Corner of Academy

Amos Grünebaum* and Frank A. Chervenak

Generative artificial intelligence for counseling of fetal malformations following ultrasound diagnosis

https://doi.org/10.1515/jpm-2025-0367
Received July 3, 2025; accepted July 13, 2025;
published online July 31, 2025

Abstract

Objectives: To explore the potential role of generative artificial intelligence (GenAI) in enhancing patient counseling following prenatal ultrasound diagnosis of fetal malformations, with an emphasis on clinical utility, patient comprehension, and ethical implementation.
Background: The detection of fetal anomalies during the mid-trimester ultrasound is emotionally distressing for patients and presents significant challenges in communication and decision-making. Generative AI tools, such as GPT-4 and similar models, offer novel opportunities to support clinicians in delivering accurate, empathetic, and accessible counseling while preserving the physician's central role.
Methods: We present a narrative review and applied framework illustrating how GenAI can assist obstetricians before, during, and after the fetal anomaly scan. Use cases include lay summaries, visual aids, anticipatory guidance, multilingual translation, and emotional support. Tables and sample prompts demonstrate practical applications across a range of anomalies.

Keywords: fetus as a patient; ultrasound; counseling; empathy; generative artificial intelligence; GAI

Introduction

The anatomic ultrasound, typically performed between 18 and 22 weeks of gestation, serves as a critical milestone in prenatal care, systematically evaluating fetal anatomy to detect structural anomalies [1, 2]. While most examinations reveal normal findings, the detection of fetal malformations occurs in approximately 2–3% of pregnancies [3]. These diagnoses are often unexpected and profoundly distressing for prospective parents, transforming what was anticipated as a routine, reassuring examination into a moment of shock, uncertainty, and grief. The emotional impact extends beyond the immediate diagnosis, as families must rapidly process complex medical information, understand prognosis, and navigate difficult decisions about pregnancy management and future care. In these pivotal moments, clinicians bear the responsibility not only to deliver accurate medical information but also to provide compassionate support, clear communication, and ongoing guidance throughout the decision-making process.

Generative artificial intelligence (GenAI or GAI) refers to advanced models capable of generating human-like text, images, audio, or code in response to user prompts. Emerging prominently in 2022–2023, models such as GPT-4 (OpenAI), Gemini (Google), Claude (Anthropic), Perplexity, Meta's LLaMA, and Mistral build on large language models trained on extensive medical, scientific, and general datasets. These tools are increasingly accessible through clinical platforms and web-based interfaces, enabling integration into healthcare workflows with appropriate training and oversight [4–16].

For clinicians, GenAI offers novel support in communicating complex and emotionally sensitive medical information. It has demonstrated utility in documentation, patient education, clinical decision support, and medical imaging interpretation [17]. In obstetrics specifically, GenAI enhances patient engagement, comprehension, and continuity of care across diverse clinical scenarios [17–19]. By translating technical findings, anticipating questions, and reinforcing key messages, it supports more effective and empathetic communication. In fetal counseling, its advantages include 24/7 availability, bias-free synthesis of current literature, and personalized, scalable communication – enabling consistent, high-quality care across varied healthcare settings (Table 1).

***Corresponding author: Amos Grünebaum**, MD, Northwell Health, New Hyde Park, NY, USA; and Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, New Hyde Park, NY, USA, E-mail: amos127@gmail.com
Frank A. Chervenak, Northwell Health, New Hyde Park, NY, USA; and Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, New Hyde Park, NY, USA

Generative AI applications in pregnancy ultrasonography

In perinatal care, before, during, and after an anatomic ultrasound, and especially following the diagnosis of and abnormal ultrasound such as a fetal anomaly, GenAI offers a new layer of support. When applied thoughtfully, it can complement the obstetrician's role by tailoring communication, improving understanding, and reinforcing empathy during one of the most challenging conversations in obstetrics [15, 16, 20].

Before the ultrasound appointment, Generative AI (GenAI) can help by creating a simple, easy-to-read information sheet for pregnant patients. This sheet can explain what the ultrasound is for, what kinds of things it might show, and what to expect during the visit. Using plain language and clear examples, GenAI can help reduce anxiety and make patients feel more prepared(Table 2).

During ultrasound and prior to formal diagnosis, clinicians can use GenAI to assist in the differential diagnosis of sonographic findings [1–3]. By entering observed features – e.g., cranial size, echogenicity, or limb abnormalities – models can generate lists of possible anomalies or syndromes, along with literature-based guidance on imaging or evaluation. These tools can enhance diagnostic confidence, support structured reporting, and link findings to relevant coding systems or clinical guidelines. Table 3 illustrates GAI's ability to enhance diagnostic accuracy by providing instant access to syndrome associations linked to specific fetal anomalies and systematically identifying additional ultrasound features that should be evaluated to confirm or exclude syndromic involvement. In real-time, GenAI can also suggest next steps for targeted

Table 1: Advantages of the use of generative artificial intelligence in fetal ultrasound and counseling.

