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Challenges and Strategies in Teaching Growth Monitoring and Interpretation of Child Growth Charts to Medical Students: A Narrative Review

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Abstract

Background: Growth monitoring and the interpretation of child growth charts are essential components of preventive pediatric care. This review aimed to examine educational challenges and effective strategies for teaching growth monitoring and child growth-chart interpretation to medical students.

Materials and Methods: We conducted a structured narrative review guided by the SANRA framework. We searched PubMed/MEDLINE, Scopus, Web of Science, Embase, ERIC, SID, Magian, CIVILICA, ISC, and Google Scholar from inception to April 2026, supplemented by citation tracking, reference-list screening, and grey-literature searches. Two researchers independently screened, extracted, quality-appraised, and thematically synthesized eligible English- and Persian-language quantitative, qualitative, interventional, and review studies.

Results: Thematic synthesis identified three interrelated domains. First, fragmented curricular delivery; predominantly hospital-based training; limited exposure to well-child and primary care settings; inadequate opportunities for repeated practice; and insufficient structured feedback hindered the translation of theoretical knowledge into clinical competence. Second, learners required proficiency in accurate anthropometric measurement; selection and plotting of appropriate growth charts; longitudinal, context-sensitive interpretation of growth trajectories; clinical reasoning; and family-centered communication. Third, structured modules; supervised skills workshops; case-based learning using serial growth data; simulation; outpatient placements; longitudinal portfolios; direct feedback; and multi-method, performance-based assessment were identified as potentially effective strategies. Although workshops and IMCI-based training improved short-term knowledge, evidence on skill retention, transfer to authentic clinical settings, and sustained effects on clinical performance remained limited.

Conclusion: A longitudinal, competency-based, primary care–oriented approach may better prepare medical students to deliver evidence-based, family-centered child health care. Integrating structured teaching; supervised anthropometric practice; case-based learning; simulation; outpatient experience; feedback; and performance-based assessment can strengthen technical accuracy, growth-trajectory interpretation, clinical reasoning, and communication with parents.

Key Words: Child growth monitoring, Growth charts, Medical education, Primary health care, Clinical competence.

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1- INTRODUCTION

Growth Monitoring and Promotion (GMP) is a core component of primary health care and preventive medicine. This process includes regular measurement of anthropometric indices, recording and plotting data, interpreting growth patterns, tracking changes over time, and providing appropriate education and care to the child and family. The World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) growth standards and charts are key tools for assessing child growth and are used to evaluate nutritional status and identify abnormal growth patterns, including underweight, wasting, stunting, overweight, and obesity (1, 2).

Assessing a child's growth involves more than locating a single measurement on a chart. Appropriate interpretation requires accurate measurement of length or height, weight, head circumference, and, at appropriate ages, body mass index; correct recording of data; attention to the child's age and sex; and evaluation of changes in growth indices across serial measurements. In addition, family growth history, previous growth patterns, and relevant clinical information should be considered when interpreting growth trajectories. Thus, growth monitoring is a multidimensional skill that integrates foundational knowledge, proficiency in anthropometric measurement, ability to plot and interpret growth charts, and clinical judgment. Acquiring these competencies is particularly important in pediatric medical education, especially for physicians who will work in primary care settings (3, 4).

Within the health system of the Islamic Republic of Iran, general practitioners play a key role in providing preventive and outpatient care for children, particularly in urban and rural comprehensive health service centers and within the Family Physician Program (5). These physicians are often the first health-care providers to interact with the child and family. Therefore, undergraduate medical education should prepare them to accurately measure growth indices, interpret growth charts, identify cases requiring follow-up or referral, and communicate effectively with parents.

The importance of teaching this skill is further highlighted by the fact that children may present with diverse patterns of nutritional and metabolic problems. Undernutrition, stunting, failure to gain weight, overweight, obesity, and emerging metabolic conditions such as early-onset type 2 diabetes each require appropriate assessment and long-term follow-up (6, 7). In this context, the physician must be able to distinguish between normal variations in growth, individual and familial differences, and patterns that suggest an underlying problem. Such decision-making requires an understanding of the concepts of growth trajectory and velocity, rather than merely memorizing numerical cutoffs or percentiles.

Despite the importance of this topic, the teaching of growth monitoring and growth chart interpretation in medical education programs may be insufficient or inconsistent. Previous studies have reported gaps in nutrition-related knowledge among medical trainees and have shown that structured educational interventions can improve students' knowledge and clinical skills (8, 9). These findings highlight the need for more systematic and practice-oriented instruction in child growth monitoring and nutrition.

Education in this area should not be limited to the transmission of information about growth charts. A comprehensive learning program should also aim to develop practical competencies, including accurate anthropometric measurement, appropriate plotting of measurements on growth charts, assessment of growth patterns over time, and interpretation of findings in the context of the child's clinical condition. Where relevant, students should also learn to communicate growth-related findings to parents in clear and understandable language. Accordingly, theoretical instruction should be complemented by hands-on practice, clinical case analysis, and timely feedback (9, 10).

The learning environment also plays an important role in developing these competencies. Pediatric clinics, comprehensive health service centers, child care programs, and electronic health systems can provide opportunities to link theoretical education with real-world practice. In such settings, students can become familiar with the process of recording growth data, reviewing prior records, interpreting changes over time, educating families, and making decisions about follow-up or referral. Utilizing these capacities requires purposeful educational design and coordination between medical schools and health-care delivery centers (5).

In addition, the method of student assessment should be aligned with the practical and multidimensional nature of this skill. Written examinations alone cannot adequately assess a student's ability to perform measurements, plot growth charts, interpret growth trajectories, or communicate with parents. Therefore, methods such as clinical scenarios, case-based learning, simulation, longitudinal portfolios, and Objective Structured Clinical Examinations (OSCEs) can be considered in designing a comprehensive assessment of this competency, in line with competency-based medical education frameworks (11–13).

