

Scenario Analysis Reveals How Generative AI Will Impact The Mental Health of Medical Students

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Submitted to: JMIR Medical Education
on: October 06, 2025

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Abstract

Background: Introduction: Generative artificial intelligence (AI) is rapidly transforming medical education, while medical students continue to face high levels of stress, anxiety, and burnout. This dual pressure stemming from technological disruption and psychological vulnerability raises urgent questions about the future of training physicians.

Objective: Introduction: Generative artificial intelligence (AI) is rapidly transforming medical education, while medical students continue to face high levels of stress, anxiety, and burnout. This dual pressure stemming from technological disruption and psychological vulnerability raises urgent questions about the future of training physicians.

Methods: We used scenario analysis, a foresight methodology, to explore possible futures at the intersection of generative AI and medical students' mental health. The exploratory scanning identified weak signals and emerging trends, which were clustered using a macro-meso-micro framework and interpreted through a multi-level perspective of socio-technical change. Scenarios were analyzed along two key dimensions: the extent of generative AI integration into medical curricula and the availability of mental health support.

Results: Four distinct scenarios emerged: Analogue Happiness (high support, low AI integration), Gen AI Paradise (high support, high integration), Disconnected Struggles (low support, low integration), and Gen AI Takeover (low support, high integration). Each illustrates different risks and opportunities for students' digital readiness and psychological well-being.

Discussion: The findings suggest that technological innovation and mental health support must co-evolve in medical education. Prioritizing one without the other risks producing either digitally unprepared or emotionally fragile physicians. Faculty readiness, ethical frameworks, and participatory curriculum design are critical to ensuring balanced integration. We formulated practical recommendations tailored to students, educators, and other stakeholders to guide balanced adaptation.

Conclusions: Generative AI is not an optional add-on but a transformative force, while mental health support is a prerequisite for competence. Institutions must rise to the dual responsibility of preparing students to become both digitally fluent and emotionally resilient. Failing to integrate these pillars constitutes not only a missed opportunity but an ethical failure with consequences for students, educators, healthcare professionals, and ultimately, patients.

(JMIR Preprints 06/10/2025:85373)

DOI: <https://doi.org/10.2196/preprints.85373>

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Original Manuscript

Scenario Analysis Reveals How Generative AI Will Impact The Mental Health of Medical Students

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Keywords: artificial intelligence, mental health, healthcare professionals, medical students, AI

ABSTRACT

Introduction: Generative artificial intelligence (AI) is rapidly transforming medical education, while medical students continue to face high levels of stress, anxiety, and burnout. This dual pressure stemming from technological disruption and psychological vulnerability raises urgent questions about the future of training physicians.

Methods: We used scenario analysis, a foresight methodology, to explore possible futures at the intersection of generative AI and medical students' mental health. The exploratory scanning identified weak signals and emerging trends, which were clustered using a macro-meso-micro framework and interpreted through a multi-level perspective of socio-technical change. Scenarios were analyzed along two key dimensions: the extent of generative AI integration into medical curricula and the availability of mental health support.

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Conclusions: Generative AI is not an optional add-on but a transformative force, while mental health support is a prerequisite for competence. Institutions must rise to the dual responsibility of preparing students to become both digitally fluent and emotionally resilient. Failing to integrate these pillars constitutes not only a missed opportunity but an ethical failure with consequences for students, educators, healthcare professionals, and ultimately, patients.

INTRODUCTION

At the beginning of the 21st century, the field of healthcare (HC) started to experience a cultural shift known as digital health. Digital health can be defined as the cultural transformation that occurs when disruptive technologies provide digital and objective data, accessible to both caregivers and patients, leading to an equal level of doctor-patient relationship with shared decision-making and the democratization of care^{1,2}.

Numerous studies have shown that the mental well-being of healthcare professionals (HPSs) and medical students (MSs) is poor, with high levels of stress, anxiety, and burnout being commonly reported²⁻⁵, even though their welfare would increase the quality of care, productivity, and patient satisfaction.⁶ Burnout usually increases gradually, with the highest levels typically occurring during the fourth year of medical school.⁷

Studies suggest that AI could bring relief to both the professional duties and academic challenges faced by HCPs and MSs by offering support in diagnostics, decision-making, data analysis, especially administrative tasks, improved consultations, personalized health guidance, medical record analysis, precision medicine, and custom treatment plans.⁸

Among various AI technologies, generative AI stands out due to its potential impact on the work of HCPs. Generative AI is the first form of AI to be used by hundreds of millions of people on a daily basis. It has attracted the attention of over 100 million users in only 2 months.⁹

The spread of generative AI has had a particularly significant impact on medical training, as it has fundamentally changed students' learning habits and called into question the legitimacy of traditional assessment methods.¹⁰⁻¹⁸ MSs experience these effects in diverse and highly individual ways.

Generative AI, represented by large language models (LLMs), has the potential to transform HC and medical education. In particular, the impact of generative AI on higher education can alter both students' learning experiences and faculty members' teaching practices.¹⁹

Generative AI tools, especially LLMs such as ChatGPT, are designed to create or generate new

content, text, images, or music from their trained parameters. With free access online and an easy-to-use conversational interface, ChatGPT quickly accumulated more than 100 million users within the first few months of its launch.^{20,21} New opportunities for learning, assessment, and research in medical education have sparked excitement, alongside concerns about the implications of cheating and plagiarism in assessments.¹⁵ Studies showed that these models excelled in many areas of medicine previously thought to be exclusive to humans, such as performing well on the United States Medical Licensing Examination, taking a patient history to build a differential diagnosis, diagnosing complex cases, and accurately answering patient questions. These preliminary investigations have shown that generative AI systems have the potential to be generalizable throughout many aspects of medical education, clinical decision-making, and the HC workflow.¹⁶ Concerns have been raised about ethical considerations and the decreased reliability of the existing examinations. Furthermore, in medical education, curriculum reform is required to adapt to the revolutionary changes brought about by the integration of generative AI into medical practice and research.^{19,22}

As future HCPs prepare for this new reality, they are already incorporating generative AI tools into their learning, which presents challenges for both students and educators, and it seems MSs show curiosity and openness to participate in training related to this field.²²

Both MSs and educators now require skills and competencies that were previously unnecessary. As more patients and HPs use AI-based tools, LLMs being the most popular representatives of that group, it seems inevitable to address the challenge of improving this skill.²³ How stakeholders will respond to this new situation remains to be seen.

The gap between what technology could do and what technology is actually being used for is rapidly widening. While many solutions are proposed to address this gap, clinician resistance to the adoption of AI remains high.²⁴

We have already demonstrated that although AI can support HCPs in numerous ways, many of them still approach it with fear and perceive AI as a potential threat rather than an opportunity. Their concerns include fear of job displacement, replacement, erosion of professional identity, and loss of expertise, losing control to AI, leading to deskilling and overreliance on technology, and they also dread the potential negative impact on doctor-patient relationships. It seems that the key to helping them successfully implement medical AI into their everyday practice is to address HPs' and MSs' concerns, which requires comprehensive training, ethical guidelines, and ongoing support.²⁵

With this study, we aim to contribute to helping stakeholders successfully adapt to these changes and effectively tackle the new kinds of challenges they face. We also aim to explore possible futures of medical education with a particular focus on the mental health of MSs. More specifically,

we examine how the mental well-being of MSs may be affected by the changes introduced through the integration of AI into medical education. To assess this, we apply a futures research method, scenario analysis (SA), a well-known method in foresight. It helps to discover possible future scenarios based on key driving forces and major uncertainty ties.

SA is rooted in the structured construction of unique and complex scenarios, and allows organizations to build coherent narratives about possible developments. A scenario is a 'story' or a narrative illustrating visions of possible futures.

This approach diverges from the concept of a single "most likely future" and instead considers multiple alternative futures.

The scenario approach, originating from the idea of a "script," can be likened to versions of literary works adapted for stage or screen. Much like a repertory theater, where it is unclear which play will be performed, we prepare for multiple possibilities and interpret the situation from subtle cues to determine which one is unfolding. In essence, scenario building is a way of rehearsing the future in advance. For scenarios to be effective, they must be believable, coherent/logical, and insightful about the future, so they can contribute to decision-making.²⁶

METHODS

Exploratory scanning

This study employed a qualitative foresight methodology to explore the potential futures of medical education, with a focus on MS's mental health and the integration of generative AI. The research process began with structured exploratory scanning, based on a literature review in the PubMed database. Environmental scanning is the process of systematically exploring and interpreting relevant external information to identify potential opportunities, threats, trends, and emerging issues that may affect future planning or decision-making.²⁷ Environmental scanning is widely applied in foresight research and HC strategy, especially when aiming to identify weak signals and emerging trends. Weak signals are ambiguous early indicators of possible but not certain changes that may become significant in the future.²⁸

Emerging trends, in contrast, are patterns of change that are becoming increasingly visible and coherent across time and domains. They have more support in the present and suggest a directional shift that is gaining momentum.²⁹

Environmental scanning provides a broader lens than formal reviews, making it well-suited for the exploratory nature of SA. For example, the World Health Organisation's Global Health

Foresight program uses environmental scanning to identify early indicators of potential health system disruptions.

To effectively navigate the existing literature, we formulated the following three guiding questions: What are the main applications and emerging directions of generative AI in medical education? What do we know about the global state of MS' mental health? And finally, have any studies previously examined the intersection of these two areas?

The literature search was conducted using the following queries: (1) (medical education[Title/Abstract]) AND (generative artificial intelligence) [Title/Abstract]), (2) (medical students Title/Abstract]) AND (mental health [Title/Abstract]), and (3) (medical education [Title/Abstract]) AND (generative artificial intelligence [Title/Abstract]) AND (mental health [Title/Abstract]).

We deliberately relied on PubMed as a robust and authoritative source to explore the phenomenon, and therefore did not convene separate foresight workshops at this point.

This was an exploratory phase aimed at gaining a general understanding of the field and identifying recurring patterns in medical education. From these recurring patterns, we identified a set of emergent phenomena that illustrate early signs of transformation at the intersection of generative AI and student mental health in medical education.