Advantage	Description	Application in fetal counseling
24/7 Availability	GAI systems operate continuously without tiredness, maintaining consistent performance regardless of time or workload	Provides reliable support for urgent consultations and after-hours patient questions without compromising quality
Comprehensive literature integration	Instantly accesses and synthesizes vast medical databases, journals, and clinical guidelines	Incorporates latest research on fetal anomalies, treatment protocols, and outcome data into counseling materials
Objective & bias-free analysis	Eliminates human emotional fatigue, personal biases, and subjective interpretations	Ensures consistent, evidence-based information delivery regardless of clinician mood, experience, or personal views
Enhanced empathetic communication	Generates patient-centered language with emotional validation and compassionate phrasing	Creates counseling materials that acknowledge parental distress and provide emotional support through carefully crafted language
Multilingual & cultural adaptation	Provides accurate translations while preserving medical nuance and cultural sensitivity	Delivers culturally appropriate counseling content in multiple languages for diverse patient populations
Personalized content generation	Tailors information to specific gestational age, anomaly type, severity, and family circumstances	Creates individualized explanations and care plans based on unique patient characteristics and clinical findings
Rapid information processing	Analyzes complex medical data and generates comprehensive summaries within seconds	Quickly produces detailed counseling materials, FAQs, and educational content during or immediately after ultrasound
Standardization of quality	Ensures consistent, high-quality counseling materials across all providers and institutions	Reduces variability in counseling quality regardless of clinician experience or institutional resources
Real-time knowledge updates	Incorporates newest medical findings, guidelines, and best practices as they become available	Ensures counseling content reflects most current evidence-based recommendations and treatment options
Visual aid creation	Generates diagrams, illustrations, and simplified anatomical representations	Creates customized visual explanations of fetal anomalies that enhance patient understanding and retention
Anticipatory guidance generation	Predicts common questions and concerns to prepare comprehensive responses	Develops personalized FAQ sheets and prepares families for upcoming consultations and decision points
Documentation enhancement	Creates detailed, structured records of counseling sessions and patient interactions	Generates comprehensive documentation for continuity of care and medicolegal protection
Decision support integration	Links counseling content to evidence-based treatment algorithms and outcome predictions	Provides families with data-driven insights about prognosis, treatment options, and expected outcomes
Scalability & accessibility	Extends high-quality counseling support to resource-limited settings and underserved populations	Democratizes access to expert-level counseling materials regardless of geographic or economic constraints

Prompt Example to create this table: "Create a comprehensive table listing the top advantages of using generative AI for [specific medical domain]. For each advantage, include: (1) a clear title, (2) a brief description of the capability, and (3) specific application examples in the medical context. Organize by priority/importance and focus on practical benefits like objectivity, 24/7 availability, empathy enhancement, literature integration, personalization, and scalability. Format as a markdown table with columns for rank, advantage, description, and application".

Table 2: Example of a patient-facing information sheet generated by GenAI to prepare pregnant individuals for the 20-week anatomic ultrasound (6th-grade reading level).

Your 20-week ultrasound: what to expect

What is this ultrasound for?

This special ultrasound is sometimes called the "anatomy scan." It usually happens between 18 and 22 weeks of pregnancy. It helps your doctor check how your baby is growing and developing.

What will the doctor look at?

During the ultrasound, the doctor or technician will carefully look at many parts of your fetus' body. They will check:

- **The head and brain** – to make sure the shape and size look normal
- **The face** – including the nose, lips, and eyes
- **The heart** – to check the heartbeat and the four chambers of the heart
- **The spine** – to look for curves or gaps
- **The stomach and kidneys** – to check for size and placement
- **The bladder** – to make sure it's filling and emptying
- **The arms, legs, hands, and feet** – to count fingers and toes and see movement
- **The sex (if you want to know)** – sometimes it's clear, sometimes not
- **The amount of amniotic fluid** – the water around your baby
- **The placenta** – where it is and how it's working
- **The umbilical cord** – to make sure blood and oxygen are flowing well

What happens during the ultrasound?

You will lie down on a soft bed. Gel will be placed on your belly, and a small device called a probe will glide over your skin. It does not hurt. A screen will show images of your baby in real time.

How long will it take?

It usually takes about 30–45 min. If your fetus is moving a lot, it may take a bit longer.

Why is this ultrasound important?

This scan helps find out if everything looks okay or if something might need a closer look. Most fetuses are healthy, but if there is something different, this test helps your doctor plan next steps.

What should I do before the ultrasound?

You may be asked to drink water beforehand. This helps get better pictures. You can ask your clinic for instructions.

Can someone come with me?

Yes! You can usually bring a support person, but check with your provider or clinic first.

Prompt example to create this table: "create a 6th-grade reading level information sheet for pregnant patients preparing for their 20-week anatomy ultrasound. Explain clearly what the ultrasound is for, what body parts are examined, what to expect during the visit, and why it is important. Use simple language, short sentences, and a reassuring tone suitable for wide patient use."

imaging, help identify atypical or rare presentations, and flag potential syndromic associations for further consideration. For trainees and less experienced providers, GenAI may serve as an educational support, reinforcing pattern recognition and improving familiarity with anomaly-specific terminology. Used judiciously, these applications can contribute to more consistent, informed, and timely assessment of complex cases.

After the ultrasound, and especially when there is an abnormal ultrasound and a fetal issue has been identified (Table 4), GenAI can help bridge the gap between clinical findings and patient understanding. It can generate individualized summaries of the ultrasound results using plain language, tailored to the specific diagnosis, gestational age, and care plan. These summaries can be reviewed with the patient, printed, or accessed at home – allowing families time to reflect and revisit the information at their own pace. GenAI can also create visual aids, such as labeled diagrams or simplified illustrations of the affected anatomy, which enhance comprehension and make abstract or unfamiliar diagnoses more concrete. In addition, it can generate anticipatory guidance, such as personalized FAQs, likely next steps, and questions to consider during upcoming consultations. For patients facing language or literacy barriers, GenAI can translate content into multiple languages while preserving nuance and clinical accuracy. By supporting clarity, repetition, and emotional preparedness, these tools can reduce confusion, improve shared decision-making, and extend the reach of the clinical team.