Despite its centrality to primary pediatric care, there is limited synthesized evidence on how growth monitoring and growth chart interpretation are currently taught to medical students, what competencies are expected at graduation, and which educational strategies are most effective. Discussions related to curriculum content, learning environments, teaching methods, skills assessment, and strategies for student empowerment are scattered across various sources. Thus, a narrative review can provide a framework for examining these dimensions, identifying areas requiring attention, and introducing educational approaches that can be applied in medical education.

The aim of this narrative review is to examine the challenges and strategies in teaching growth monitoring and interpretation of child growth charts to medical students. Specifically, this study addresses three main areas:

- Examining educational dimensions and challenges in the curriculum, clinical learning environments, and the process of teaching skills related to growth monitoring and interpretation in children;
- Assessing students' educational and skill needs in the areas of anthropometric measurement, plotting and reading growth charts, interpreting growth trajectories, and communication with parents;
- Reviewing appropriate educational strategies, including case-based learning, simulation, training in outpatient settings, use of longitudinal portfolios, and performance-based assessment methods, with emphasis on their applicability in medical education and primary health care.

2- MATERIALS AND METHODS

2-1. Study Design

This study was conducted as a structured narrative review. This approach was selected because the topic encompasses heterogeneous evidence, including quantitative, qualitative, observational, interventional, and educational literature, which was not expected to be sufficiently homogeneous for meta-analysis. The review used a transparent and structured process for literature searching, study selection, data extraction, critical appraisal, and narrative synthesis.

The design and reporting of the review were informed by the domains of the Scale for the Assessment of Narrative Review Articles (SANRA), including justification of the review’s importance, clear statement of aims, description of the literature search, appropriate referencing, scientific reasoning, and presentation of relevant evidence (14). SANRA was used as a quality-oriented framework for reporting the narrative review rather than as a formal guideline for systematic-review conduct (14).

2-2. Review Question and Eligibility Framework

The eligibility criteria were developed using the Population, Concept, and Context (PCC) framework to define the scope of the review (15). The population included undergraduate medical students, including clinical clerks and interns, and, where relevant, postgraduate trainees if the findings directly informed undergraduate medical education. The concept was education and competency development related to child growth monitoring, anthropometric measurement, plotting and interpretation of growth charts, growth trajectory assessment, communication with parents, and assessment of these competencies. The context included medical schools, pediatric clinical settings, primary health-care centers, outpatient clinics, community-based training settings, and health-care delivery systems, with particular attention to the applicability of findings to the Iranian context.

2-3. Search Strategy and Information Sources

A comprehensive literature search was conducted from database inception to 30 April 2026. International electronic databases included PubMed/MEDLINE, Scopus, Web of Science, Embase, and ERIC. Persian databases included the Scientific Information Database (SID), Magiran, CIVILICA, and the Islamic World Science Citation Center (ISC).

To increase coverage of relevant literature, the reference lists of included articles and relevant review papers were manually screened. Forward citation tracking was also undertaken where available. In addition, Google Scholar was searched to identify grey literature, potentially relevant reports, theses, and preprints.

The search strategy combined controlled vocabulary, where available, with free-text keywords. The principal English search terms included: “growth monitoring,” “growth promotion,” “growth chart,” “growth curve,” “growth chart interpretation,” “anthropometric measurement,” “medical education,” “medical student,” “clinical clerk,” “intern,” “curriculum,” “simulation,” “primary health care,” and “Iran.” Persian search terms included:

“پایش رشد,” “ارتقای رشد,” “منحنی رشد,” “نمودار رشد,” “تفسیر نمودار رشد,” “اندازه‌گیری آنتروپومتریک,” “آموزش پزشکی,” “دانشجوی پزشکی,” “کارورز,” “کارآموز,” “برنامه درسی,” “شبیه‌سازی,” and “ایران”.

Boolean operators (AND and OR), truncation, and database-specific field tags were used as appropriate. In PubMed/MEDLINE, Medical Subject Headings (MeSH) were combined with free-text terms searched in title and abstract fields. The complete search strategies for all databases should be provided in a supplementary appendix to improve reproducibility.

2-4. Inclusion and Exclusion Criteria

Studies were included if they met the following criteria:

- Original quantitative, qualitative, mixed-methods, observational, or interventional studies relevant to teaching or assessing child growth monitoring and growth chart interpretation.
- Review articles that provided relevant conceptual, educational, or methodological evidence.
- Studies involving medical students, clinical clerks, interns, or, where directly relevant to undergraduate medical education, residents or other health-professions learners.
- Studies addressing one or more relevant domains, including anthropometric measurement, use of growth charts, interpretation of growth trajectories, nutritional-growth assessment, curriculum content, learning environments, educational interventions, learner challenges, instructor challenges, or performance-based assessment.
- Studies published in English or Persian from database inception through 30 April 2026.
- Studies with accessible full texts.

Studies were excluded if they focused exclusively on the clinical, epidemiological, diagnostic, or therapeutic aspects of pediatric growth disorders without an educational component. Letters to the editor, commentaries, editorial articles, conference abstracts lacking a full text, duplicate publications, and documents for which the full text could not be obtained after reasonable efforts were also excluded.

2-5. Study selection and data extraction

All retrieved records were imported into reference-management software and deduplicated. Two reviewers independently screened titles and abstracts against the predefined eligibility criteria, followed by full-text review of potentially eligible articles. Disagreements were resolved through discussion and consensus, with a third reviewer consulted when needed. The selection process was documented using a PRISMA 2020-style flow diagram (16).

Data were extracted independently by the two reviewers using a piloted, researcher-developed form. Extracted items included: bibliographic details; country; study design; population and sample size; educational and clinical setting; learner group; description of the educational intervention or curriculum; content on growth monitoring and growth-chart interpretation; identified challenges; assessment methods; and reported outcomes across knowledge, attitudes, practical skills, clinical reasoning, communication, and application in practice (16).