The identification and clustering of these phenomena followed a macro–meso–micro framework adapted from established conceptual models in health systems research.³⁰ This allowed us to organize the findings according to their level of structural impact, from broad systemic trends to institutional dynamics and individual-level experiences.

To ensure analytical robustness, we only selected phenomena that were supported by at least three independent and credible sources. In this study, we define phenomena as early, identifiable patterns, dynamics within medical education that reflect the emerging influence of generative AI. These are not merely isolated observations, but conceptually meaningful trends that have appeared across multiple credible sources.

Drawing on the logic of environmental scanning and futures studies, these phenomena represent early indicators, known as "weak signals," of potential systemic transformation. Each selected phenomenon points to an area where change is already underway and may accelerate.

By defining and clustering these phenomena, we aim to build plausible scenario narratives and anticipate future needs, risks, and opportunities. In total, we identified five macro-level, five meso-level, and seven micro-level phenomena, which were categorized and analyzed based on their thematic focus and level of impact (macro, meso, or micro). For this, we used a multi-level

conceptual framework. The identified phenomena, along with their brief descriptions and supporting references, are presented in the supplementary material.

Multi-Level Framework

A conceptual framework is a network of interlinked concepts that provides a comprehensive understanding of a phenomenon or problem by organizing and structuring related ideas and relationships in a coherent way. (Jabareen et al) Several studies in healthcare previously used this conceptual framework and have supported it with a micro-, meso-, and macro-level analysis, so we followed the same path.^{31–33}

To further structure and interpret the identified phenomena, we applied a Multi-Level Framework, which conceptualizes socio-technical change across three analytical levels: macro (landscape), meso (regime), and micro (niche). This approach draws on the foundational work of Geels and colleagues: the typology of transition pathways³⁴, the articulation of multi-level dynamics³⁵, and a critical review and theoretical refinement of the Multi-Level Framework³⁶. This approach helped us map and connect the relevant concepts, and served as a guiding analytical lens to interpret their interaction and evolution across levels of the HC system.

Preparatory Stage and Scenario Analysis

This approach allowed us to map the landscape of relevant research with clarity and accountability, serving as a robust foundation for subsequent SA. This structured and multi-validated selection process provided a strong foundation for identifying key trends, driving forces, and critical uncertainties used in our SA. To create a detailed scenario analysis, we followed five well-defined steps.

First, in the Preparatory Stage, we defined the scope and time horizon. The scope is the transformation of medical education driven by generative AI and the mental health status of students. Given the rapid pace of technological development, we set a time horizon of five years.

Second, we identified key driver and uncertainty. Key drivers are the primary factors or forces that have a significant influence on the outcome of future developments, such as technological advancements, economic trends, societal changes, environmental conditions, and political shifts. Uncertainties are elements or events that are unpredictable and have the potential to significantly impact future outcomes, as the direction or impact is unknown. We analysed possible scenarios, and while doing so, we assigned descriptive titles to each of them.

We created four distinct scenarios by combining the key driver and uncertainty. After all that,

in the fourth step, we analyzed the implications of each scenario and identified opportunities and threats associated with each. The entire methodology process is shown in the flowchart below.

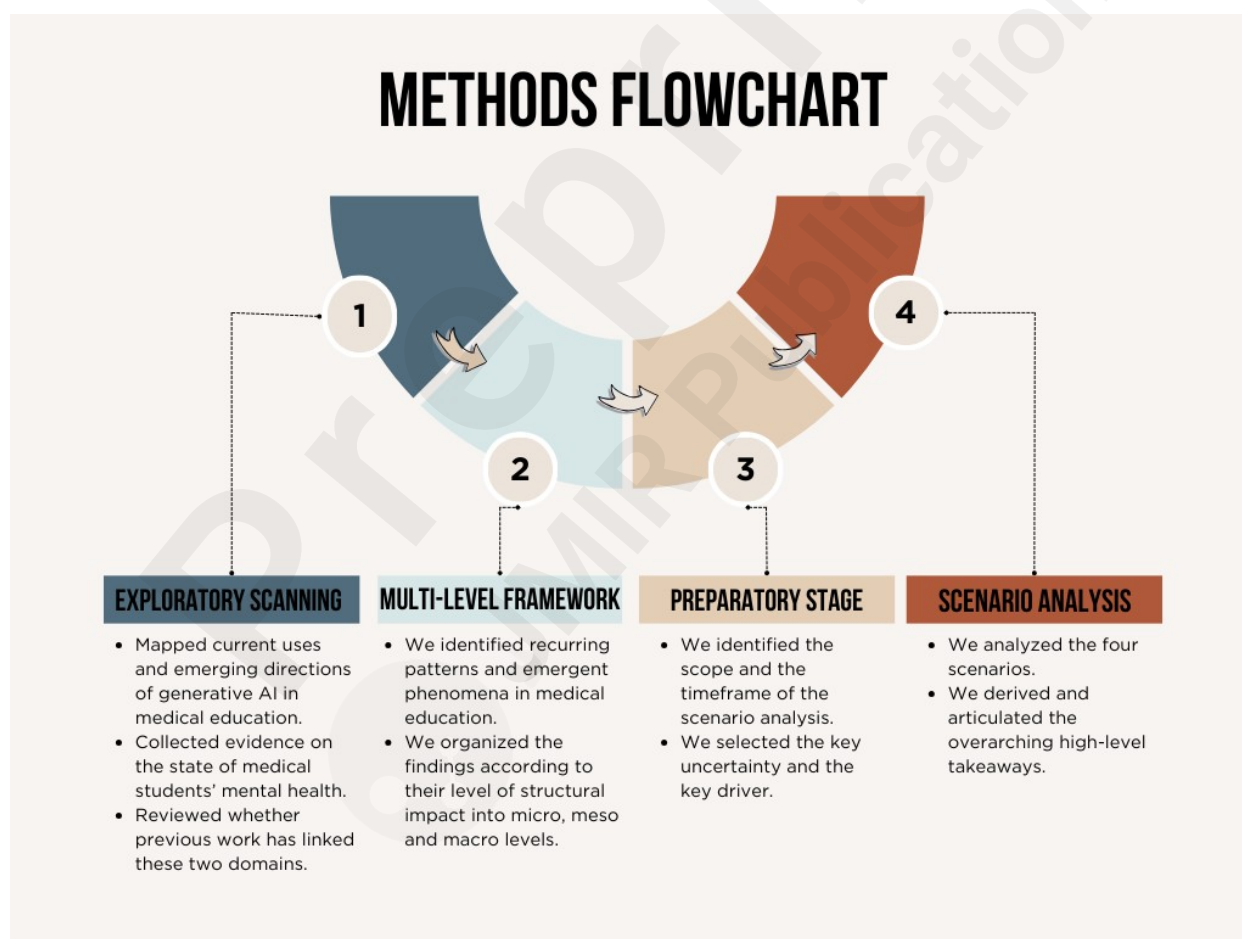


Figure 1

RESULTS

3.1 Exploratory scanning

Out of the three guiding questions we formulated in the Introduction, the results for our first guiding question regarding AI applications in medical education reflect a well-researched and rapidly evolving field.. This is evidenced by the fact that a search in the PubMed database using the query (medical education[Title/Abstract]) AND (generative artificial intelligence[Title/Abstract]) yielded 745 results, which increased to 841 in just three months. Yet, most papers highlight the need for further research to explore the effectiveness of generative AI applications in medical education.¹³

Generative AI is increasingly used to support MS's learning journeys, providing personalized experiences and improved outcomes.

Generative AI, especially ChatGPT, is readily available, with its free versions, and is already changing medical education. Boscardin et al. even introduce a generative AI literacy framework, offering considerations for potential impacts and opportunities to optimize the integration of generative AI for admissions, learning, assessment, and medical education research. This helps medical educators navigate and plan for this new environment. As generative AI tools continue to expand, educators need to increase their AI literacy through education and vigilance regarding new advances in the technology, serving as stewards and coaches of generative AI literacy to foster social responsibility and ethical awareness around AI use.¹⁵

Preiksaitis et al conducted a scoping review, and the thematic analysis revealed diverse potential applications for generative AI in medical education, including self-directed learning, simulation scenarios, and writing assistance. However, the literature also highlighted significant challenges, such as issues with academic integrity, data accuracy, and potential detriments to learning. Based on these themes and the current state of the literature, they suggested the following three key areas for investigation: developing learners' skills to critically evaluate generative AI, rethinking assessment methodologies, and studying human-AI interactions.^{14,37}

Sian Chang et al identified three primary uses of generative AI in medical education: learning support (n=32), assessment of students' learning (n=4), and curriculum review (n=1). The main reasons for its use are its ability to provide feedback and a guided learning pathway, and to decrease costs. Subgroup analysis revealed that medical undergraduates are the primary target audience for generative AI use. In addition, 34 articles described the challenges of implementing generative AI in medical education, with two main reasons identified: the difficulty in assessing the effectiveness of generative AI in medical education and the technical challenges encountered while developing applications.³⁷

The increasing use of generative AI in medicine has raised ethical concerns, such as patient autonomy, bias, and transparency. Many of the recent studies suggest a need for teaching AI ethics as part of medical curricula.³⁸ (Weidener et al)

The second guiding question we asked was what we know about students' global mental health. This also proved to be an area of strong scientific interest. The search query (medical students[Title/Abstract]) AND (mental health[Title/Abstract]) in the PubMed database yielded 1,963 records.

