exploration of lived experiences in their full contextual richness. Rather than focusing on outcomes or decisions alone, phenomenological inquiry delves into how individuals experience, interpret, and assign meaning to those decisions. In the context of young biotechnology researchers, this approach allows for a deeper understanding of how ethical and regulatory environments are internalized, navigated, and transformed into personal and professional narratives.

Several studies have explored the ethical dimensions of biotechnology through policy analysis, risk perception surveys, or professional guidelines. For instance, Singh et al. (2020) examined the role of wearable health technology and its impact on autonomy, while Liao and Kim (2021) investigated

patient responses to immunotherapy protocols using interpretive phenomenological analysis. However, limited research has focused on the lived experiences of young researchers as they navigate ethical and regulatory uncertainty in real-world settings. Existing literature often fails to examine how early-career scientists reflect on their roles and responsibilities in the development of biotechnology products. This study addresses that gap by focusing on the subjective experiences and meaning-making processes of these individuals.

To explore these experiences, the study adopts an interpretative phenomenological approach. This method was chosen for its ability to uncover personal perceptions and emotional responses within complex professional contexts. Unlike standard qualitative methods, interpretative phenomenology highlights the evolving and contextual nature of meaning as experienced by individuals. The study responds to the need for a richer understanding of how young researchers interpret ethical and regulatory constraints not just as external systems, but as internal struggles and learning processes. Through this method, the essence of the phenomenon—being a young scientist in a constrained system—can be meaningfully captured.

The article is structured as follows. The introduction outlines the broader context of biotechnology research and presents the rationale for a phenomenological inquiry. The methodology section details the interpretative phenomenological design, participant selection, data collection, and thematic analysis procedures. The results section presents emergent themes supported by participant quotations. The discussion connects these findings to existing literature and theoretical insights, and the article concludes by reflecting on the implications for policy, education, and future research.

## **RESEARCH METHODS**

### **Study Design**

This study employed an interpretative phenomenological approach to explore the lived experiences of young researchers involved in the development of medical biotechnology products amid regulatory and ethical constraints. Phenomenology was selected as the methodological framework due to its emphasis on understanding the essence of subjective human experience within a specific context. The interpretative variant of phenomenology, rooted in the hermeneutic tradition of Heidegger, was particularly appropriate as it allows for the uncovering of layered meanings behind participants' reflections, enabling a deeper comprehension of how researchers make sense of their roles, challenges, and ethical dilemmas in innovation processes. This design facilitated a rich examination of the personal and professional meanings constructed around their engagement with biotechnology under conditions of regulatory ambiguity.

### **Participants**

Participants were selected using purposive sampling to ensure that individuals with direct and meaningful experiences related to the phenomenon were included. Eligibility criteria required that participants be early-career researchers (within their first ten years of research practice) actively involved in biotechnology-related projects within academic, clinical, or industrial settings. Participants were excluded if they had no prior engagement in ethical or regulatory aspects of biotechnology development.

The sample comprised eight participants (four males and four females) aged between 26 and 34 years, with an average age of 29. All had formal academic backgrounds in biotechnology, molecular biology, or biomedical sciences and had experience initiating or developing at least one medical biotechnology product in the past three years. This demographic diversity offered nuanced insights into the complexities encountered by young professionals at various stages of innovation.

### **Data Collection**

Data were collected through in-depth, semi-structured interviews designed to elicit reflective narratives from participants regarding their professional experiences. An interview guide was developed

based on the literature and aligned with phenomenological principles, allowing for flexibility in probing personal meanings and perceptions.

Interviews were conducted in quiet, private settings, either face-to-face or via secure video conferencing platforms, depending on participant preference. Each interview lasted between 60 to 90 minutes and was audio-recorded with participant consent. To ensure comfort and openness, interviews were preceded by a brief rapport-building session, and participants were assured of confidentiality. All interviews were transcribed verbatim, and identifiers were anonymized. The use of member checking was incorporated by offering participants an opportunity to review their transcripts for accuracy and clarification. To enhance trustworthiness, peer debriefing sessions were conducted regularly during data analysis to examine theme formulation critically. An audit trail was maintained to document analytic decisions, and thick description was employed to support transferability.

### **Data Analysis**

Data were analyzed using Interpretative Phenomenological Analysis (IPA), which involves a step-by-step examination of how participants make sense of their experiences. This process included repeated readings of the transcripts, identification of significant statements, development of emergent themes, and clustering of themes into broader conceptual categories.