2-6. Critical Appraisal of Included Studies

Given the narrative nature of this review and the heterogeneity of study designs, formal quality appraisal was not used as a basis for excluding studies. Instead, key methodological features of each included study were documented to inform the interpretation and relative weighting of findings, with greater caution applied when drawing conclusions from studies with important limitations (16, 17).

2-7. Data Synthesis

Because of substantial heterogeneity in study designs, learner populations, interventions, outcomes, and assessment tools, meta-analysis was not appropriate. Findings were synthesized using a narrative thematic approach guided by the Popay framework for narrative synthesis of diverse evidence (16).

Extracted findings were organized into three overarching themes:

1. Educational and curricular challenges in teaching child growth monitoring and growth-chart interpretation;

2. Learner-related cognitive and skill challenges, including misconceptions and common errors in anthropometric measurement, plotting, and chart interpretation;

3. Evidence-informed educational strategies, including case-based learning, simulation, outpatient and primary care training, longitudinal portfolios, workplace-based learning, and performance-based assessment (16).

Within each theme, findings were compared across educational settings and health systems, with attention to contextual factors affecting transferability to Iranian medical education (e.g., undergraduate training structure, the role of general practitioners, the Family Physician Program, comprehensive health service centers, and the primary health-care delivery network) (16).

2-8. Ethical Considerations

This study was based exclusively on published and publicly available literature and did not involve direct contact with human participants, collection of identifiable personal information, or access to confidential patient data. Therefore, formal ethics committee approval and individual informed consent were not required (18).

Nevertheless, the review was conducted in accordance with principles of research integrity. These included transparent reporting of the search and selection process, accurate citation of original sources, faithful representation of study findings, acknowledgment of methodological limitations, and efforts to minimize selection and interpretation bias (18).

3- RESULTS

3-1. Characteristics of Sources and Methodological Considerations

Following the structured search, title and abstract screening, full-text assessment, and removal of duplicate and irrelevant records, eligible sources were included in the narrative synthesis. The evidence base comprised educational intervention studies involving medical students and interns, observational studies of health professionals' use of growth charts, quality-improvement initiatives addressing anthropometric measurement, surveys of parents' understanding of growth charts, educational-development reports, and professional guidelines and technical documents (1–12, 19–32).

The included sources were heterogeneous in design, setting, population, intervention characteristics, and reported outcomes. Some studies assessed short-term educational outcomes, including knowledge, attitudes, self-reported confidence, or satisfaction, whereas others examined the accuracy of anthropometric measurement, the ability to plot and interpret growth charts, clinical performance, or parental understanding of growth information. Given this heterogeneity, statistical pooling was not appropriate; findings were therefore synthesized narratively according to the prespecified objectives of the review.

Most educational intervention studies used single-group pre-test–post-test designs and generally reported improvements in interns' knowledge following nutrition, growth-monitoring, or Integrated Management of Childhood Illness (IMCI) training. However, the lack of control groups, small sample sizes, convenience sampling, reliance on knowledge-based outcomes, and limited long-term follow-up reduced confidence in the sustainability of these effects and their translation into clinical performance (8, 10).

Sargolzaie et al. reported improved knowledge of integrated child care among medical interns after IMCI education, whereas Noroozi et al. found improved knowledge of child nutrition and growth monitoring after an educational workshop for interns (8, 10).

Organizational and professional sources—including the WHO Child Growth Standards, the WHO Training Course on Child Growth Assessment, CDC growth-chart guidance, and professional recommendations on the use of WHO growth charts—were not considered primary empirical studies for methodological appraisal. Instead, they were used to establish technical standards for anthropometric measurement, chart selection, data plotting, assessment of growth trajectories, and clinical decision-making (2,11,19–21). These documents conceptualize growth monitoring as a process that includes accurate measurement, comparison with an appropriate growth reference, interpretation of the child's longitudinal growth pattern, and action such as counselling, follow-up, further assessment, or referral.

Observational studies and quality-improvement initiatives provided complementary evidence regarding performance-related challenges. Gupta et al. indicated that improving growth assessment in a pediatric hospital required more than didactic instruction; improvement depended on standardized processes, appropriate equipment, staff education, accurate documentation, and continuing feedback (22). Ezeofor et al. reported that health-care personnel had difficulty identifying slow weight gain and correctly interpreting growth charts; their judgments were influenced more by a child's current weight than by the longitudinal pattern of weight gain (23). Similarly, Wright et al.'s systematic review identified continuing difficulties among health professionals in the correct use and interpretation of growth charts (24). Ben-Joseph et al. further found that many parents experienced difficulty understanding growth charts, highlighting the importance of communication and counselling skills among health professionals who discuss growth information with families (25).

Educational theory and empirical evidence support the development of a competency-oriented approach to growth-monitoring education. Strowd et al. demonstrated the feasibility of introducing structured education on child growth during the pre-clerkship phase (4). Laird-Fick et al. showed that a progress clinical skills examination can be used to assess changes in medical students' clinical performance over time, although variations in case difficulty may limit the interpretation of longitudinal changes (12). Experiential learning, repeated practice in authentic settings, reflection, and constructive feedback are considered important components of workplace learning and clinical skill development (29). Case-based learning can promote active engagement and strengthen the connection between theoretical knowledge and clinical application (30). In addition, competency-based medical education requires alignment among intended learning outcomes, instructional strategies, and assessment methods (31). Elamin et al. reported improved academic performance after the integration of simulation-based learning into pediatric education, providing indirect support for the use of simulation to teach child growth monitoring and growth-chart interpretation (32).

Overall, the available evidence primarily addressed knowledge, anthropometric accuracy, and growth-chart interpretation. Relatively few studies assessed long-term retention of competence, sustained effectiveness of educational interventions, or transfer of learning to routine primary-care performance. The characteristics of included sources and their contribution to the synthesis are summarized in **Table 1**.