Nair et al found that students' mental health concerns can manifest in several forms. MSs juggling a multitude of trials (i.e., intense academic rigor, financial debt, sleep deprivation, lack of control, continual exposure to sickness and death, and training mistreatment) can help explain the higher prevalence of psychological disorders within this population. These mental health difficulties are not static; it seems certain challenges move into the forefront as students face key transition points during their education. Primary examples include the entry year of medical school, the shift from preclinical curriculum to clinical training, and the final moments prior to beginning residency. The authors concluded that the COVID-19 pandemic has exacerbated the stress, anxiety, and depression associated with medical education. They emphasize that solutions do indeed exist to address the moral injury MSs face, from expanded crisis management training and implementation of peer support networks to destigmatization of and improved access to professional mental health resources, and it depends on the curators of the medical education system to realize them.³

Sleep deprivation seems to be a huge concern. It has been previously shown that a high percentage of medical students have sleep problems that interfere with academic performance and mental health. In Perotta et al's study, MSs who reported more sleep deprivation showed significantly greater odds ratios of presenting anxiety and depression symptoms and lower odds of good quality of life or perception of educational environment.³⁹

According to Backovic et al, medical studies bring many stressful activities to students. Prolonged stress can have adverse effects on mental health and lead to further professional burnout. Studies across different countries have consistently demonstrated high rates of several psychiatric disorders among MSs.⁴

Studies suggest that mental health worsens after students begin medical school and remains poor throughout training. On a personal level, this distress can contribute to substance abuse, broken relationships, suicide, and attrition from the profession. On a professional level, studies suggest that student distress contributes to cynicism and may subsequently affect students' care of patients, relationships with faculty, and ultimately the culture of the medical profession.⁴⁰

According to Watson et al, MSs' suicide is likely related to both social and environmental

factors. Structural systems in medical schools may play a role, including curricula, accommodations, social support, and academic pressures. Interpersonal factors that may be implicated include social isolation, the competitive nature of learning, and being away from home at an early age. There may also be endemic factors unique to medical training, such as simulation training, working with cadavers, and witnessing trauma throughout placements. The socio-cultural environment, for example, the role of ragging, expectations from teachers, and patients, may place extra pressure on vulnerable students. Rates have been shown to be higher among females, which raises further discussion on the nature of gender roles and gender role expectations within medicine.⁴¹

Worldwide, medical schools have responsibilities to respond to concerns about students psychological, social, and physical well-being, but guidance for medical schools is still limited.⁴²

Depression among MSs may be undertreated. Medical schools can assist depressed students by addressing issues such as the stigma of using mental health services, confidentiality, and documentation. Early treatment of impaired future caregivers may have far-reaching implications for the individual students, their colleagues, and their future patients.⁴³

Despite all these potential issues, MSs often don't seek professional help because they fear it might put their professional identity at risk. There is an underlying expectation that medical students should be invulnerable. According to Hankir et al., MSs and doctors have low levels of help-seeking for their own psychiatric problems, often only presenting to MH services once a crisis arises. Fear of exposure to stigmatisation is a crucial factor contributing to symptom concealment and is a barrier to accessing mental health services.⁵

Autobiographical narratives of the 'Wounded Healer' are gaining popularity among MS and doctors with mental health challenges, both as an effective form of adjunctive therapy and as a means to campaign against stigma. The results of a randomised controlled trial to assess the efficacy of Coming Out Proud with mental illness revealed immediate positive effects on stigma and stress-related variables.⁴⁴

According to Dederichs et al, as many MSs in need don't seek help, easily accessible interventions are required. Several evidence-based internet- and mobile-based interventions (IMIs) have been proposed; they were curious about MSs' attitudes toward them. MSs valued IMIs for their low-threshold and flexible access, their potential to bridge waiting times, and as a first step towards face-to-face therapy. However, medical students preferred face-to-face interventions in case of severe mental health problems. Their results show an overall positive view regarding IMIs for mental health promotion, but concerns regarding their use for severe mental disorders and acute crises. These findings indicate that IMIs may represent promising tools for stress prevention and early

interventions for MSs. It's important to mention that students explicitly stated to prefer quality-approved IMIs recommended and provided by their university.²²

The growing presence of medical influencers on platforms like TikTok and Instagram has introduced a new kind of voice into conversations around mental health in medical education. Although they are not necessarily tied to formal institutional structures, they are still part of the professional community, speaking both to the public and to insiders, such as MSs and residents. Their content is more than just personal storytelling; it also helps shape norms. By addressing how mental health should be approached during training, what it means to maintain physical and emotional well-being, and what kind of expectations might be placed on institutions, they influence how students think about their education and their future profession. In this way, they contribute indirectly to the broader culture and practices of medical institutions.

At the same time, their influence on the individual level is significant. Their messages often resonate emotionally with students, offering reassurance, relatability, and even practical advice. Statements like “you’re not alone” or “I’ve been through this too” serve as both support and informal guidance. Many students find this kind of communication more authentic than official messages from universities or healthcare organizations. Because of this dual impact—both cultural and personal—these influencers might be understood as digital intermediaries or boundary spanners, operating between the institutional and individual levels. They don’t just produce content; they help bridge the gap between the system and the people within it. As I write these lines, Jake Goodman has 1.2 million followers on TikTok; his most-viewed video has reached 2.1 million people. He has spoken at the White House and delivered a TED Talk. He spoke openly about the MH crisis in medical training, highlighting the alarming rates of depression among students, the persistence of 24-hour shifts, and how the fear of speaking out, due to potential retaliation, continues to block meaningful change.

On Instagram, numerous coaches present themselves as business mentors, specifically teaching HPs how to avoid burnout by working part-time and building a side hustle. Numerous influencer similarly focuses on helping HPs create and sell online courses, also as a strategy to reduce workload, increase income, and prevent burnout.

This phenomenon is gaining increasing acceptance and popularity, offering a genuine alternative perspective for HPs seeking balance and sustainability in their careers. However, while these new paths gain momentum, the profession as a whole continues to struggle with a severe workforce shortage, placing even greater pressure and expectations on those who remain in full-time clinical roles. The reality is that either the system must train and retain significantly more physicians, or the

profession must be made more appealing and enjoyable again. This would require creating humane working conditions and restoring a sense of purpose and dignity, starting from medical training itself. Medical AI offers a promising opportunity in this regard, as discussed in our previous article.²⁵

The result of searching for the third guiding question-the intersection of the previous two topics-does not appear to be a particularly well-explored area. The following search- ((medical education[Title/Abstract]) AND (generative artificial intelligence[Title/Abstract])) AND (mental health[Title/Abstract]) - yielded 12 results, with a few specifically focused on MSs. Its investigation remains largely open, offering an opportunity for original contribution. It is, however, worth noting a few preliminary mentions in the literature.

Qinying et al's findings indicate that medical postgraduate students have a higher level of awareness in using generative AI than undergraduate students. The intention to use it is positively associated with factors such as performance expectancy, habit, hedonic motivation, and trust. Therefore, medical education should prioritize promoting students' performance in training, and courses should be designed to be both easy to learn and engaging, ensuring that students are equipped with the necessary skills to succeed in their future medical careers.¹¹

Thesen et al introduced a novel precision well-being framework for medical education that is built on a comprehensive and individualized view of mental health, combining measures from mental health and positive psychology in a unified, data-driven framework. Unsupervised machine learning techniques commonly used in precision medicine were applied to uncover patterns within multidimensional mental health data of 3632 MSs. Clusters were formulated based on recognized metrics for depression, anxiety, and flourishing. The analysis identified three distinct clusters. Membership in the 'Healthy Flourishers' well-being phenotype was associated with no signs of anxiety or depression while simultaneously reporting high levels of flourishing. Students in the 'Getting By' cluster reported mild anxiety and depression and diminished flourishing. Membership in the 'At-Risk' cluster was associated with high anxiety and depression, languishing, and increased suicidality. Nearly half (49%) of the medical students surveyed were classified as 'Healthy Flourishers', whereas 36% were grouped into the 'Getting-By' cluster and 15% were identified as 'At-Risk'. Findings show that a substantial portion of MSs report diminished well-being during their studies, with a significant number struggling with MH challenges.

Thesen et al's precision well-being framework represents an integrated empirical model that classifies individual medical students into distinct and meaningful well-being phenotypes based on their holistic mental health. This approach has direct applicability to student support and can be used to evaluate the effectiveness of personalized intervention strategies based on cluster membership,

also providing an example of how AI can be used to support MS's mental health.⁴⁵

While reviewing the literature, we found only two studies that use SA to explore the future of medical education, and one that used scenario planning. The first study used ChatGPT to develop the scenarios, the second examined the future of midwifery practice in Antwerp, and the third aimed to explore the potential of scenario planning to bridge the understanding gap and frame strategic planning for interprofessional education and practice, as well as to implement innovative techniques and technologies for large-group scenario planning.

Knopp et al employed generative AI to develop the scenarios. OpenAI's GPT model created 4 worlds: AI Harmony, AI Conflict, The World of Ecological Balance, and Existential Risk. Risks include disinformation and misinformation, loss of privacy, widening inequity, erosion of human autonomy, and ethical dilemmas. Benefits involve improved efficiency, personalized interventions, enhanced collaboration, early detection, and accelerated research.⁴⁶

The second study explored the future of midwifery praxis using structuration theory and intuitive logics scenario planning methods to structure contextual midwifery scenarios. Three scenarios described the plausible future of midwifery: (a) midwife-led care monitoring maternal health needs, (b) midwife-led holistic care, and (c) midwife/general practitioner-led integrated maternity care. (Bleijenbergh et al.) In the third study, they organised a full-day scenario planning workshop where an innovative methodology was designed and offered to participants. The 71 participants included academics from nine universities, as well as service providers, government, students, and consumer organisations. The outcomes were evaluated through statistical and thematic analyses of a mixed-methods survey questionnaire. They concluded that the scenario planning method can be used by tertiary academic institutions as a strategy in developing, implementing, and embedding IPE, and for the enculturation of IPP in practice settings.⁴⁷

3.2 Phenomena identified

Having addressed our three guiding questions and examined how different studies have approached SA in medical education, the next step was to synthesise what these diverse findings reveal about the underlying forces shaping the field. To do this, we shifted our focus from the level of individual studies to the broader patterns that emerged across the literature. Based on our literature scanning, we identified the phenomena, which can be weak signals or trends, and we classified the observed phenomena into micro, meso, and macro levels based on a conceptual framework.

At the macro level, we are dealing with broad, societal forces that shape medical education but cannot be directly influenced by individual participants. These include overarching factors that

determine what is considered possible and acceptable in the future of medical training. This is where technological pressures and shifting societal expectations emerge most clearly.

The meso level is at the institutional level, where the majority of structural transformations occur. It focuses on changes taking place within medical faculties and educational systems,

Here, we can examine how universities are responding to the presence of generative AI and its impact on students. This is the domain of institutional resistance or adaptation of generative AI, and this is where we can examine how it takes space and shapes the professional norms. In our previous work, we summarized the currently available AI-related courses.²⁵

An important part of these changes includes the increasing openness around MH: what was once taboo is now openly discussed, often promoted by physician-influencers on platforms like TikTok and Instagram. While the fact that these topics can be talked about at all may stem from macro-level shifts, the institutional embrace of these conversations clearly belongs to the meso level.