Counseling with GAI

Counseling following the detection of a fetal anomaly during the anatomic ultrasound is one of the most sensitive and consequential encounters in obstetrics. Communication must be clear, compassionate, and tailored to the patient's emotional readiness and level of understanding. Although

Table 3: Classic fetal malformations: syndrome associations and additional features to evaluate.

Primary malformation	Associated syndromes	Additional features to assess
Ventricular septal defect	DiGeorge syndrome, down syndrome, CHARGE	Thymic hypoplasia, great vessel abnormalities, facial profile, nuchal fold thickness, shortened limbs
Spina bifida	Arnold-Chiari II, Meckel-Gruber	Hydrocephalus, cerebellar abnormalities, encephalocele, polycystic kidneys, polydactyly
Cleft lip/palate	Pierre Robin Sequence, Trisomy 13	Micrognathia, cardiac defects, holoprosencephaly, polydactyly, growth restriction
Omphalocele	Beckwith-Wiedemann, pentalogy of cantrell	Macroglossia, organomegaly, cardiac defects, diaphragmatic hernia, sternal defects
Cystic Hygroma	Turner syndrome, Noonan syndrome	Hydrops fetalis, cardiac defects, renal abnormalities, growth restriction
Holoprosencephaly	Trisomy 13, Smith-Lemli-Opitz	Facial clefts, polydactyly, cardiac defects, growth restriction, limb abnormalities
Congenital diaphragmatic hernia	Pallister-Killian, Fryns syndrome	Cardiac defects, limb abnormalities, facial dysmorphisms, growth restriction
Renal agenesis	VACTERL, Fraser syndrome	Vertebral defects, cardiac anomalies, esophageal atresia, limb defects, genital abnormalities
Gastroschisis	Isolated (rarely syndromic)	Bowel atresia, cardiac defects, growth restriction, oligohydramnios
Encephalocele	Meckel-Gruber, Walker-Warburg	Polycystic kidneys, polydactyly, cerebellar abnormalities, eye abnormalities
Clubfoot	Distal arthrogryposis, Myelomeningocele	Joint contractures, spinal abnormalities, facial abnormalities
Polydactyly	Trisomy 13, Bardet-Biedl, Ellis-van creveld	Cardiac defects, holoprosencephaly, short limbs, renal abnormalities
Cardiac defects (complex)	CHARGE, Noonan, DiGeorge	Choanal atresia, growth restriction, ear abnormalities, genital abnormalities
Duodenal atresia	Down syndrome, VACTERL	Cardiac defects, nuchal fold thickness, vertebral abnormalities, limb defects
Anencephaly	Amniotic band sequence	Limb defects, abdominal wall defects, facial clefts

Example of a prompt to create this table: "generate a clinical reference table linking common fetal anomalies to their syndrome associations and additional ultrasound features to evaluate. Include the most clinically relevant syndromes and specific anatomical structures to assess for each anomaly to guide comprehensive fetal evaluation." This prompt structure helps create systematic differential diagnosis aids for any specialty where pattern recognition and comprehensive evaluation protocols are important.

many institutions have developed protocols for delivering serious diagnoses, the quality and consistency of counseling vary widely. Generative AI can offer valuable support at multiple stages of this process [21–24].

GenAI can generate layperson summaries that reflect the specific anomaly, gestational age, and management plan – offering families a more accessible and personalized explanation than generic educational material. It can also create visual aids, such as annotated diagrams and simplified anatomical illustrations, to make structural abnormalities more comprehensible. These tools help bridge gaps in health literacy and improve retention of complex information.

Additionally, GenAI can simulate common questions and provide anticipatory guidance in the form of customized FAQ sheets, helping patients prepare for multidisciplinary consultations or genetic counseling. It can translate content into multiple languages while preserving nuance and clinical accuracy, enhancing communication in diverse populations. Used ethically and under clinical oversight, GenAI has the potential to improve patient understanding, reduce decisional conflict, and reinforce empathy during some of the most difficult conversations in obstetric care.

GenAI can be especially valuable when counseling involves specific malformations, such as spina bifida, congenital diaphragmatic hernia, cleft lip and palate, or cardiac anomalies. It is particularly helpful in cases involving rare or unfamiliar anomalies, where clinicians may have limited time or resources to prepare tailored explanations. Each of these diagnoses carries a distinct range of prognostic implications, care pathways, and emotional responses. GenAI can generate condition-specific summaries that are not only medically accurate but also appropriately framed for the patient's emotional and cognitive readiness. These summaries can be updated in real time as new information emerges – from additional imaging, genetic testing, or multidisciplinary input – ensuring that the content evolves alongside the clinical picture.

For example, in the case of a suspected ventricular septal defect, GenAI can initially provide a general explanation of the condition and potential implications, and later revise the content if follow-up echocardiography confirms isolated vs. syndromic involvement. Importantly, GenAI can help convey both present findings and future steps, such as surveillance plans, likely consultations, and potential postnatal interventions. For families coping with uncertainty,

Table 4: Generative AI (GenAI) assistance after a fetal malformation detected by ultrasound.