Themes were developed inductively through close engagement with the data, with attention to both convergence and divergence in participant experiences. NVivo 12 software was used to assist in data management and initial coding organization; however, manual coding remained primary in guiding interpretative decisions. The analytic process was grounded in iterative reading, memo-writing, and theme validation through discussion among the research team. Through this iterative process, essential meanings and structural patterns were identified, revealing how young researchers construct and navigate meaning in the face of ethical and regulatory complexity.

### **Ethical Considerations**

Ethical approval was obtained from the relevant institutional research ethics committee prior to data collection. Written informed consent was obtained from all participants, who were informed of their right to withdraw at any point without penalty. Anonymity and confidentiality were maintained throughout the study by using pseudonyms and secure data storage. The research adhered to internationally recognized ethical standards for human subjects research, including the Declaration of Helsinki and local institutional guidelines.

## **RESULTS**

This section presents the lived experiences of young researchers in developing medical biotechnology products within the constraints of regulatory and ethical environments. The findings are organized into thematic categories that emerged through interpretative phenomenological analysis (IPA). Each theme reflects the subjective meaning and emotional dimensions that surfaced during the interviews. Participant quotations are used to strengthen the authenticity and contextual depth of the findings.

### **Navigating Uncertainty in Regulatory Ambiguity**

A dominant theme that emerged was the persistent sense of uncertainty experienced by young researchers when interpreting or applying regulatory frameworks. Participants described national and institutional regulations as either outdated or vague, especially in fast-evolving biotechnological domains.

"Sometimes, I feel like we are working in a gray zone—there's no clear rule for what we're doing, and that makes every step feel risky." (Participant 3)

This ambiguity often led to hesitation in decision-making and a heightened emotional burden, especially when ethical dilemmas were involved.

"We are trying to innovate, but the fear of violating something we don't fully understand is always there." (Participant 7)

These reflections indicate that beyond technical barriers, the perceived regulatory vacuum directly impacts the psychological confidence and ethical clarity of young innovators.

### **Ethical Tensions Between Innovation and Responsibility**

Participants expressed inner conflicts between the desire to push the boundaries of medical innovation and the responsibility to adhere to ethical norms. Many felt ethically isolated, lacking experienced mentors or ethical boards familiar with biotechnology-specific issues.

"I wanted to test a novel bio-agent, but even the ethics committee seemed unsure how to assess my proposal. It felt like they were evaluating from a pharmaceutical lens, not biotech." (Participant 1)

Some described this tension as emotionally draining, especially when patient-related applications were involved.

"There were moments when I questioned myself—am I innovating for science, or am I unintentionally harming by rushing things?" (Participant 6)

This theme highlights how ethical uncertainties are not just procedural issues but deeply affect the researchers' personal identity as scientists and moral agents.

### **Institutional Constraints and Lack of Infrastructure**

Another significant theme was the institutional unpreparedness to support biotechnological innovation. Participants recounted structural limitations such as limited access to updated bioethical training, absence of interdisciplinary collaboration platforms, and minimal regulatory advisory support.