At the micro level, we see the most immediate and personal impact of AI, as experienced by individuals. This includes the tools that MS use in their daily routines, changes in their learning strategies, and, crucially, their mental health. It also involves the coping mechanisms they adopt and how they experience the medical school years on a personal level. A summary table of the phenomena, along with the list of supporting articles, can be found in the supplementary materials. Figure 1 provides a summary of the phenomena occurring at the three levels.

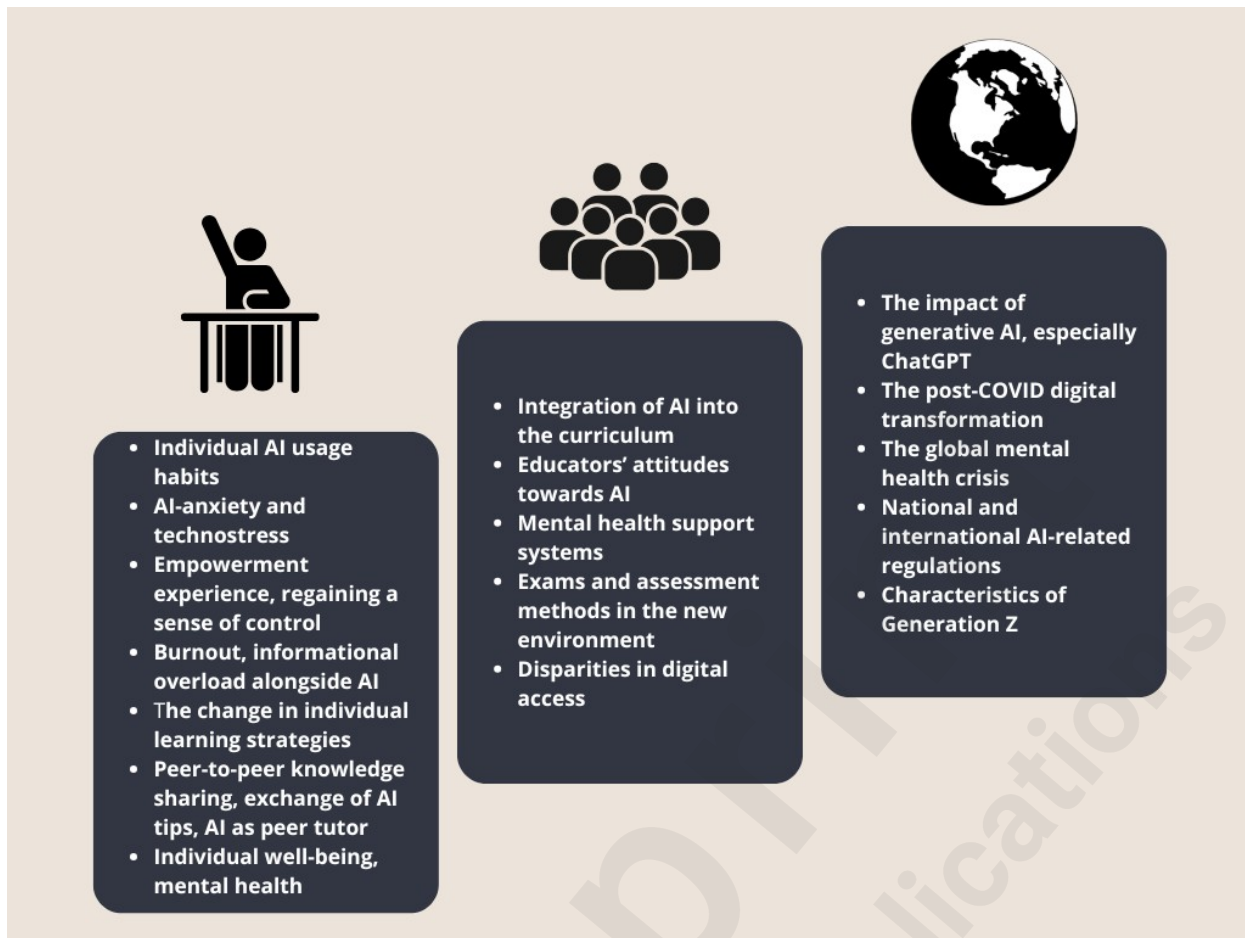


Figure 2

This structured and multi-validated selection process provided a strong foundation for identifying key trends, driving forces, and critical uncertainties used in our SA. These scenarios are grounded in current trends and incorporate phenomena highlighted in the framework. Following an in-depth analysis, we identified a key driver and an uncertainty to help us create the scenarios.

This involves defining the scope, the time frame, the key driver, and the main uncertainty, based on which we developed the scenarios.

All four scenarios share a common scope: the transformation of medical education driven by generative AI and the mental health status of students. Given the rapid pace of technological development, we have set a five-year time horizon, projecting the scenarios to the year 2030.

This time horizon reflects both the rapid evolution of generative AI technologies and the urgency of mental health challenges among MSs. Innovations such as multimodal AI agents,

personalized learning platforms, and AI-assisted assessment tools are already being piloted in several institutions, suggesting that large-scale educational disruption is not only possible but imminent.²³ Simultaneously, student mental health has become a widely recognized crisis requiring near-term interventions.^{2-5,44,48} Therefore, we chose a five-year time frame that offers both relevance and feasibility for building the scenarios.

3.3 Driver and uncertainty selection

We identified the extent of generative AI integration into curricula as the key driver, and access to mental health support as the key uncertainty. These emerged from the multi-level conceptual framework as the phenomena with the most far-reaching impact, best describing and shaping the field. To strengthen the validity of our choices, the selection was subsequently reviewed by an independent expert.

The key driver and the uncertainty were selected because they both represent high-impact factors. The first concerns not only technological feasibility, but also faculty acceptance, ethical considerations, and curricular redesign. The latter reflects systemic variability in institutional capacity, stigma, funding, and cultural attitudes toward psychological care. Our choices were grounded in the conceptual framework and supported by at least three independent high-quality sources each, highlighting their significance as phenomena with system-wide influence.

This methodology serves to map the evolving landscape and provide a coherent foundation for building plausible scenarios.

3.4 Scenario descriptions

SCENARIO 1: Analogue happiness

Key driver: Integration of generative AI into medical curricula is low.

Uncertainty: Access to the MS support system is high.

In the first scenario, there is high access to the MS support system, but the integration of generative AI into medical curricula is low.

We named this scenario “Analogue happiness”. Institutions prioritize the mental health of MSs. Inspired by research highlighting the importance of accessible mental health services (Moutier et al), universities invest in comprehensive support infrastructures. Mental health is openly discussed, and stigma around it has significantly decreased, influenced by broader cultural shifts and the visibility of physician-influencers advocating for the mental well-being of MSs.

As there is a strong institutional focus on supporting MSs’ psychological well-being, they aim to address a wide range of needs. Accordingly, both professional mental health services and peer-led support initiatives are available, as shown in Hale et al’s study.⁴⁹ In this study, a peer-led, virtual workshop series designed specifically for and by MSs seemed to be a feasible and effective method to improve student well-being, reducing measures of stress, anxiety, and depression in MSs. On the professional side, when psychiatrists provide mental health treatment to MSs, they are well aware that it is important to consider transference and countertransference issues, over intellectualization, and instances of strong idealization and identification.⁴⁸

However, the use of generative AI remains marginal. Faculties are hesitant, citing ethical concerns and a lack of guidance.⁵⁰ Curricula rely on traditional methods. MSs use AI informally, but this use is inconsistent and sometimes ethically ambiguous.²¹ Without clear institutional direction, the inappropriate usage of generative AI leads to missed opportunities in personalization and innovation. Students may be emotionally supported but lack digital readiness. Educational inequities may grow between digitally progressive and resistant institutions. In Alkhaadi et al’s study, surveyed MSs had minimal formal and informal experience with AI tools and limited perceptions of the potential uses of AI in health care, but had overall positive views of ChatGPT and AI and were optimistic about the future of AI in medical education and HC.²¹ With structured curricula and formal policies and guidelines, it would be possible to adequately prepare MSs for the forthcoming integration of AI in medicine, so this scenario is the future of missed opportunities.

SCENARIO 2 : Gen AI Paradise

Key driver: Integration of generative AI into medical curricula is high.

Uncertainty: Access to mental health support is high.

In the second scenario, both access to mental health support and integration of generative AI into medical curricula are high. We referred to this scenario as “Gen AI Paradise.” This scenario represents a future in which medical education institutions have both embraced generative AI and prioritized student mental well-being. AI tools are deeply integrated into all levels of the curriculum, guided by international best practices and ethical standards^{19,51}

Students are not only taught how to use generative AI tools for research, simulation, and diagnostics, but also how to critically reflect on their implications, thus building strong AI literacy. In this future, educators consciously design the integration of generative AI into the curriculum based on research findings such as the study by Shimizu et al, which provides an in-depth analysis of the impact of generative AI on medical education curricula and proposes reform strategies. The authors use SWOT analysis and identify three main learning approaches: "learning about GenAI," "learning with GenAI," and "learning beyond GenAI. The study emphasizes the importance of teaching the ethical use of GenAI, the benefits of adaptive learning, and the continued value of non-substitutable skills such as communication and clinical experience.¹⁹ MSs also utilize generative AI tools as virtual patient and clinical decision-making tutors.⁵²

At the same time, robust mental health support services are in place, tailored to the psychological needs of MSs who experience learning and stress differently than previous cohorts. The specific design of mental health support systems is also grounded in empirical research, like the study by Duan et al, which outlines key strategies for student-centered, stigma-free MH services in medical schools.