Function	Description	Benefit to patient and clinician
1. Layperson summary generation	Creates plain-language explanations of findings tailored to diagnosis and gestational age	Enhances understanding and reduces patient anxiety
2. Personalized care plan summaries	Outlines individualized next steps based on clinical context	Facilitates informed decision-making and follow-up
3. Visual aid creation	Generates labeled diagrams or simplified illustrations of the anomaly	Aids in visual comprehension of complex findings
4. Anticipatory guidance content	Provides FAQs, likely next steps, and common concerns	Prepares families for future consultations and decisions
5. Multilingual translation	Translates content while preserving clinical nuance and cultural appropriateness	Improves access for non-english-speaking families
6. Health literacy optimization	Adjusts readability to match patient's literacy level (e.g., 6th-grade reading level)	Ensures information is accessible to a broader population
7. Print-ready summaries	Produces summaries that can be printed or shared digitally	Supports home review and family discussions
8. Question prompt lists	Suggests questions for parents to ask at future visits	Increases patient agency and engagement
9. Psychosocial resource linking	Identifies appropriate support groups, counseling services, or educational sites	Extends support beyond clinical encounter
10. Values-based framing	Tailors tone and emphasis to align with patient's preferences and emotional readiness	Promotes respectful, patient-centered communication
11. Timeline visualization	Builds stepwise care timelines, including future tests, consults, or delivery plans	Clarifies expectations and improves planning
12. Documentation support	Automatically generates structured notes or summaries for clinician review	Enhances charting efficiency and documentation quality

Prompt example to create this table: "Create a table listing 10–15 ways generative AI can assist after an abnormal fetal ultrasound diagnosis. For each item, include: (1) the function or task, (2) a brief description of what the AI does, and (3) the benefit to patients or clinicians. Focus on applications that improve patient understanding, emotional preparedness, shared decision-making, and follow-up planning."

this continuity can reduce confusion and help restore a sense of agency. Whether outlining the schedule for follow-up ultrasounds, providing questions to ask during a pediatric surgical consult, or preparing a summary for a second-opinion visit, GenAI serves as a tool to help families understand the arc of care. When reviewed and personalized by the clinician, this support enhances shared decision-making while preserving the physician's role as the central guide and interpreter.

Ethical and professional considerations

The deployment of GenAI in obstetric counseling requires careful attention to ethical principles and professional responsibilities [25, 26]. AI-generated content must support, not replace, the physician-patient relationship [27–29]. The principle of respect for autonomy dictates that patients should remain central in decision-making, with AI tools serving only as enhancements to informed discussions [30–32]. Clinicians should safeguard against misinformation or errors. GenAI system do not – and cannot – decide what is true and what is false. Sometimes, they just confabulate, a phenomenon known as hallucinations, especially in rare or borderline conditions [33, 34]. As of June 2025 the newest and most powerful technologies – so-called *reasoning systems* from companies like OpenAI, Google and the Chinese start-up DeepSeek – are generating more errors, not fewer.

Consequently, any content created by GenAI must be reviewed and approved by a qualified clinician. Similarly, beneficence requires that AI outputs be helpful and supportive, not overwhelming or distressing. Tone, length, and readability must be optimized to avoid information overload. Professional accountability remains paramount. GenAI tools should never be presented as authoritative by themselves. The clinician must remain the interpreter of medical findings and the guide for decision-making. Finally, considerations of equity must inform implementation. Access to GenAI-enhanced counseling should not be limited by geography, language, or socioeconomic status.

How to get the most of GenAI

Generative AI is not autonomous. It does not generate useful or clinically appropriate content on its own. Instead, its effectiveness depends entirely on the expertise and direction provided by the clinician. In the context of fetal counseling,

GenAI functions as a responsive tool – its value is determined by the quality of the input it receives. To harness its full potential, clinicians must understand how to structure prompts, define clinical objectives, and critically review the output. This requires not only medical knowledge but also familiarity with the capabilities and limitations of GenAI systems [17, 35, 36].

A prompt is the set of instructions, context, or questions a user provides to the AI to elicit a specific output [37]. Much like framing a clinical consultation or asking a colleague for input, the clarity, completeness, and tone of the prompt directly influence the relevance and quality of the AI's response. In clinical settings, effective prompts must be purposefully designed to reflect patient needs, medical facts, and counseling goals.

Prompt engineering refers to the design of specific instructions to guide GenAI outputs. In ultrasound counseling, this technique is critical to ensure that generated content is accurate, empathic, and aligned with clinical goals [38]. Poorly designed prompts can result in misinformation, inappropriate tone, or irrelevant content.

There is a clear evolving science of how to create effective prompts. Effective prompts must include a multitude of clinical context, patient demographics, diagnosis, and desired tone (e.g., neutral, supportive, hopeful). For example, a prompt to generate a lay explanation of tetralogy of Fallot might include the specific findings, planned interventions, and the emotional state of the family. The output should be informative yet comforting, avoiding alarmist or overly technical language.

Prompt engineering also enables localization – the tailoring of content to regional policies [15], cultural norms, and legal frameworks. This is especially relevant when discussing options like termination or perinatal palliative care, which vary significantly across jurisdictions. Clinical teams must be trained in constructing effective prompts and reviewing outputs for fidelity to the medical facts and the values of the patient.

How GAI can help delivering difficult news: the need for sensitivity and support

Receiving a diagnosis of a fetal malformation is among the most distressing experiences an expectant parent can face [39]. What was anticipated as a routine ultrasound can abruptly become a moment of shock, fear, and grief. In these emotionally charged situations, the clinician's sensitivity is not ancillary – it is essential. Patients confronted with such news are often overwhelmed by the complexity of the medical information and the weight of decisions ahead. In these moments, what patients most need is not only clinical clarity but human compassion. How the information is conveyed – tone, pacing, word choice – can shape a family's understanding, emotional response, and long-term trust in the healthcare system. Cultivating clinical empathy in these encounters is therefore both a moral and professional imperative [40, 41].