Table-1: Characteristics of sources and summary of evidence relevant to education in child growth monitoring and growth-chart interpretation.

Source	Type of study/source	Participants or setting	Focus or intervention	Finding relevant to the review	Role in narrative synthesis
WHO (2, 11)	Standard and training guidance	Children and health workers	Anthropometry and child-growth assessment	Provides principles for accurate measurement, plotting, interpretation, and clinical action	Technical and conceptual framework
Strowd et al. (4)	Educational module	Pre-clerkship medical students	Structured child-growth teaching module	Demonstrated the feasibility of introducing child-growth education during the pre-clerkship phase	Educational-development report; informs curriculum design
Sargolzaie et al. (8)	Pre-test–post-test study	Medical interns in a pediatric ward	IMCI training	Improved knowledge after training	Short-term educational evidence; no control group
Noroozi et al. (10)	Pre-test–post-test study	Medical interns	Child nutrition and growth-monitoring workshop	Increased knowledge of child nutrition and growth monitoring	Short-term, primarily knowledge-based outcome
Laird-Fick et al. (12)	Longitudinal educational assessment	Medical students	Progress clinical skills examination	Demonstrated the feasibility of assessing changes in clinical performance across educational stages	Supports longitudinal assessment of competence
CDC and NCHS (19, 20)	Guideline and technical report	Health workers	Use of growth charts	Provides guidance on chart selection, age groups, and interpretation of growth indicators	Technical framework
Dietitians of Canada et al. (21)	Professional guideline	Health professionals	Use of WHO growth charts	Emphasizes longitudinal interpretation and integration of chart findings with clinical context	Professional framework for clinical interpretation
Gupta et al. (22)	Quality-improvement initiative	Pediatric hospital	Standardization of growth assessment	Training, appropriate tools, standardized procedures,	Supports system-based and feedback-oriented skills

Source	Type of study/source	Participants or setting	Focus or intervention	Finding relevant to the review	Role in narrative synthesis
				documentation, and feedback improved growth-assessment processes	training
Ezeofor et al. (23)	Observational cross-sectional study	Health-care personnel in Nigeria	Application and interpretation of growth charts	Identified poor detection of slow weight gain and inadequate interpretation of longitudinal growth trajectories	Identifies real-world interpretive challenges
Wright et al. (24)	Systematic review	Health professionals	Use and interpretation of growth charts	Reported persistent difficulties in correct growth-chart use and interpretation	Synthesized evidence supporting educational needs
Ben-Joseph et al. (25)	National Internet-based survey	Parents of children	Understanding of growth charts	Parents reported difficulty interpreting growth charts	Supports communication and counselling training
Yardley et al. (29)	AMEE guide	Medical education	Experiential learning	Highlights authentic clinical experience, feedback, reflection, and repeated practice	Theoretical framework for workplace learning
McLean (30)	Educational review	Medical and health professions education	Case-based learning	Supports active learning and links theoretical knowledge with clinical application	Theoretical support for case-based learning
Holmboe et al. (31)	Educational article	Competency-based medical education	Competency assessment	Emphasizes alignment among intended outcomes, teaching strategies, and assessment methods	Assessment framework
Elamin et al. (32)	Pre–post educational study	Fifth-year medical students undertaking pediatric education	Integration of simulation-based learning	Improved educational performance following simulation-based curricular integration	Indirect evidence supporting simulation in pediatric education

Note: In this narrative review, the methodological limitations of empirical studies were considered when interpreting findings. Professional standards, clinical guidelines, technical reports, educational guides, and theoretical sources were included to provide technical or conceptual context and were not appraised as primary empirical studies (2,11,19–21,29–31).

3-2. Objective 1: Challenges in Curriculum, Learning Environments, and Teaching

The first objective of the review was to identify educational challenges related to curriculum content, clinical learning environments, and the teaching of skills required for child growth monitoring and growth-chart interpretation. Overall, the findings suggest that the principal challenge is not simply insufficient curricular content. Rather, it is the lack of a sustained connection between theoretical learning, repeated skills practice, feedback, and real-world clinical application.

During the pre-clinical phase, students may learn principles of child growth and development, anthropometric indicators, percentiles, and Z-scores. However, classroom- or lecture-based exposure alone does not ensure that students can select the appropriate chart, obtain accurate measurements, plot data correctly, interpret growth trajectories, or make appropriate decisions regarding follow-up and referral. The educational module developed by Strowd et al. showed that a structured child-growth module can be implemented during pre-clerkship education (4). The module included both didactic and interactive components and aimed to help learners accurately plot growth data and apply growth curves to clinical reasoning. Nevertheless, achieving sustained competence requires that learning be revisited and reinforced during subsequent curricular phases and across different clinical settings (3, 29).

From a curricular perspective, an exclusive focus on percentiles and Z-scores may encourage memorization rather than clinical reasoning. WHO standards and related training guidance emphasize accurate measurement, correct plotting, appropriate selection of indicators, comparison with prior measurements, and interpretation of the growth pattern over time (2, 11). CDC guidance similarly provides specific instruction on use of WHO growth standards for children from birth to 2 years, while professional recommendations on WHO growth-chart use emphasize interpreting growth indicators alongside clinical information, feeding history, health status, family characteristics, and the child's longitudinal growth pattern (19–21).

A further challenge is the predominance of hospital-based training. Pediatric inpatient wards are essential for teaching acute, chronic, and complex disorders. However, routine growth monitoring most commonly occurs in well-child clinics, primary health-care centers, public health networks, and outpatient settings. These settings provide opportunities to assess routine growth, identify common nutritional problems, recognize poor weight gain or excessive weight gain, counsel parents, and conduct longitudinal follow-up (1, 5, 6, 11). Limited exposure to such settings may leave graduates insufficiently familiar with the actual process of growth monitoring and growth-chart interpretation in primary care.