They analyzed MSs’ perceptions, trust, and attitudes toward generative AI in medical education, and explored their willingness to integrate generative AI in learning and teaching practices. The majority of participants reported familiarity with generative AI concepts, whereas only 43.5% had an understanding of generative AI applications specific to medical education. In this ideal future, decision-makers also take into account age- and gender-related differences, ensuring that support systems and educational strategies are responsive to the diverse needs of students. Postgraduate students exhibited significantly higher levels of awareness of generative AI tools in medical contexts compared with undergraduate students. Male students showed more enthusiasm and higher engagement with AI technologies than female students. Female students expressed greater concerns regarding privacy, data security, and potential ethical issues related to generative AI in medical education than male students. Male students or postgraduate students showed stronger behavioral intentions to integrate these tools in their future learning and teaching practices.¹⁸

In this scenario, technostress and other generative AI-related anxieties are proactively addressed, and digital well-being is embedded into the culture of medical training. Faculty members are supportive and trained to utilize generative AI in ways that reduce, rather than increase, student burden. Educators are trained to guide students in ethical, effective generative AI use.

Simultaneously, mental health support is robust and student-centered. Further, generative AI is recognized as a tool that can enhance efficiency and involve patients in education. Stakeholders understand that medical education should focus on competencies that generative AI hardly replaces, such as clinical experience and communication. Notably, involving both faculty and students in curriculum reform discussions fosters a sense of ownership and ensures broader perspectives are encompassed.¹⁹

Technostress is mitigated through proactive digital well-being education.⁵³ Students report reduced anxiety, increased self-efficacy, and improved learning satisfaction. This scenario reflects a successful co-evolution of technology and care.

This model enhances academic efficiency and personalization while safeguarding emotional health. It may become the benchmark for 21st-century medical education.

SCENARIO 3 : Disconnected struggles

Key driver: The level of generative AI integration is low.

Uncertainty: Access to mental health support is low.

In the third scenario, access to mental health support and the level of generative AI integration are low. We named this scenario “Disconnected struggles”. In this scenario, institutions fail to adequately respond to either the emotional or technological challenges of contemporary medical education. Mental health services remain limited, fragmented, or stigmatized, even as students face rising levels of stress and burnout.^{54,55}

The pandemic-induced digital shift exacerbated isolation, yet long-term MH responses have been inconsistent.⁵⁶ Simultaneously, generative AI tools are largely ignored at the curricular level. There is little institutional support for their integration, and faculty may lack both interest and digital fluency. Students may try to use generative AI on their own, but without institutional guidelines, this leads to uncertainty, inconsistent outcomes, and increased anxiety.⁵⁷ As a result, learners operate in a

high-pressure, low-support environment, facing both digital and emotional disorientation.

Students' well-being is declining, while academic inequalities are widening and trust in institutions is eroding. The lack of coordinated support during rapid digital transitions places students at risk of experiencing what might be described as "academic trauma," marked by confusion, anxiety, and a diminished sense of belonging within the educational environment.

There is ambiguity around when students should use these tools, what constitutes plagiarism, and how to detect when text has been authored by generative AI. Most importantly, there is a lack of availability and experimentation, as well as a lack of competencies and guidance on how to incorporate the new and rapidly evolving world of generative AI and large language models into the core medical school curriculum and experiences of medical education.¹⁶ Even professors are confused, and they seem to be afraid of generative AI.

According to Cervantes et al, the faculty's major concerns are cheating in home assignments and in assessment (97%), they are afraid of blunder and false information (95%), lack of context (86%), and removal of human interaction in important feedback processes (83%). The majority of the faculty agrees on the lack of guidelines for safe use of generative AI from both governmental and institutional policies. The primary perceived challenges are cheating, the tendency of generative AI to make errors, and concerns about privacy.⁵⁸

Those who themselves fear the technology are neither able to teach it effectively nor represent it credibly, and in this scenario, they do not even intend to.

SCENARIO 4 : Gen AI Takeover

Key driver: The level of generative AI integration is high.

Uncertainty: Access to mental health support is low

In the final scenario, access to mental health support is low, but the level of generative AI integration is high. The name of this scenario is "Gen AI Takeover". This future envisions a system

where technological innovation outpaces emotional preparedness, highlighting the risks associated with innovation without adequate support. Institutions push AI integration aggressively⁵⁹, embedding tools like ChatGPT into every learning domain.

Students gain fluency in AI tools, but the emotional burden grows unchecked. Students and faculty have broad enthusiasm for generative AI in medical education. MSs and trainees increasingly use generative AI on their own to support learning, clinical reasoning, and the operational tasks of their education. Faculty use generative AI to create curricula, assist in their teaching, and write and grade assessments.¹⁶

Generative AI tools are thoroughly integrated into the curriculum, driven by institutional enthusiasm and a desire for global competitiveness. Students engage with AI-based tutoring, simulation, and assessment systems from their first year, benefiting from individualized feedback and enhanced learning pathways.

Yet, the emotional cost is high. Mental health services have not evolved in parallel, and students report high levels of technostress, AI-anxiety, and burnout.^{60,61} Without adequate mental health infrastructure, the fast-paced digital transformation leads to emotional fatigue, performance pressure, and an erosion of intrinsic motivation.

Coping strategies vary: while some students thrive in the new environment, others feel overwhelmed or unsupported, and some even experience disconnection. Students may feel isolated and disoriented. They turn to unregulated online tools or peer forums for support, but without structure, these solutions only increase stress. Burnout and dropout rates rise. Without adequate mental health systems, generative AI-related anxiety and information overload escalate.⁶²⁻⁶⁷

The curriculum becomes performance-driven at the expense of well-being. Just as Sallam et al showed in their study, when gen AI integration is high but emotional support is not available, notable anxiety, fear, mistrust, and ethical concerns rise among medical students regarding the deployment of generative AI in HC, indicating the necessity of curriculum modifications that focus specifically on these areas. Interventions should be tailored to increase familiarity and competency with generative AI. This would alleviate concerns and equip future HPs to engage with this inevitable technology effectively. This study also highlights the importance of incorporating ethical discussions into medical courses to address mistrust and concerns about the human-centered aspects of generative AI. Their study calls for the proactive evolution of medical education to prepare students for new AI-driven HC practices, ensuring that physicians are well-prepared, confident, and ethically informed in their professional interactions with genAI technologies.⁶⁸

In this scenario, the education system is driven by efficiency but devoid of care. Students may

become proficient but emotionally fragile practitioners. The four scenarios and their high-level takeaways are presented in Figure 3.

3.4 Summary of key insights

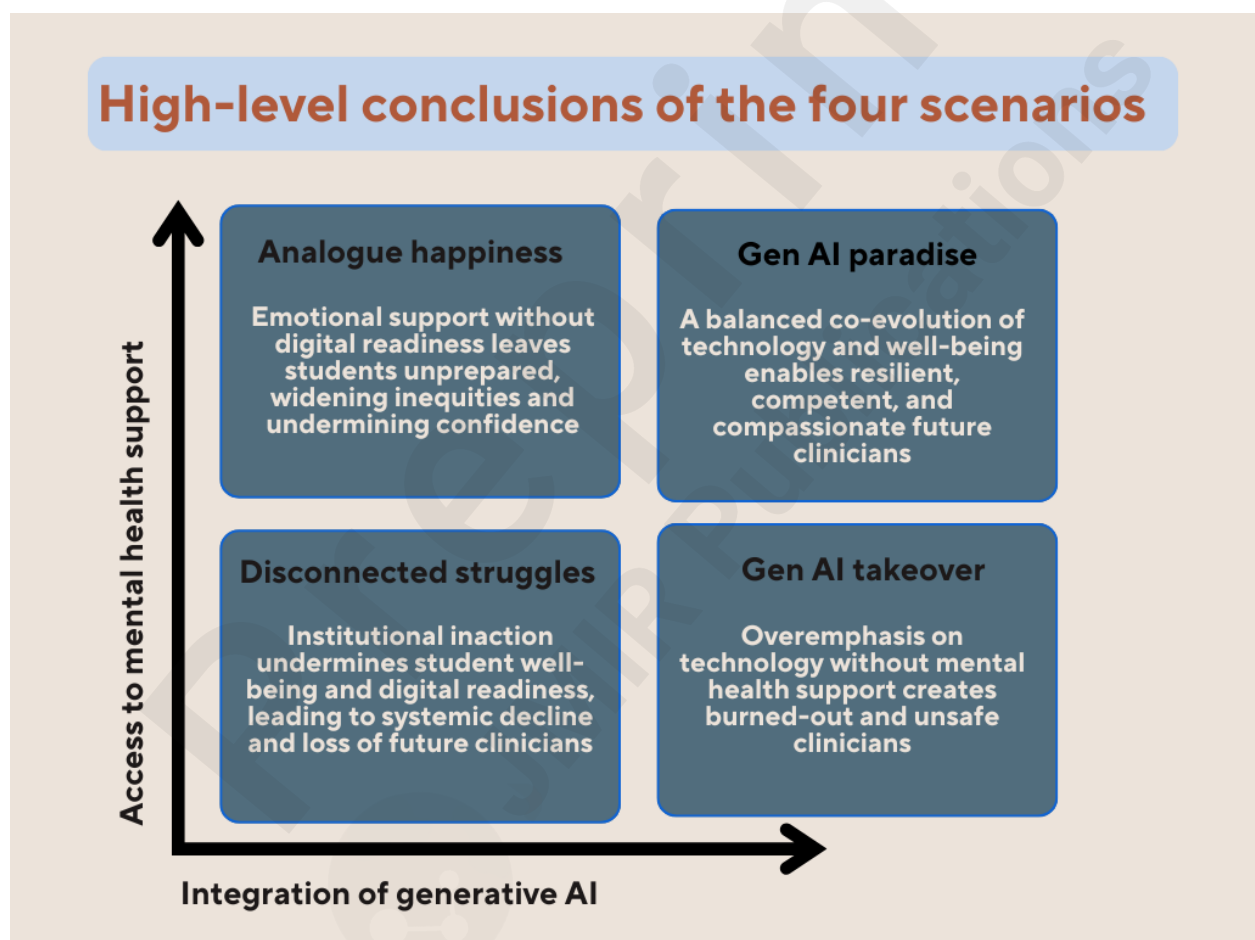


Figure 3

Over time, the scenarios could be assessed against a set of evolving indicators. On the macro level, shifts in national funding priorities or changes in AI regulation may signal broader structural trajectories. On the meso level, curriculum revisions, the adoption of new pedagogical and exam

formats, and institutional data on student well-being can highlight how organizations adapt. At the micro level, longitudinal feedback from students, including patterns of AI use in everyday study practices and self-reported mental health trends, may reveal which scenario resonates most closely with the lived reality in the timeframe of our scope.