Empathy is a foundational element of clinical excellence. Patients consistently rate empathetic physicians as more competent, trustworthy, and effective, even when clinical outcomes remain unchanged [42, 43]. In emotionally charged settings – such as the disclosure of a fetal anomaly – empathy plays a vital role in building trust, reducing anxiety, and facilitating shared decision-making. It conveys not only understanding, but presence and commitment, and strongly influences how patients remember and respond to the counseling experience.

Patients often express dissatisfaction not with the medical care itself, but with what was traditionally called a clinician's "bedside manner" – a concept now better understood as empathy. One frequent critique of technology in medicine is its perceived inability to replicate empathy. However, when guided by skilled prompts and clinician oversight, generative artificial intelligence (GenAI) can enhance – not diminish – perceived empathy by reinforcing the human elements of care. Empathic language, patient-centered phrasing and anticipatory validation of emotions can be integrated into GenAI-generated content, helping families feel seen and supported [44–46].

Emerging evidence suggests that GenAI may outperform humans in perceived empathy under certain conditions. In experimental studies, third-party evaluators and patients have rated AI-generated responses to emotionally sensitive scenarios as more empathic than those of clinicians, particularly in written formats [47–49]. These findings, while preliminary, highlight the potential of GenAI to reinforce core elements of compassionate care – especially when used as a supplement to, not a substitute for, clinician communication. Language models can be tuned to avoid clinical detachment, reflect emotional resonance, and tailor phrasing to patient distress, thereby strengthening the therapeutic alliance.

Moreover, GenAI can reinforce these messages after hours or between visits, offering consistent empathic support at moments of uncertainty or distress. When families review materials at home or share them with others, the embedded tone and language continue to reflect the clinician's commitment. Used responsibly, GenAI becomes a tool for extending – not replacing – the empathic voice of the care team.

Families often leave counseling sessions feeling overwhelmed and uncertain about where to turn next. One of the notable strengths of GenAI is its ability to curate and deliver relevant support tools to patients. GenAI can compile condition-specific educational material from reputable organizations, ensuring that the information is both current and comprehensible [50].

In cases of poor prognosis, families may require introductions to perinatal palliative care or hospice planning. GenAI can deliver such content with sensitivity and clarity, emphasizing that support continues even in the absence of curative options. In more treatable conditions, GenAI can connect patients with early intervention services, surgical centers, and advocacy organizations, offering guidance tailored to the specific diagnosis and stage of care.

Families also frequently seek peer support. GenAI can identify and suggest moderated forums, support groups, and local or national organizations that align with the family's needs and values. By personalizing these resources, the technology can meaningfully extend the reach and effectiveness of the care team.

Case examples and sample prompts

(1) Fetal diaphragmatic hernia. For example, a well-constructed prompt might read: "*Generate a compassionate, easy-to-understand explanation of a diagnosis of congenital diaphragmatic hernia at 22 weeks' gestation. Begin by acknowledging that this is difficult news to hear. Use reassuring and supportive language to explain the condition, next steps, and how the care team is committed to walking alongside the family throughout the process.*" Such prompts yield responses that open with emotional validation – e.g., "*We understand that hearing this diagnosis can be overwhelming…*" – and continue with clear, gentle explanations of the diagnosis and its implications. This combination of clarity and compassion reflects what patients value most in high-quality, human communication.

(2) Anencephaly. The diagnosis is devastating, and the prognosis is uniformly fatal. A GenAI tool could generate a gentle, comprehensible summary for the family explaining the anomaly, expected clinical course, and local options for palliative care or pregnancy termination. The content could be aligned with the family's language preference, religious considerations, and access to care. For example, a brief prompt might read: "*Write a compassionate, easy-to-understand explanation for parents whose fetus has been diagnosed with anencephaly at 22 weeks. Acknowledge the emotional difficulty, explain the diagnosis and prognosis clearly, and describe options for care, including comfort-focused pathways. Use gentle, supportive language throughout.*" This type of prompt can help ensure that the generated content balances medical clarity with emotional sensitivity, matching the gravity of the situation while offering reassurance and support.

(3) Isolated mild ventriculomegaly. The prognosis is uncertain and depends on the progression and presence of other findings. Here, GenAI could produce a summary emphasizing the need for follow-up imaging, potential neurologic outcomes, and support resources. The family could receive a printable set of questions for their next consultation, increasing their agency and engagement. A sample prompt might read: "*Write a supportive, easy-to-understand summary for expectant parents following a prenatal diagnosis of mild isolated ventriculomegaly. Explain what this means, the importance of follow-up ultrasounds or MRIs, and possible outcomes. Include 3–5 helpful questions the parents might ask their provider.*"

(4) Cleft lip and suspected cleft palate. The anomaly is correctable postnatally, but families often need reassurance and planning support. GenAI could provide diagrams, links to surgical centers of excellence, and a stepwise timeline from prenatal planning to pediatric surgery consultation, easing the transition between specialties. A brief prompt could be: "*Generate a reassuring explanation for parents whose fetus has a prenatal diagnosis of cleft lip with possible cleft palate. Emphasize the condition's treatability, outline expected care steps from birth to surgical correction, and include a calm and supportive tone.*"

As shown in Table 5, effective GenAI implementation requires carefully crafted prompts that specify the clinical scenario, gestational age, desired communication tone, and specific counseling objectives to generate appropriate, empathetic responses tailored to each unique fetal diagnosis and family situation.