IMCI training for medical interns also illustrates the potential value of integrated child-health education. WHO's IMCI learning resources include a well-child module specifically addressing growth monitoring and feeding. In this type of integrated approach, assessment of growth and nutritional status can be linked to practical decisions, counselling, and follow-up planning (7, 8, 10, 11). Experiential-learning principles further suggest that competence develops through active participation, relevant clinical exposure, feedback, reflection, and repeated practice. Accordingly, simple attendance in a clinical setting without clear learning objectives, supervision, or feedback is unlikely to be sufficient for skill acquisition (29, 33).

In addition, competency-based assessment frameworks and workplace-based assessment tools highlight the importance of aligning learning outcomes, teaching strategies, and assessment methods for growth monitoring (31, 34–37). Without such alignment, assessment may fail to capture students' ability to measure, plot, interpret, and act on growth information in authentic clinical contexts.

As summarized in **Table 2**, fragmented curriculum content, hospital-centered training, limited practice opportunities, and insufficient feedback are interconnected challenges. Together, they may restrict students' ability to translate theoretical knowledge into accurate measurement, trajectory-based interpretation, and appropriate clinical decision-making in primary-care settings.

Table-2: Educational challenges in child growth monitoring and growth-chart interpretation: curriculum, learning environments, and teaching.

Challenge	Description	Evidence or guidance source	Implication for education	References
Fragmented curriculum content	Growth monitoring and growth-chart interpretation are often taught as isolated topics—for example, percentiles and Z-scores—without integration across the pre-clinical, clinical, and internship phases.	COMSEP curriculum competencies; WHO growth standards and training guidance; CDC growth-chart training	A spiral curriculum is needed to revisit growth monitoring at multiple stages, with progressively increasing complexity and clinical integration.	(2, 3, 11, 19)
Overemphasis on numerical indicators	Excessive focus on percentiles and Z-scores may encourage memorization rather than trajectory-based clinical reasoning.	WHO standards and training materials; CDC and NCHS technical reports; professional guidance on WHO chart use	Teaching should prioritize the interpretation of longitudinal growth patterns, clinical context, and appropriate decision-making rather than isolated numerical thresholds.	(2, 11, 19–21)
Limited integration of theory and practice	Pre-clerkship teaching may not be sufficiently linked to authentic clinical tasks, such as accurate measurement, chart plotting, interpretation, and counselling in primary-care settings.	Strowd et al.'s pre-clerkship growth module; WHO training course on child growth assessment; experiential-learning frameworks	Structured bridging activities—including OSCEs, case-based exercises, and supervised clinical sessions—are needed to connect classroom learning with real-world practice.	(4, 11, 29)
Hospital-centered clinical training	Most pediatric clinical exposure occurs in inpatient wards, whereas routine growth monitoring is primarily conducted in well-child clinics and primary-care settings.	Reviews of growth monitoring and promotion; public-health and nutrition studies in children; WHO guidance on growth monitoring as a primary-care process	Students should be deliberately placed in well-child clinics, vaccination clinics, and community health centers to observe and perform routine growth-monitoring activities.	(1, 5, 6, 11)

Challenge	Description	Evidence or guidance source	Implication for education	References
Limited opportunities for repeated practice and feedback	Students may have insufficient opportunities to perform growth assessments and may receive limited structured feedback on measurement technique, chart plotting, and interpretation.	Quality-improvement studies emphasizing standardized processes and feedback; experiential-learning and feedback literature	Workplace-based assessment tools, direct observation, repeated practice, and structured feedback should be incorporated into growth-monitoring training.	(22, 29, 33)
Insufficient integration of IMCI and well-child modules	IMCI and related child-health curricula may emphasize acute illness management more than routine growth monitoring, nutrition counselling, and longitudinal follow-up.	IMCI education studies among interns; WHO IMCI and child-growth-assessment materials	The well-child and nutrition components of IMCI should be strengthened and explicitly linked to growth-monitoring competencies.	(7, 8, 10, 11)
Weak alignment between assessment and competencies	Assessment methods may not adequately capture students' ability to measure, plot, interpret, and act on growth information in authentic clinical contexts.	Competency-based assessment frameworks; workplace-based assessment guides; portfolio and in-training assessment literature	Learning outcomes, teaching strategies, and assessment methods should be aligned. Assessment should include direct observation, case discussions, and reflective portfolios.	(31, 34–37)

Note: Sources cited in this table correspond to the full reference list (1–41). Empirical studies, guidelines, and theoretical frameworks were used to characterize educational challenges; methodological limitations of primary studies were considered when interpreting findings. IMCI: Integrated Management of Childhood Illness; WHO: World Health Organization; CDC: Centers for Disease Control and Prevention; NCHS: National Center for Health Statistics; COMSEP: Council on Medical Student Education in Pediatrics; OSCE: Objective Structured Clinical Examination.

3-3. Objective 2: Students' Educational and Skill Needs

The second objective was to examine students' educational and skill needs related to anthropometry, plotting and reading growth charts, interpretation of growth trajectories, and communication with parents. The findings indicate that these needs can be organized into three interconnected domains: practical measurement skills, cognitive and clinical-reasoning skills, and communication and counselling skills.

At the practical level, valid interpretation of growth depends on accurate measurement of weight, recumbent length or standing height, and head circumference. Errors related to weighing procedures, child positioning, use of equipment, age recording, equipment calibration, or data entry may alter the child's plotted position and lead to inaccurate clinical conclusions (2, 10, 22). Gupta et al. suggested that improving growth assessment requires a multicomponent approach involving standardized measurement techniques, appropriate equipment, staff training, data-recording procedures, and feedback (22).

Selecting an appropriate chart is also a practical and cognitive skill. Students should understand that chart selection depends on the child’s age, sex, indicator under assessment, and growth reference in use. WHO and CDC charts are used in different age groups and settings, and inaccurate age calculation, incorrect use of recumbent length versus standing height, or inappropriate chart selection can affect interpretation (2, 10, 19–21). CDC training materials specifically address the use of WHO Child Growth Standards for children from birth to 2 years and recommend transitioning to CDC growth charts at age 2 years, with caution in interpreting any change in percentile classification that may reflect differences between chart references rather than a true change in the child’s growth (19, 20).