DISCUSSION

In this study, we employed scenario analysis to explore the possible futures of medical education along two key dimensions: the level of integration of generative AI into learning and teaching, and the level of availability of mental health support. To understand how our findings might contribute to a better understanding of the role of generative AI in medical education, we need to examine the current situation from a bird's-eye perspective first. Medical education currently faces two interconnected challenges: preparing students for the integration of generative AI during their training, and safeguarding their mental health throughout this demanding process. These shape not only how students learn but also what kind of clinicians they ultimately become.

The four scenarios we created represent the possible futures that medical education could face depending on how institutions respond to the two crucial challenges: integration of generative AI and the mental health state of MSs. While each scenario explores different balances between these dimensions, the overarching insight is clear: technological innovation should be matched with emotional support. They are not opposing goals, but deeply interdependent factors in building resilient, future-ready HCPs.

The “Gen AI Paradise” scenario illustrates the potential of a balanced future, where AI supports learning and efficiency without compromising the psychological well-being of MSs. On the other hand, the “Gen AI Takeover” and “Disconnected Struggles” scenarios illustrate the dangers of one-sided development, whether it's rapid digital advancement without mental health support or stagnation in both domains. “Analogue Happiness” shows that even a supportive environment can fall short if MSs are not adequately prepared for the digital demands of modern medicine. Importantly, they reveal that technological innovation and emotional support are not opposing goals, but deeply interdependent factors in building resilient, future-ready HCPs.

The “Gen AI Paradise” scenario depicts a future where technological fluency is complemented by emotional support and enhanced well-being. This scenario exemplifies co-evolution, where generative AI tools enhance learning efficiency and diagnostic skills, while comprehensive mental health services buffer the stressors of medical training. Generative AI is not seen as a replacement but as a complementary tool that empowers rather than alienates. Institutions in this future invest in

both infrastructure and culture. With that, they are ensuring that students feel supported and actively involved in shaping their educational pathways.

This scenario offers a promising foundation for modern medical education, one that doesn't force a choice between care and competence, but weaves them together. This scenario serves as a call to restore the original contract of medicine, not as a choice between compassion and competence, but as a new lineage of healers who embody both. Modern medical education must remember what we already know, ever since Balint: the doctor is the medicine.⁶⁹ Healing is not just a science; it is also a soul work. And the well-being of the healer is a key driver of both patient satisfaction and recovery.⁶

In contrast, the "Gen AI Takeover" scenario warns against an overly technocratic future, where performance and efficiency are prioritized at the expense of MS's -and also educators'- mental well-being. Although students may become technically competent, the lack of emotional and psychological support often leads to burnout, anxiety, technostress, and disengagement. This echoes broader societal risks of digital acceleration without human-centered design. The emotional fragility of future practitioners in this scenario could ultimately compromise the quality of patient care.

The "Disconnected Struggles" scenario is the bleakest and reflects an institutional paralysis where neither digital nor emotional challenges are adequately addressed. In this scenario, MSs are navigating a high-pressure environment with minimal support. The absence of structured generative AI integration and mental health resources leads to stress, anxiety, mistrust, and academic trauma. Academic trauma can lead to dropping out, a career change, diminished self-worth, persistent self-doubt, and even suicide. This scenario reflects current warning signs already visible in some institutions, such as rising burnout rates, unprepared faculty, and a lack of consensus on the ethics and pedagogy of generative AI.

Meanwhile, the "Analogue Happiness" scenario demonstrates that a caring and emotionally supportive educational culture, though essential, is insufficient on its own. Without equipping students with digital readiness and critical generative AI literacy, even the best-intentioned systems can fall behind. Not even the best mental health services can relieve the tension caused by a real, unmet need; they can only chase symptoms, fighting a losing battle, like tilting at windmills. MSs in this scenario are emotionally supported but digitally vulnerable, widening institutional inequities and leaving graduates unprepared for the technological realities of modern clinical practice. There is a growing concern that MSs who are dissatisfied with the current level of generative AI integration will seek out training independently, outside of validated or regulated environments. This increases the risk of misinformation and errors, which may lead to guilt, despair, and a decline in their confidence and belief in their professional abilities.

Across all four futures, a central insight emerges: technological preparedness must evolve together with emotional support systems. Ignoring one for the other creates an imbalanced and ultimately unsustainable training environment. Institutions must recognize that generative AI is not merely a tool, but a promising transformational force that reshapes learning, decision-making, professional identity, and even the doctor–patient relationship for the better. Simultaneously, the emotional terrain of medical education is shifting. MSs today navigate increased academic pressure and digital overload. Failing to respond to these dual pressures risks creating emotionally exhausted, uncertain, or digitally unprepared physicians.

Additionally, the scenarios emphasize the importance of faculty readiness and institutional clarity. Without proper training and policy frameworks, even the most promising technologies may create confusion or misuse. Educators themselves must be emotionally equipped and technologically literate to guide students through this new landscape.

Ultimately, the scenarios highlight the necessity of inclusive, participatory design in curriculum reform. Engaging both students and faculty in shaping the integration of generative AI and mental health strategies ensures relevance and adaptability. Future policy and research should explore hybrid approaches that combine the possibilities of foresight methods with student-centered design and real-time feedback loops.

CONCLUSION

Medical education seems to be at a crossroads. Institutions shouldn't see technological and emotional development as competing priorities, but as mutually important pillars of responsible and future-ready education. In Figure 4 we present our practical advice to students, educators, and stakeholders based on our scenarios.

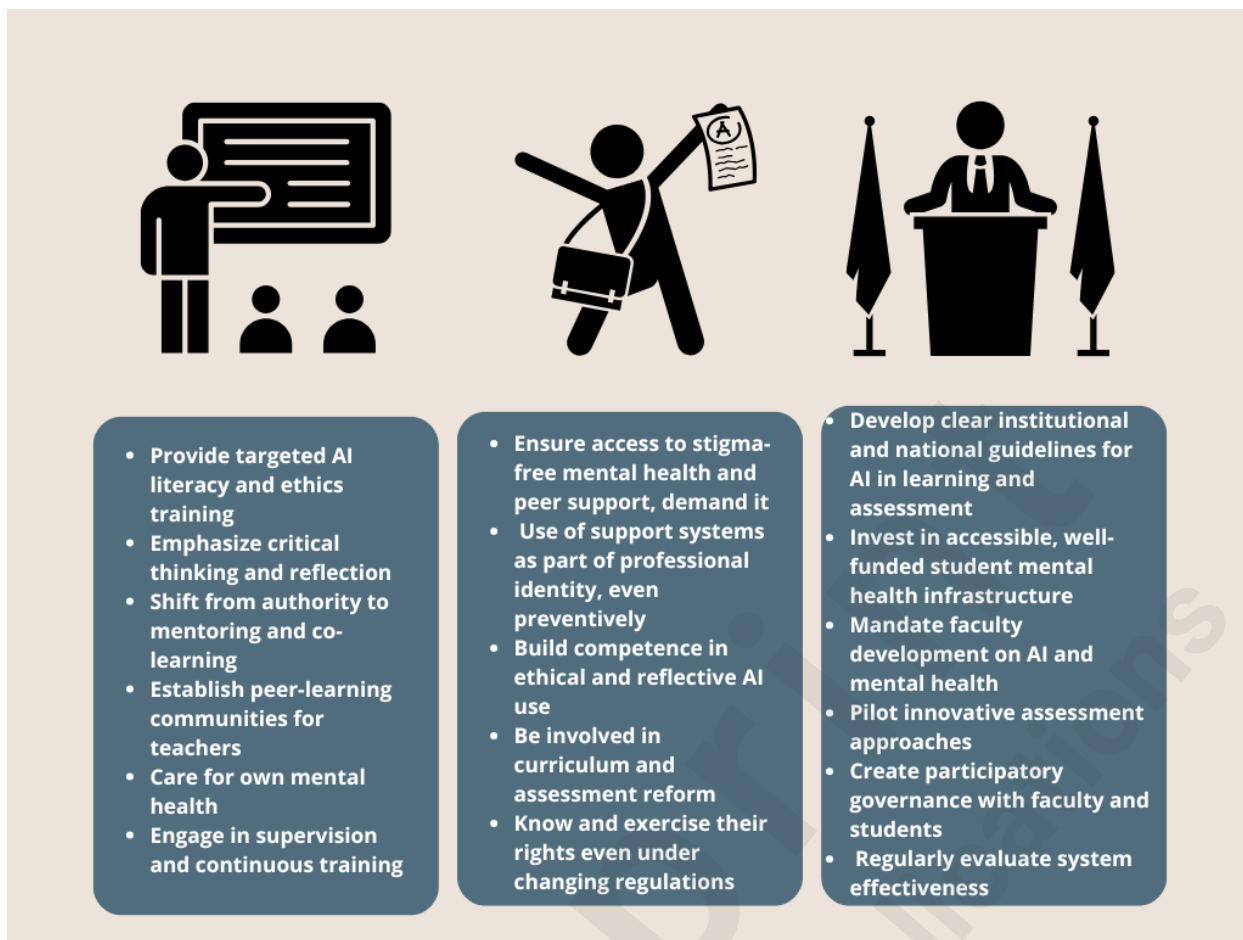


Figure 4

Ensuring the ethical integration of generative AI, while simultaneously investing in accessible and stigma-free mental health services, is essential. To prepare tomorrow's HCPs for the realities of a generative AI-enabled HC landscape, stakeholders should co-evolve both care and innovation, empowering students to become not only digitally fluent but also emotionally resilient professionals. Ignoring either the psychological or digital readiness of future HCPs is not a neutral act; it has ethical and professional implications. Institutions must rise to this dual responsibility, or risk breeding burnout instead of brilliance.