Future directions and research needs

Counseling following the prenatal diagnosis of a fetal malformation is one of the most delicate and consequential conversations in obstetric care. These moments are filled with uncertainty, vulnerability, and the urgent need for accurate, compassionate guidance. Generative artificial

Table 5: Examples of GAI prompts for fetal malformation counseling.

Malformation	Gestational age example	Prompt template
Ventriculomegaly	28 weeks	"I am a high-risk obstetrician counseling a patient at 28 weeks whose baby has mild ventriculomegaly. Please explain the condition, common causes, possible next tests, and outcomes. Use calm, 6th-grade language."
Hydronephrosis	20 weeks	"My patient's fetus has hydronephrosis seen at the 20-week scan. Create a simple, reassuring explanation, including causes, follow-up imaging, and whether it often resolves."
Spina bifida (Myelomeningocele)	21 weeks	"Counsel a patient whose baby was diagnosed with spina bifida at 21 weeks. Explain what it is, potential neurological impacts, delivery planning, and available treatments. Keep the tone supportive."
Omphalocele (isolated)	22 weeks	"A 22-week ultrasound shows an isolated giant omphalocele. Write a counseling script explaining what this means, expected surgeries, NICU stay, and likely long-term outcomes. Use 6th-grade readability."
Congenital diaphragmatic hernia	24 weeks	"I need to explain CDH to a family at 24 weeks. Include what it is, how it affects the lungs, fetal MRI, delivery planning, and NICU expectations. Use clear and compassionate tone."
Cystic hygroma	12 weeks	"A cystic hygroma was seen at 12 weeks. Please write a script explaining its significance, possible genetic associations, testing options, and what happens next. Use emotionally gentle and simple language."
Clubfoot	20 weeks	"Counsel a patient after the 20-week scan showed isolated clubfoot. Explain what it means, how it is treated after birth, and expected outcomes. Keep it encouraging and easy to understand."
Echogenic bowel	20 weeks	"I'm speaking with a patient whose fetus has echogenic bowel at 20 weeks. Provide a script covering possible causes, whether it needs testing, and how it may affect the baby. Aim for a 6th-grade level."
Hypoplastic left heart syndrome	22 weeks	"Create a script for HLHS diagnosis at 22 weeks. Include what it is, required surgeries, survival rates, and the long-term prognosis. Use a calm, kind, 7th-grade explanation."
Agenesis of the corpus callosum	22 weeks	"Explain agenesis of the corpus callosum to a parent at 22 weeks. Include what the corpus callosum does, potential outcomes, and additional tests. Keep tone neutral and reassuring."
Absent nasal bone	12 weeks	"A 12-week scan shows an absent nasal bone. Provide a simple explanation of its link to chromosomal anomalies, optional testing, and follow-up plans. Use very gentle, low-literacy language."
Tetralogy of Fallot	20 weeks	"Please create a parent explanation for tetralogy of Fallot found at 20 weeks. Include a short description of the heart defects, surgical correction, and long-term prognosis. Keep tone hopeful and clear."
Duodenal atresia	22 weeks	"My patient's fetus has duodenal atresia. Write a script explaining what this is, how it's linked to down syndrome, the expected surgery, and recovery after birth."
Fetal growth restriction (FGR)	24 weeks	"Counsel a patient whose baby is measuring small at 24 weeks. Explain fetal growth restriction, potential causes, what monitoring will be done, and possible delivery timing. Use a supportive tone."
Polycystic kidney disease	20 weeks	"Write a script for a 20-week diagnosis of polycystic kidney disease. Include types (ARPKD/ADPKD), prognosis, possible complications, and follow-up. Use 7th-grade readability."
Holoprosencephaly	18 weeks	"Counsel a patient after diagnosis of holoprosencephaly at 18 weeks. Explain what it is, brain development, related syndromes, and emotional support resources. Use clear and compassionate language."

Prompt example to create this table: "generate a collection of sample GAI prompts for counseling different fetal anomalies. Each prompt should specify the clinical scenario, gestational age, desired tone (supportive/calm), reading level (6th–7th grade), and specific information to include. Focus on prompts that would generate empathetic, clear, and medically appropriate counseling content for families." This prompt structure can be adapted for any medical specialty where standardized, empathetic communication templates are needed for difficult diagnoses or sensitive patient conversations.

intelligence, when applied thoughtfully and under clinical supervision, can significantly augment this process. Rather than replacing the clinician's role, GenAI can serve as a powerful extension of the healthcare team's voice and empathy.

To realize the potential of GenAI in perinatal counseling, several priorities must be addressed. First, rigorous evaluation of GenAI-generated content is essential. Clinical validation studies should assess accuracy, readability, and emotional impact. Second, systems should include feedback mechanisms so that patients and providers can report inaccuracies or suggest improvements.

Integration with electronic health records (EHRs) will be important for scalability. This could allow automatic generation of summaries or resources based on imaging findings. Collaboration with professional organizations could help standardize templates, train clinicians in AI use, and ensure equitable access across health systems.

Research should also examine whether GenAI reduces decisional conflict, improves satisfaction, or supports better

outcomes for families facing complex diagnoses. Ethical frameworks must continue to evolve alongside the technology.