At the cognitive level, the central educational need is a shift from cross-sectional interpretation toward longitudinal and context-sensitive analysis. A single percentile position does not independently establish whether a child’s growth is normal or abnormal. For example, a child who consistently follows a low percentile may have a familial or constitutional growth pattern, whereas a child whose weight or height trajectory declines across repeated visits may require further assessment even when the current measurement remains within a reference range (2, 10, 21, 26).

Wright et al.’s systematic review found persistent difficulties among health professionals in the use and interpretation of growth charts (24). Similarly, Ezeofor et al. reported limited identification of slow weight gain, with judgments influenced more by a child’s current weight than by the longitudinal pattern of weight gain (23). These findings indicate that students require explicit education in interpreting curve slope, growth velocity, crossing of percentile lines, consistency across multiple growth indicators, and relevant clinical risk factors.

At the communication level, students need to explain growth findings to parents using clear, understandable, and non-alarmist language. Providing an isolated statement—such as “your child is at the 5th percentile” or “your child is at the 95th percentile”—without discussing the growth trajectory, clinical context, and follow-up plan may create anxiety or misunderstanding. Ben-Joseph et al. reported that parents may experience difficulty interpreting growth charts, although 64% considered seeing the growth chart important for understanding their child’s health status (25). Therefore, medical students should be trained to use plain language, visual aids, teach-back questions, and practical recommendations that families can understand and apply. Communication skills can be further supported by structured assessment and feedback during clinical encounters (12, 33).

As shown in **Table 3**, practical and cognitive errors may compound one another. Accurate interpretation is impossible when anthropometric data are invalid; conversely, correct measurements alone do not ensure appropriate decisions if students cannot interpret the data longitudinally and in clinical context. The clinical benefit of growth assessment is realized only when findings can also be communicated clearly, empathetically, and in a manner that supports parent engagement.

Table-3: Students' practical, cognitive, and communication needs in education on child growth monitoring and chart interpretation.

Competency level	Educational need	Likely error or misconception	Potential consequence	Suggested educational and assessment strategy	Sources
Practical skills	Accurate weight measurement	Weighing with heavy clothing/diaper, inappropriate equipment, or recording error	Misestimation of weight-for-age or BMI-for-age	Practice with checklists, direct observation, and immediate feedback	(2, 10, 22)
Practical skills	Measurement of length, height, and head circumference	Improper child positioning, incorrect tool use, or recording error	Misclassification of length/height-for-age or head circumference-for-age	Simulation, repeated practice, and direct performance assessment	(2, 10, 22)
Practical/cognitive skills	Selecting appropriate chart and indicator	Choosing a chart mismatched to age, sex, or growth reference	Incorrect plotting and interpretation of data	Practice with diverse scenarios and standard charts	(2, 10, 19–21)
Cognitive skills	Analyzing trajectory and growth velocity	Focusing on a single point or percentile	Missing growth faltering or unnecessary referral	Analysis of longitudinal cases and case-based learning	(21, 23, 24, 26)
Clinical reasoning	Integrating growth data with nutritional and clinical status	Interpreting indicators in isolation and ignoring risk factors	Inappropriate decisions on follow-up, investigation, or referral	Decision-making scenarios and case discussions	(2, 10, 21, 26)
Professional communication	Explaining results to parents	Using complex language, labelling based on a single percentile, or vague advice	Parental anxiety, misunderstanding, or reduced engagement	Role-play, standardized parents, and communication feedback	(10, 12, 25, 33)

Note: Technical standards for measurement and interpretation are drawn from WHO, CDC, and the professional guide to using WHO growth charts. Difficulties in chart use and interpretation have been reported in studies of health staff, systematic reviews, and parental surveys (2, 10, 19–26). BMI: Body Mass Index; WHO: World Health Organization; CDC, Centers for Disease Control and Prevention.

3-4. Objective 3: Educational Strategies and Performance-Based Assessment

The third objective of the review was to identify educational strategies that may strengthen students' competence in child growth monitoring and growth-chart interpretation, with emphasis on case-based learning, simulation, outpatient and primary-care training, longitudinal records or portfolios, and performance-based assessment. The synthesis suggests that workshops and other short-term structured interventions can improve learners' knowledge. However, the development and maintenance of practical competence are more likely to require repeated practice, constructive feedback, authentic workplace exposure, and assessment of actual performance.

Growth and nutrition workshops for medical interns were associated with improved knowledge of child growth and nutrition (9, 10). Similarly, IMCI training improved interns' knowledge of integrated child care (8). These interventions may provide a useful initial foundation for competency development. Nevertheless, because most available studies assessed short-term and knowledge-based outcomes, they do not independently establish sustained improvement in practical skills or real-world clinical performance.

Case-based learning may help students move beyond memorization of growth concepts toward clinical reasoning. Students can engage with real or simulated cases that include serial growth-chart data, nutritional and medical history, family characteristics, and follow-up information. They can then interpret growth trajectories, identify relevant risk factors, consider diagnostic and management options, and make decisions regarding counselling, follow-up, investigation, or referral. McLean's review indicated that case-based learning can strengthen the link between theoretical knowledge and clinical application and promote active learning (30). In child growth education, this approach may be particularly useful for practicing interpretation of serial weight, height, body mass index, nutritional status, and warning signs over time (21, 24, 26).