This is in the best interests of all stakeholders, educators, MSs, HCPs, and patients, as the mental well-being and technological preparedness of HCPs are critical determinants of clinical performance and, consequently, patient outcomes.⁶

Speaking of educators, although the scenarios developed in this study were intentionally student-centered, it is important to acknowledge that generative AI is also transforming the role of faculty. Medical educators are not passive observers of this shift; they too must contend with its

professional and emotional consequences. As students increasingly integrate AI tools into their daily learning, the role of faculty moves away from being the primary source of knowledge toward facilitating learning, curating resources, fostering critical thinking, and promoting engagement. This change is not only methodological but also impacts autonomy, assessment practices, and the broader context of medical education.

The presence of generative AI also alters the perception of professional authority. When students have instant access to AI-generated answers, the instructor is no longer the sole source of expertise. For some educators, this can feel like a threat, while for others it opens the possibility of highlighting what remains distinctly human in teaching. Such a shift, however, requires careful support, as moving from a position of authority to one of partnership can be experienced as both professionally and personally destabilizing.

Generative AI further exposes existing gaps in digital literacy. Students often adopt new tools quickly, whereas faculty vary widely in their confidence and acceptance. These discrepancies can undermine consistency in educational quality and highlight the need for structured training and institutional strategies that foster competence across the teaching workforce. At the same time, the ongoing pressure to adapt, acquire new skills, and even reframe one's professional identity can add to the already considerable psychological burden of academic medicine. Without adequate organizational support, the risk of fatigue and burnout is amplified.

Taken together, these considerations highlight that the integration of generative AI is not only a matter of student adaptation. The ability of faculty to adjust will play a decisive role in determining whether AI enhances the quality of medical education or instead deepens existing inequities and strains within the profession.⁷⁰

Another area that merits discussion is the future of assessment in medical education. Traditional high-stakes examinations, administered at fixed intervals, may increasingly fail to align with the personalized and dynamic nature of contemporary medical training. Computerized adaptive testing (CAT), grounded in item response theory, offers a promising alternative that has been successfully simulated in national medical assessments. One study using the Standardized Competence Test for Clinical Medicine Undergraduates in China constructed a CAT item bank and found that this approach could significantly reduce test length while maintaining precision and validity. Similarly, psychometric simulations in health professions assessment have shown that CAT can enhance reliability and reduce the burden on the examinee.^{71,72}

Beyond efficiency, adaptive testing brings the potential for competency-based timing of assessments. Rather than confining students to predetermined exam schedules, adaptive systems

could signal when a student has demonstrated sufficient mastery to be tested. Although such individualized timing holds promise for reducing stress and aligning assessments with readiness, it also raises concerns about transparency and fairness, as well as maintaining consistent standards across cohorts.

We also need to acknowledge the role of students in shaping these systems. When learners are engaged in the design or evaluation of adaptive assessment, such as in pilot programs, they tend to exhibit higher levels of acceptance and trust. Conversely, lack of involvement can breed skepticism. While direct evidence from medical schools remains limited, broader educational research underscores that student participation can legitimize technology-mediated assessment and ensure it supports pedagogical goals.^{18,73,74}

Moreover, generative technologies are beginning to automate parts of assessment creation. For example, generative AI tools have been used to generate multiple-choice items tailored to clinical training levels and to support test blueprinting and standard setting. More recent comparisons between clinician-written and AI-generated questions, such as those produced by ChatGPT-4, are emerging to explore psychometric equivalence and item quality.⁷⁵

If assessment becomes more adaptive and technology-mediated, students' voices should not be an afterthought but a central part of the process. Their involvement can enhance perceptions of fairness, mitigate concerns about automation, and help align assessment systems with actual learning needs. Ultimately, striking a balance between technological capability, institutional responsibility, and student agency will be crucial in ensuring that assessment reform fosters both competence and trust in future physicians.

Generative AI is not an optional add-on but a transformative force that will reshape medical education. Equally, mental health support is not a luxury but a prerequisite for competence, and faculty readiness is as important as student readiness. These insights are not only theoretical: the NHS Topol Review has already emphasized the urgent need to prepare the workforce for AI-enabled medicine,^{76,77} while the CanMEDS 2025 framework explicitly integrates digital health competencies into physician training.⁷⁸

At the same time, long-standing practices such as Schwartz Rounds and the Healer's Art course demonstrate that structured support for emotional well-being can reduce burnout and help students connect to the meaning of their future profession. (hivatkozas) Finally, global guidance, such as the WHO's recommendations on AI ethics, underscores that safe integration requires both governance and education.

When students feel both seen and supported, they are far more likely to become the kind of

clinicians our evolving world urgently needs: competent, compassionate, connected, and deeply human. To let it be, it is a collective, shared responsibility of ours: for researchers, to speak our truths and illuminate what must be seen; for educators, to hold both rigor and reverence in how they shape minds; for students, to claim the dignity of being fully supported; and for decision-makers, to invest not just in systems, but in the humanity of the healers we are called to cultivate.

LIMITATIONS

This study has several limitations that should be acknowledged. First, scenario analysis is inherently exploratory rather than predictive; therefore, the scenarios we present are not forecasts of what will happen but structured narratives of what could happen. Their purpose is to stimulate decision-making, but they cannot capture the full complexity of future developments.

Second, the scenarios were developed primarily by the authors themselves, which ultimately carries the risk of subjective interpretation and bias, despite the independent review process we applied. Including a broader group of stakeholders, such as medical students, faculty, policymakers, and mental health professionals, in the scenario-building process could have yielded additional perspectives and potentially different emphases.

Third, the literature base we used, although broad, is still limited by language, as we relied solely on English sources, and by the rapidly evolving nature of research on both generative AI and student mental health. At the time of our data collection, some weak signals may not yet be visible in the literature or may have emerged later.

Fourth, we deliberately set a five-year time horizon to maintain practical relevance, but this necessarily limits our exploration of longer-term systemic transformations that may occur beyond this period, such as generational cultural shifts in medical education or the broader restructuring of health systems.

Fifth, we emphasized generative AI and mental health as the two central dimensions; however, there are other important drivers, such as global health inequities, climate change, financing models, and interprofessional education, that were not explicitly integrated into our scenarios. Future research could broaden the scope by including these additional systemic drivers.

Finally, our study focuses on the perspective of medical education in higher-income countries, where digital infrastructure and access to mental health services are more available. Realities in low- and middle-income countries may differ significantly; therefore, our findings should be applied with

caution to these contexts.

ABBREVIATIONS

MS- medical student
AI- artificial intelligence
SA-scenario analysis
HC-healthcare
HCP-healthcare professional
LLM- large language model
IMIs- internet and mobile-based interventions
CAT- Computerized adaptive testing

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article and its supplementary information files.

AUTHORS CONTRIBUTIONS

AN compiled the data for the review and wrote the initial draft. BM gave methodological guidance and a review of the text. GK assisted with reviewing the text and proofreading.

TABLES AND FIGURES

Table 1: We categorized the key phenomena of medical education into micro, meso, and macro levels based on a conceptual framework. Table 1 summarizes the phenomena on all levels, together with the supporting references, in the Supplementary Materials.

Figure 1: We conducted a scenario analysis on the future of medical education using the four-scenario method. A visual representation of all the steps of our methods is provided in Figure 1 as a flowchart.

Figure 2: We categorized the key phenomena of medical education into micro, meso, and macro levels based on a conceptual framework. The figure summarizes the phenomena at all levels.

Figure 3: We conducted a scenario analysis on the future of medical education using the four-scenario method. Figure 2 presents the selected uncertainty, the key driver, and the scenarios, based on the two key determining factors: availability of mental health support and the level of generative AI integration. Figure 2 presents the main high-level conclusions of the four scenarios.

Figure 4: We conducted a scenario analysis on the future of medical education using the four-scenario method, based on the two key determining factors: availability of mental health support and the level of generative AI integration. Figure 4 presents our practical advice to students, educators, and stakeholders based on our scenarios.