By helping clinicians generate accurate, personalized, and culturally sensitive explanations, GenAI can support both the informational and emotional needs of patients and their families. It can reinforce key messages outside the clinical setting, translate complex findings into accessible language, and link patients to reliable educational resources and psychosocial support. Importantly, GenAI has the potential to democratize access to high-quality counseling materials, bridging gaps in health literacy, language, and location.

Ethical implementation is paramount. When embedded into a framework of clinical oversight, patient feedback, and transparent communication, GenAI becomes a tool for deepening trust rather than undermining it.

As perinatal medicine continues to evolve, GenAI stands not as a replacement for human presence but as a meaningful adjunct in the art and science of prenatal counseling. With careful design and ethical stewardship, generative AI can amplify the clinician's ability to inform, comfort, and guide families through some of the most challenging decisions they may ever face, for transforming the counseling of fetal malformations identified by ultrasound. When designed and used ethically, with attention to empathy, cultural relevance, and clinical accuracy, these tools can enhance communication, support patient understanding, and improve access to high-quality resources. Rather than replacing the human connection, GenAI can amplify the capacity of clinicians to inform, comfort, and guide families through difficult and often life-altering conversations.

Research ethics: The local Institutional Review Board deemed the study exempt from review.
Informed consent: Not applicable.
Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.
Use of Large Language Models, AI and Machine Learning Tools: For help and grammar as indicated.
Conflict of interest: The authors state no conflict of interest.
Research funding: None declared.
Data availability: Not applicable.

References

1. Dolk H, Loane M, Garne E. Epidemiology of congenital anomalies. Lancet 2010;375:1156–65.
2. Salomon LJ, Alfirevic Z, Da Silva CF, Bilardo C, Hernandez-Andrade E, Johnsen SL, et al. Practice guidelines for performance of the routine mid-trimester fetal ultrasound scan. Ultrasound Obstet Gynecol 2011; 37:116–26.
3. Williams CE, Morris RK. The fetal anomaly screening scan: an international perspective. Obstet Gynaecol Reprod Med 2024;34: 312–15.
4. Acikgoz EC, İnce OB, Bench R, Boz AA, Kesen İ, Erdem A, et al. Hippocrates: an open-source framework for advancing large Language models in healthcare. arXiv. 2024;2404.16621. https://doi.org/10.48550/arXiv.2404.16621.
5. Sorin V, Klang E, Sklan EH, Cohen-Zada D, Grossman E, Matalon N, et al. The path forward for large language models in medicine is open. Nat Med 2024;30:3040–3.
6. Mehandru N, Erpelding A, Kankanhalli A. Large language models in healthcare and medical domain: a review. arXiv. 2024;2401.06775v2. https://doi.org/10.48550/arXiv.2401.06775
7. Basheer KCS. Llama-3-Based OpenBioLLM models outperform GPT-4 and Med-PaLM. Anal Vidhya 2024. Available from: https://www.analyticsvidhya.com/blog/2024/04/llama-based-openbiollm-models-outperform-gpt-and-med-palm/.
8. AIM Research. Komodo health launched AI assistant using llama, Mistral & Phi, orchestrated by LangGraph. AIM Res 2024. Available from: https://aimresearch.co/generative-ai/komodo-health-launched-ai-assistant-using-llama-mistral-phi-orchestrated-by-langgraph.
9. OpenAI. GPT-4 technical report. arXiv. 2023;2303.08774. Available from: https://arxiv.org/abs/2303.08774.
10. Google DeepMind. Gemini: a family of highly capable multimodal models. Available from: https://deepmind.google/technologies/gemini/.
11. Anthropic. Claude AI assistant. Available from: https://www.anthropic.com/claude.
12. Touvron H, Lavril T, Izacard G, Martinet X, Lachaux MA, Lacroix T, et al. LLaMA: open and efficient foundation language models. arXiv. 2023; 2302.13971. Available from: https://arxiv.org/abs/2302.13971.
13. Jiang AQ, Sablayrolles A, Mensch A, Bamford C, Chaplot DS, Casas DL, et al. Mistral 7B. arXiv. 2023;2310.06825. Available from: https://arxiv.org/abs/2310.06825.
14. Perplexity AI. Perplexity AI search engine. Available from https://www.perplexity.ai.
15. Xiao S, Zhang J, Zhu Y, Zhang Z, Cao H, Xie M, Zhang L. Application and Progress of Artificial Intelligence in Fetal Ultrasound. J Clin Med 2023 May 5;12(9):3298.
16. Horgan R, Nehme L, Abuhamad A. Artificial intelligence in obstetric ultrasound: a scoping review. Prenat Diagn 2023;43:289–303.
17. Reddy S. Generative AI in healthcare: an implementation science informed translational path on application, integration and governance. Implement Sci 2024;19:27.
18. Traylor DO, Kern KV, Anderson EE, Henderson R. Beyond the screen: the impact of generative artificial intelligence (AI) on patient learning and the patient-physician relationship. Cureus 2025;17:e76825.
19. Yim D, Khuntia J, Parameswaran V, Meyers A. Preliminary evidence of the use of generative AI in health care clinical services: systematic narrative review. JMIR Med Inform 2024;12:e52073.
20. Coghlan S, Gyngell C, Vears DF. Ethics of artificial intelligence in prenatal and pediatric genomic medicine. J Commun Genet 2024;15:13–24.
21. Lafarge C, Mitchell K, Fox P. Women's experiences of coping with pregnancy termination for fetal abnormality. Qual Health Res 2013;23: 924–36.