Regarding assessment, the findings support the use of multimethod, performance-based approaches aligned with the multidimensional nature of growth-monitoring competence. Competency-based medical education requires alignment between intended learning outcomes, instructional strategies, and assessment methods (31). Written examinations can assess knowledge of growth indicators, cut-off points, chart selection, and interpretation principles. However, the ability to perform anthropometric measurements, plot data accurately, analyze growth trajectories, make clinical decisions, and communicate with parents requires direct observation and performance-based assessment. Potential approaches include Objective Structured Clinical Examinations (OSCEs), Direct Observation of Procedural Skills (DOPS), mini-Clinical Evaluation Exercises (mini-CEX), workplace-based feedback, and portfolios (11, 12, 31, 33).

An OSCE may provide a standardized setting in which students select appropriate instruments, perform anthropometric measurements, plot and interpret growth data, and communicate their findings to a standardized parent. OSCEs are particularly useful for assessing defined clinical tasks in controlled and standardized conditions, whereas DOPS and mini-CEX may be more suitable for observing students' performance in authentic clinical environments and providing immediate, formative feedback. Simulation-based training can also support repeated practice, structured debriefing, and the assessment of both technical and communication skills in a safe learning environment (39). Laird-Fick et al. demonstrated that a progress clinical skills examination can be used to assess changes in students' clinical performance over time and document the development of competence across successive stages of medical education (12). However, no single assessment method can capture all dimensions of clinical competence. Therefore, the selection of assessment methods should be aligned with the intended learning outcomes, the specific skill being assessed, the learner's level of training, the clinical context, and the purpose of the assessment (31, 36–39).

Simulation may also support the development of anthropometric measurement, chart plotting, interpretation of challenging scenarios, and communication with parents. Students can initially practice with mannequins, standardized data, standardized patients, or virtual scenarios and subsequently apply their skills in real clinical settings after receiving structured feedback. Elamin et al. reported improved performance in written, clinical, and continuous assessment components after the incorporation of simulation-based education into a pediatric curriculum involving 2,251 fifth-year medical students over 12 years (32). Although this study did not specifically address growth monitoring, it provides indirect support for simulation-based learning in pediatric education.

Outpatient and primary-care training should complement case-based and simulated learning. Because growth monitoring is preventive, longitudinal, and family-centered, well-child clinics, comprehensive health service centers, family medicine clinics, and other primary-care settings may provide particularly relevant learning environments (1, 5, 8, 10). In these settings, students can obtain anthropometric measurements in real conditions, review previous growth records, identify risk factors, discuss findings with parents, and contribute to follow-up planning. This approach is consistent with experiential-learning principles, including active participation in authentic clinical work, feedback, reflection, and repeated practice (29).

Longitudinal growth records or portfolios may offer an additional strategy for helping students understand growth as a dynamic process. Students can record, plot, and interpret the growth of one or more children across several visits, document their clinical reasoning, and receive feedback from faculty members or clinical supervisors. Such an approach may help students connect numerical growth data with nutritional status, family circumstances, clinical decision-making, and follow-up plans (11, 21, 29, 36).

Taken together, the reviewed evidence suggests that reliance on a single educational intervention may be insufficient for developing comprehensive and sustained competence in child growth monitoring and growth-chart interpretation. A staged and integrated educational approach may be more appropriate, beginning with foundational teaching of growth concepts and standards, followed by supervised practice of anthropometric measurement and chart interpretation in simulated settings. Students can then apply these competencies in outpatient and primary-care environments and consolidate their learning through direct observation, constructive feedback, and multimethod performance-based assessment (8–12, 21, 22, 29–32, 36).

Educational strategies and performance-based assessment methods, their target competencies, and key implementation considerations are summarized in **Table 4**.

3-5. Summary of Results

This structured narrative review indicates that challenges in teaching child growth monitoring and growth-chart interpretation extend beyond limited knowledge of percentiles and growth indicators. Fragmented curriculum delivery, hospital-centered training, limited exposure to primary-care settings, inadequate opportunities for supervised practice, anthropometric measurement errors, cross-sectional interpretation of growth data, and difficulty communicating with parents may all hinder competence development. The available evidence suggests that workshops and IMCI-based training can improve learner knowledge, but it provides limited evidence regarding durable changes in clinical performance. Development of sustained competence is therefore likely to require a longitudinal and integrated educational approach combining structured teaching, repeated skills practice, case-based learning, simulation, active outpatient participation, longitudinal records or portfolios, direct observation, timely feedback, and multimethod performance assessment (8–12, 21, 22, 29–32, 36).

Table-4: Educational strategies and performance-based assessment methods in education on child growth monitoring and chart interpretation.

Strategy	Suggested educational activity	Target competency	Appropriate assessment method	Implementation considerations	Sources
Structured module	Teaching growth indicators, anthropometry, chart selection, and interpretation	Conceptual knowledge and readiness for clinical application	Knowledge test, case assignment, and post-teaching quiz	Content should be revisited across curriculum stages	(3, 4, 10)
Skills workshop	Practice of weight, height/length, head circumference, data recording, and chart plotting	Accuracy of anthropometry and data recording	Direct observation checklist and DOPS	Should include repetition, feedback, and standard tools	(8–10, 22)
Case-based learning	Analysis of real or simulated cases with serial growth charts	Trajectory interpretation and clinical reasoning	Case-based test, group discussion, or analytical report	Scenarios should include risk factors and longitudinal data	(4, 21, 24, 26, 30)
Simulation	Practice of anthropometry, chart plotting, and counselling with standardized parents	Practical skills, communication, and decision-making	OSCE and structured checklist	Suitable for safe, repeated practice before real clinical exposure	(12, 22, 32)
Outpatient training	Active participation in well-child clinics and primary care centers	Application of skills in real settings and family-centered care	Mini-CEX, DOPS, and direct feedback	Requires clear objectives, clinical supervisor, and sufficient participation opportunities	(1, 5, 8, 10, 29)
Longitudinal record or portfolio	Recording, plotting, and analyzing child growth over multiple visits	Understanding the dynamic nature of growth and professional reflection	Portfolio assessment, faculty feedback, and self-assessment	Assessment criteria and follow-up schedule must be clear	(11, 21, 29, 36)
Multi-method assessment	Combination of knowledge test,	Comprehensive assessment of	Written test, OSCE, DOPS,	Tools should align with learning	(11, 12, 31, 36–