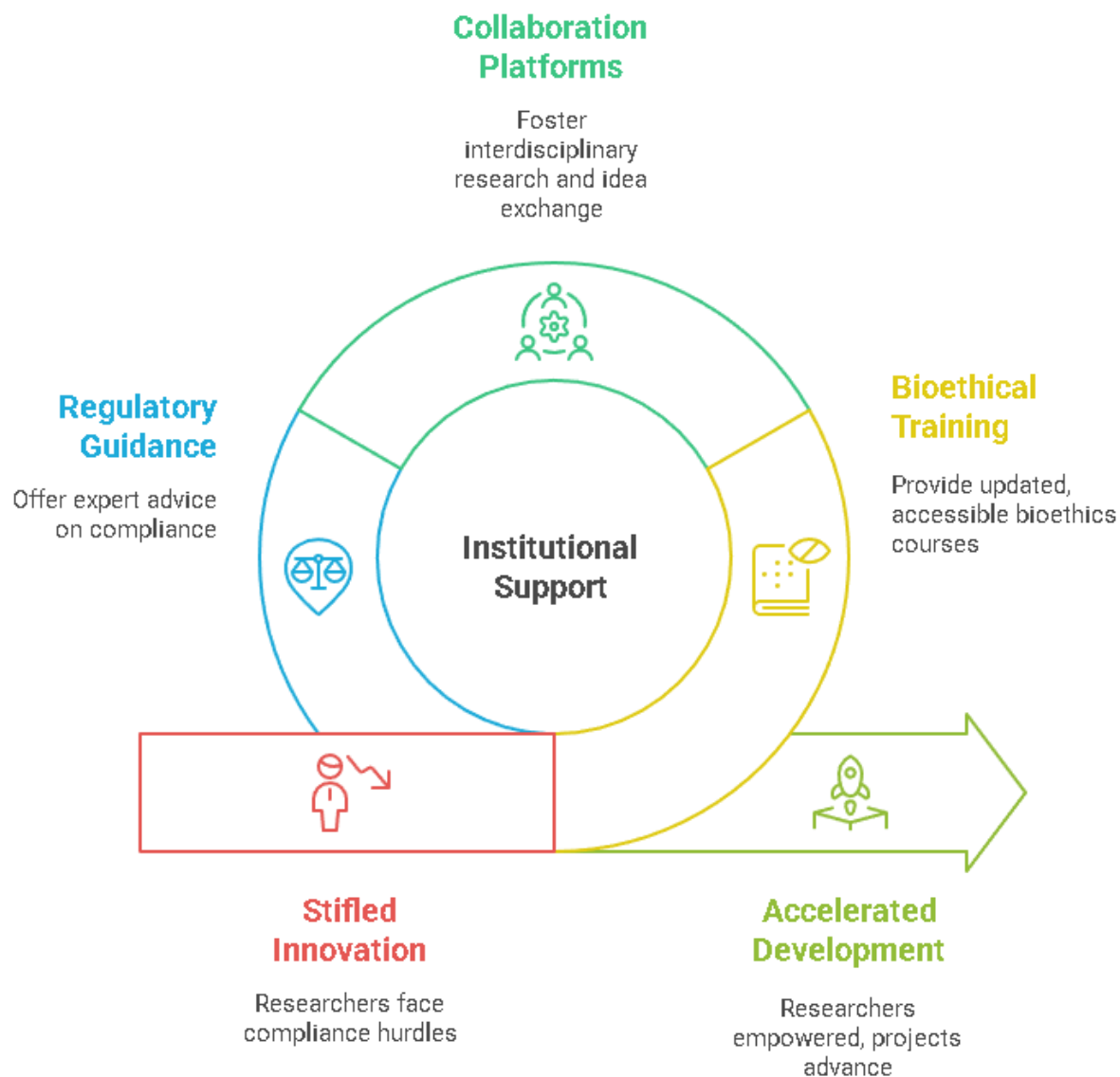
"Our campus encourages innovation, but there is no dedicated unit to help us understand the biotechnological compliance process. We're left to Google things on our own." (Participant 2)

This situation led to feelings of frustration and institutional disillusionment, especially among those attempting to commercialize their innovations.

"I had a ready prototype, but without legal or regulatory guidance, I felt paralyzed. It was like having wings but no runway." (Participant 5)

The lack of institutional scaffolding contributed to both stagnation in project development and emotional fatigue among young researchers.

### **Overcoming Institutional Barriers to Biotech Innovation**



### Personal Transformation Through Ethical Reflection

Despite the constraints, participants also shared moments of growth and personal transformation. Navigating complex ethical landscapes appeared to foster deeper critical thinking and self-awareness. Several participants described developing a stronger ethical compass and professional resilience.

"At first, I was frustrated. But over time, I realized that reflecting on ethical boundaries made me a more responsible scientist." (Participant 4)

For some, these reflections even shifted their research priorities toward more socially responsible innovation.

"Now I no longer ask what can be done, but what should be done—and that has changed everything about how I approach biotechnology." (Participant 8)

This theme illustrates how struggles with regulation and ethics can catalyze meaningful internal development, shaping a more ethically grounded scientific identity.

The results reveal a multidimensional experience among young biotechnology researchers: one marked by regulatory confusion, ethical tension, institutional limitation, and personal growth. Their reflections underscore a profound interplay between innovation and integrity, demonstrating how subjective experiences shape the trajectory of scientific development in ethically sensitive fields.

## **DISCUSSION**

The results demonstrate that young researchers do not passively comply with regulatory or ethical frameworks, but instead engage in an ongoing, reflexive process of negotiating responsibility and scientific identity. This finding aligns with the interpretative phenomenological framework, which emphasizes meaning-making as a dynamic, situated process.

The theme of ethical tension, for instance, is not merely descriptive of moral discomfort; it signifies a deeper internalization of responsibility. The participant who spoke of being in a “grey zone” exemplifies how ambiguity can prompt ethical introspection, rather than paralysis. Rather than being impeded by unclear norms, participants often used these situations as catalysts for ethical reasoning and professional growth.