22. Wool C. Systematic review of the literature: parental outcomes after diagnosis of fetal anomaly. Adv Neonatal Care 2011;11:182–92.
23. Redlinger-Grosse K, Bernhardt BA, Berg K, Muenke M, Biesecker BB. The decision to continue: the experiences and needs of parents who receive a prenatal diagnosis of holoprosencephaly. Am J Med Genet A 2002;112:369–78.
24. Helm P, Munthe C, Akre H. Genetic counseling after diagnosis of fetal malformations: factors affecting pregnancy outcome. Prenat Diagn 1999;19:1004–9. 11<1004:AID-PD692>3.0.CO;2-R.
25. Saccà S, Corrias A, Ciullo V, La Monaca E, Liuzza MT, Bruno F, et al. Artificial intelligence and patient consent: a review of medico-legal and bioethical implications. Front Med 2024;11:1477371.
26. Funer F, Wiesing U. Artificial intelligence support tools and physician autonomy. Front Med 2024;11:1477371.
27. Flynn D, Moloney W, Bhattarai N, Scott J, Breckons M, Avery L, et al. The impact of artificial intelligence on the person-centred, doctor-patient relationship: some problems and solutions. BMC Med Inf Decis Making 2023;23:73.
28. Chan B. Black-box assisted medical decisions: AI power vs ethical physician care. Med Health Care Philos 2023;26:285–92.
29. Chervenak FA, McCullough LB. The professional responsibility model of obstetric ethics and caesarean delivery. Best Pract Res Clin Obstet Gynaecol 2013;27:153–64.
30. Park JS, Han K, Lee KH, Jung KJ, Choi J, Kim K, et al. Patient perspectives on informed consent for medical AI: a web-based experiment. Digit Health 2024;10:20552076241247938.
31. Koné Pefoyo AJ, López-Gómez V. Using artificial intelligence to enhance patient autonomy in healthcare decision-making. AI Soc 2024;39: 2347–57.
32. Chervenak FA, McCullough LB. The fetus as a patient: an essential ethical concept for maternal-fetal medicine. Am J Obstet Gynecol 2003; 189:123–7.
33. Alkaissi H, McFarlane SI. Artificial hallucinations in ChatGPT: implications in scientific writing. Cureus 2023;15:e35179.
34. Graber ML, Siegal D, Riah H, Johnston D, Kenyon K. Electronic health record-related events in medical malpractice claims. J Patient Saf 2019; 15:77–85.
35. Meskó B. Prompt engineering as an important emerging skill for medical professionals: tutorial. J Med Internet Res 2023;25:e50638.
36. Wang J, Shi E, Yu S, Chen Y, Xu K, Li Y. Prompt engineering for healthcare: methodologies and applications. arXiv. 2023;2304.14670. https://doi.org/10.48550/arXiv.2304.14670.
37. White J, Fu Q, Hays S, Sandborn M, Olea C, Gilbert H, et al. A prompt pattern catalog to enhance prompt engineering with ChatGPT. arXiv. 2023;2302.11382. https://doi.org/10.48550/arXiv.2302.11382.
38. Patil R, Heston TF, Bhuse V. Prompt engineering in healthcare. Electronics (Basel) 2024;13:2961.
39. Korenromp MJ, Page-Christiaens GC, van den Bout J, Mulder EJ, Hunfeld JA, Bilardo CM, et al. Psychological consequences of termination of pregnancy for fetal anomaly: similarities and differences between partners. Prenat Diagn 2005;25:1226–33.
40. Chervenak FA, McCullough LB. An ethically justified framework for clinical investigation to benefit pregnant and fetal patients. Am J Bioeth 2011;11:39–49.
41. Bickford J, Barton K, McInnes RJ. The experiences of women receiving a diagnosis of fetal anomaly: a systematic review of qualitative research. J Adv Nurs 2019;75:1883–98.
42. Hojat M, Mangione S, Nasca TJ, Cohen MJ, Gonnella JS, Erdmann JB, et al. The Jefferson Scale of Empathy: evolution, psychometrics, and current status. Acad Med 2019;94:1699–707.
43. Mercer SW, Reynolds WJ. Empathy and quality of care. Br J Gen Pract 2002;52:S9–12.
44. Sorin V, Brin D, Barash Y, Konen E, Klang E, Nadkarni G, et al. Large language models and empathy: systematic review. J Med Internet Res 2024;26:e52597.
45. Lee YK, Suh J, Zhan H, Li JJ, Ong DC. Large language models produce responses perceived to be empathic. arXiv. 2024;2403.18148. https://doi.org/10.48550/arXiv.2403.18148.
46. Luo M, Warren CJ, Cheng L, Wang G, Park J, Poon J, et al. Assessing empathy in large language models with real-world physician-patient interactions. arXiv 2024;2405.16402. https://doi.org/10.48550/arXiv.2405.16402.
47. Ovsyannikova D, de Mello VO, Inzlicht M. Third-party evaluators perceive AI as more compassionate than expert humans. Commun Psychol 2025;3:4.
48. Ayers JW, Poliak A, Dredze M, Leas EC, Zhu Z, Kelley JB, et al. Comparing physician and artificial intelligence chatbot responses to patient questions posted to a public social media forum. JAMA Intern Med 2023;183:589–96.
49. Thakkar A, Gupta A, De Sousa A. Artificial intelligence in positive mental health: a narrative review. Front Digit Health 2024;6:1337915.
50. Selvaraj S, Sharma N, Bhandari M. Empowering patients with AI-driven personalized care: the transformative power of generative AI and healthcare data integration. J Med Artif Intell 2024;7:15.