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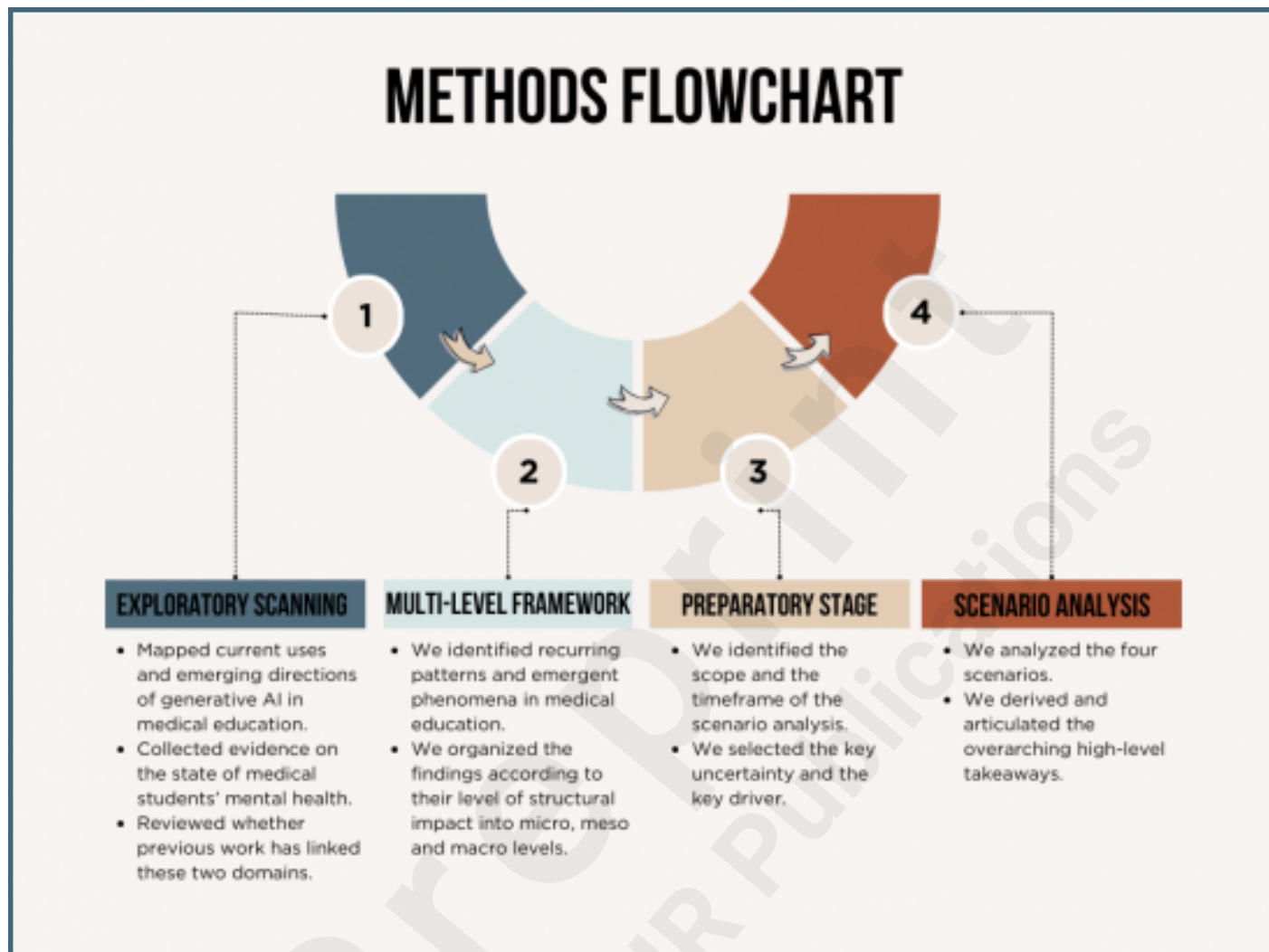
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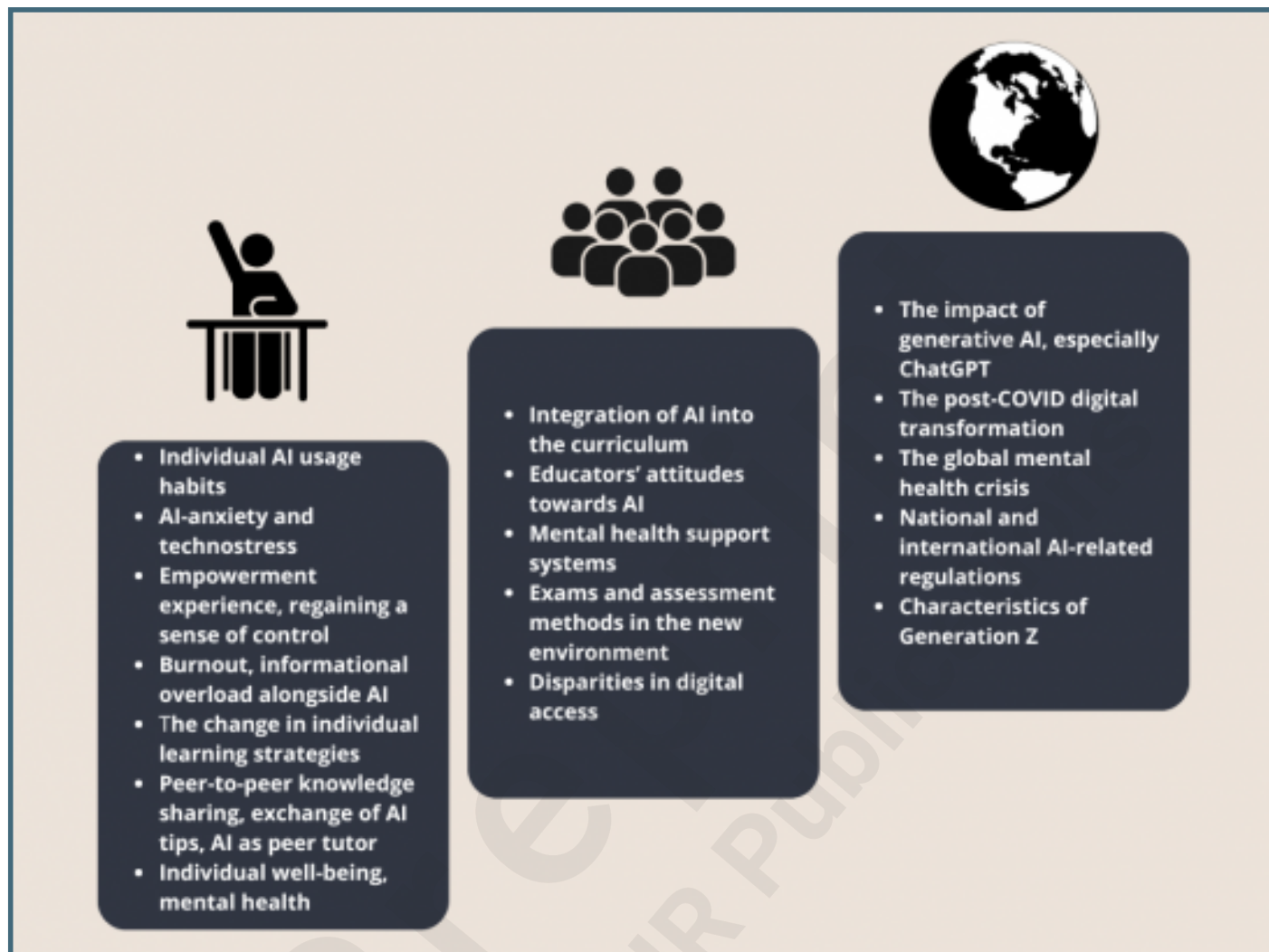
Supplementary Files

Figures

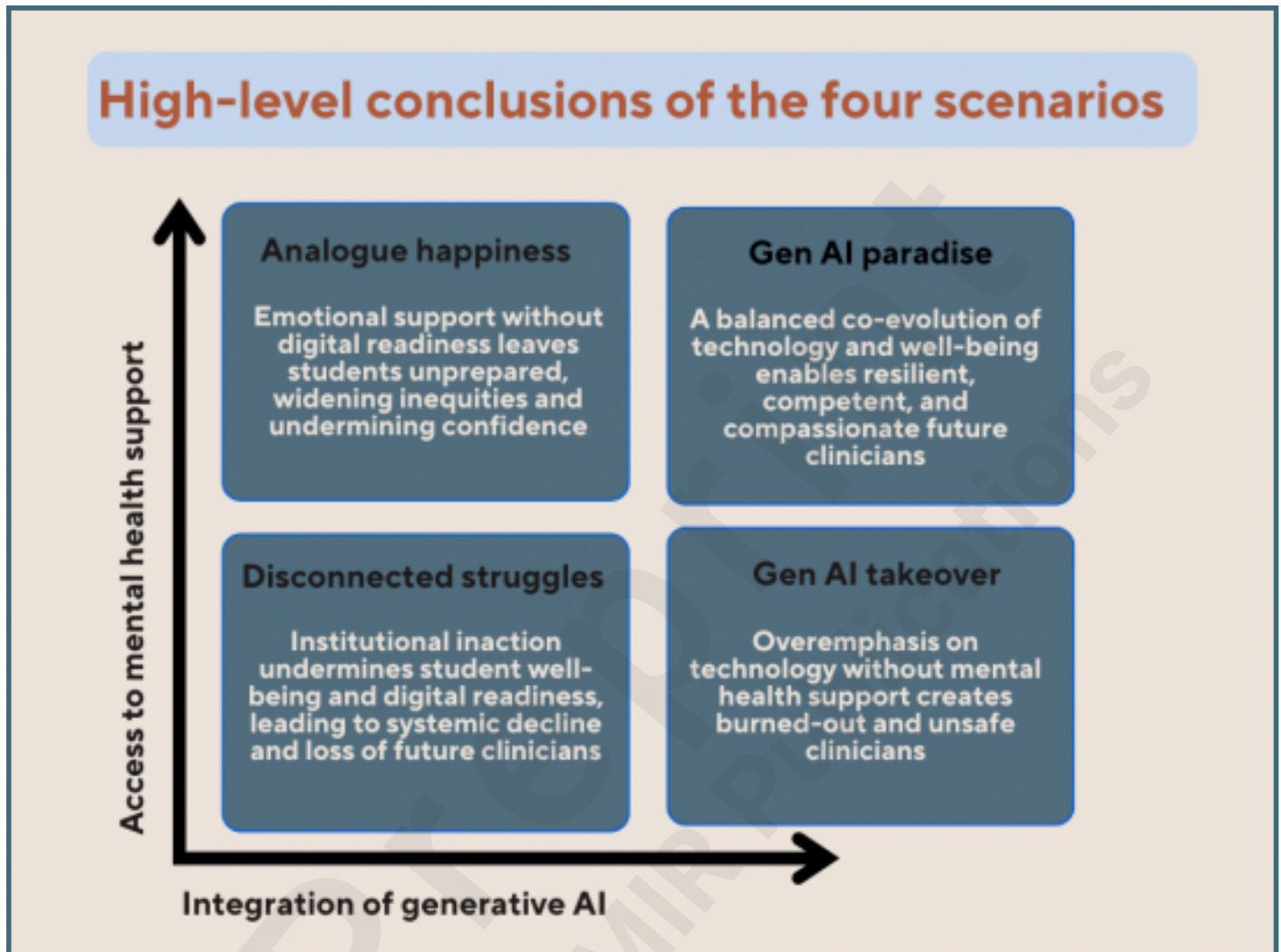
We conducted a scenario analysis on the future of medical education using the four-scenario method. A visual representation of all the steps of our methods is provided in Figure 1 as a flowchart.



We categorized the key phenomena of medical education into micro, meso, and macro levels based on a conceptual framework. The figure summarizes the phenomena at all levels.



We conducted a scenario analysis on the future of medical education using the four-scenario method. Figure 3 presents the selected uncertainty, the key driver, and the scenarios, based on the two key determining factors: availability of mental health support and the level of generative AI integration. Figure 3 presents the main high-level conclusions of the four scenarios.



We conducted a scenario analysis on the future of medical education using the four-scenario method, based on the two key determining factors: availability of mental health support and the level of generative AI integration. Figure 4 presents our practical advice to students, educators, and stakeholders based on our scenarios.



Multimedia Appendixes

In total, we identified five macro-level, five meso-level, and seven micro-level phenomena, which were categorized and analyzed based on their thematic focus and level of impact (macro, meso, or micro). For this, we used a multi-level conceptual framework. The identified phenomena, along with their brief descriptions and supporting references, are presented in the supplementary material.

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