Similarly, the experience of regulatory ambiguity did not simply indicate systemic dysfunction, but also highlighted the adaptive strategies employed by early-career scientists. The fact that participants navigated these gaps by building informal support networks underscores their agency and capacity for ethical resilience in uncertain environments.

The articulation of institutional constraints reveals not just external barriers, but a perceived misalignment between institutional priorities and ethical engagement. This suggests a need for more robust ethical infrastructures that recognize and support the lived complexities of researchers, rather than framing ethics as a procedural hurdle.

Finally, the theme of personal transformation illustrates how early-career researchers undergo identity shifts in response to ethical and regulatory challenges. This finding underscores the importance of fostering environments that encourage ethical reflection as a core component of scientific training, rather than an external or secondary concern.

Overall, this study contributes uniquely by revealing the emotional and existential dimensions of early-career research in biotechnology, which are often excluded from institutional discussions about ethics and policy. Through this phenomenological lens, the study answers the research question by illustrating how lived experiences provide insight into the deeper meanings behind ethical decision-making in scientific development.

The findings are consistent with prior research that highlights the limitations of procedural ethics in dynamic scientific contexts. For example, Yoon et al. (2022) emphasized the emotional responses of users navigating digital health technologies, while Liao and Kim (2021) explored patient confusion and adaptation during immunotherapy—both pointing to the need for interpretive, person-centered approaches. This study extends those insights to the perspective of scientists themselves, positioning the researcher not merely as an executor of protocols, but as a moral agent navigating uncertainty. In line with Heideggerian phenomenology, participants’ reflections echo the idea of “being-in-the-world,” where professional choices are shaped not only by systems but also by subjective meaning. By bridging personal narratives with broader ethical discourses, this study deepens current understandings of biotechnological innovation as an embodied and emotionally situated human experience.

The findings of this study have important implications for both the scientific community and institutional frameworks that support biotechnology research. From a social and professional perspective, the lived experiences of young researchers reflect a pressing need to reconsider how ethical responsibility is taught, facilitated, and supported within research institutions. The internalized struggles and moral reflections identified in this study suggest that current systems are insufficient in nurturing ethically grounded innovation. Integrating reflective ethical training, mentorship in regulatory navigation, and emotionally aware institutional support could empower early-career scientists to engage more confidently and responsibly with biotechnological advancement. These implications are particularly relevant in regions with emerging regulatory structures, where young professionals often bear the weight of navigating innovation in ethical isolation.

While the study offers rich insight into the subjective experiences of its participants, several limitations must be acknowledged. First, the sample size was limited to eight participants, all of whom were situated within academic and research-oriented contexts. This may restrict the applicability of findings to biotechnology professionals in industry or regulatory roles. Additionally, the interpretative nature of phenomenological analysis prioritizes depth over breadth, which limits the generalizability of results to broader populations. However, such limitations are characteristic of qualitative inquiry and serve to highlight the value of exploring meaning within context rather than seeking universal conclusions.

Future research could build upon these findings by expanding the scope of inquiry to include comparative studies across cultural or institutional contexts. Exploring how experiences differ between researchers in well-regulated versus under-regulated environments could illuminate structural factors that shape ethical agency in science. Moreover, longitudinal studies may provide deeper understanding of how ethical reflections evolve over time and influence career trajectories in biotechnology. These directions hold promise for advancing the human-centered study of innovation and fostering a more ethically engaged scientific community.

## **CONCLUSION**

This study explored the lived experiences of young researchers developing medical biotechnology products amid regulatory and ethical constraints. Using an interpretative phenomenological approach, the research uncovered key themes of uncertainty, ethical tension, institutional limitation, and personal transformation. These findings highlight how early-career scientists internalize complex external challenges and reflect critically on their roles and responsibilities in innovation. The study contributes a deeper understanding of ethical identity formation in scientific practice, addressing a gap in prior research that often overlooks subjective experiences. However, the study is not without limitations. The small sample size (eight participants) and focus on a single geographical and institutional context may affect the generalizability of the findings. These limitations point to the need for broader, cross-cultural investigations.

From a practical perspective, the findings underscore the importance of supportive institutional structures that integrate ethical reflection and regulatory guidance. More specifically, institutions should consider implementing structured ethical mentorship programs, embedding reflective training within research curricula, and developing accessible, context-sensitive ethical resources for early-career researchers. Future research may expand this inquiry across different cultural or institutional contexts to further enrich the understanding of ethical experiences in biotechnology and evaluate the effectiveness of such interventions.

## **CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest.

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