Strategy	Suggested educational activity	Target competency	Appropriate assessment method	Implementation considerations	Sources
	OSCE, and workplace assessment	knowledge, skills, reasoning, and communication	mini-CEX, and portfolio	objectives and learner level	39)

Note: This table was developed based on empirical studies of child growth monitoring and pediatric education, together with relevant clinical guidelines, professional recommendations, and theoretical literature on experiential learning, case-based learning, simulation-based education, and competency-based assessment (3, 4, 8–12, 21, 22, 24, 26, 29–32, 36–39). DOPS: Direct Observation of Procedural Skills; OSCE: Objective Structured Clinical Examination; mini-CEX: mini-Clinical Evaluation Exercise; IMCI: Integrated Management of Childhood Illness; BMI: Body mass index.

4- DISCUSSION

4-1. Study Aim and Main Findings

This structured narrative review examined the challenges and educational strategies involved in teaching child growth monitoring and growth-chart interpretation to medical students. The review addressed three areas: educational dimensions and challenges related to the curriculum, clinical learning environments, and teaching process; students' skill-related and educational needs in anthropometric measurement, plotting and reading growth charts, interpreting growth trajectories, and communicating with parents; and educational strategies and performance-based assessment methods applicable to medical education and primary health care.

The findings suggest that challenges in teaching child growth monitoring extend beyond inadequate knowledge of percentiles, Z-scores, and anthropometric indicators. A central challenge is the gap between conceptual learning and the ability to apply this knowledge in clinical practice. Fragmented curricular content, predominantly hospital-based training, limited exposure to primary care settings, errors in anthropometric measurement, reliance on single-point rather than trajectory-based interpretation, and difficulties in communicating growth information to parents may all hinder the development of student competence (1, 2, 4, 7, 9, 10, 21–26).

The review also suggests that workshops and structured educational interventions, including IMCI training, may improve learners' knowledge. However, improvement in knowledge alone does not necessarily indicate sustained clinical competence. Competence in growth monitoring encompasses accurate measurement, appropriate chart selection, accurate recording and plotting of data, longitudinal interpretation, identification of warning signs, decisions regarding follow-up or referral, and family-centered communication. An educational approach that integrates skills practice, case-based learning, simulation, outpatient exposure, feedback, and multimethod assessment may therefore be more appropriate than reliance on a single educational intervention (7, 9–12, 22, 29–32).

4-2. Curriculum, Learning Environments, and Teaching Process

The first objective was to examine educational challenges related to curriculum content, clinical learning environments, and the teaching of child growth-monitoring and growth-chart interpretation skills. The findings suggest that a major challenge is the discontinuity between theoretical teaching during the early stages of medical education and the application of these skills during clinical training. Students may be introduced to principles of growth and development, anthropometric indicators, percentiles, and Z-scores; however, without repeated opportunities for practice, feedback, and supervised clinical application, this knowledge may not translate into competence in growth-chart interpretation (2–4, 11).

Structured educational modules, including pediatric growth modules implemented during the pre-clerkship phase, may provide an appropriate foundation for focused instruction (4). Such instruction should also familiarize learners with the appropriate selection and use of standardized growth charts, including accurate plotting and interpretation of serial measurements (28). However, unless growth-monitoring education is revisited and reinforced during pediatric clerkships, internships, family medicine rotations, and primary-care placements, learners may have limited opportunities to consolidate and apply their knowledge. Child growth may therefore be addressed as a longitudinal curricular theme, with the progressive development of knowledge and skills as learners encounter increasingly complex clinical scenarios and assume greater responsibility for patient care (3, 4, 29).

Growth monitoring is inherently dynamic, and its clinical value is not limited to identifying a child's percentile at a single visit. WHO standards and growth-chart guidance emphasize accurate anthropometric measurement, appropriate indicator selection, precise data plotting, comparison with previous measurements, and interpretation of growth trajectories over time (2, 11, 21). Educational approaches that focus primarily on recalling cut-off values or Z-scores, without requiring learners to analyze serial data within clinical scenarios, may promote static and decontextualized interpretations of growth.

Hospital-centered training represents another relevant challenge. Pediatric inpatient wards are essential for learning about acute, chronic, and complex childhood conditions; however, they may provide fewer opportunities to observe and practice preventive care, well-child visits, nutritional assessment, family counselling, and longitudinal follow-up. In contrast, child growth monitoring is commonly undertaken in well-child clinics, outpatient pediatric services, primary health-care centers, public health networks, and family medicine settings (1, 5, 11).

This issue may be particularly relevant in Iran, where comprehensive health service centers and the primary health-care network play an important role in preventive care, nutritional assessment, and child growth monitoring as part of integrated national strategies to reduce preventable infant and child morbidity and mortality (5, 6, 40). Purposeful student placements in these settings may help narrow the gap between university-based education and the future responsibilities of general practitioners. Similarly, IMCI training among medical interns suggests that an integrated child-health approach can improve learners' knowledge of the assessment and management of common childhood health problems (8).

Evidence from studies involving health-care staff further supports the need to strengthen growth-monitoring education. Ezeofor et al. found that health workers had difficulty identifying slow weight gain and interpreting growth trajectories, with their judgements influenced more by a child's current weight than by the longitudinal pattern of weight gain (23). Wright et al. also identified continuing challenges among health professionals in the correct use and interpretation of growth charts (24). Although these studies did not specifically involve medical students, they identify errors that may represent relevant targets for undergraduate education.

Teaching may therefore need to extend beyond data recording to include trajectory interpretation, growth velocity, percentile crossing, and the integration of clinical and contextual factors.

Experiential-learning principles support this approach. The AMEE Guide on experiential learning describes competence development as involving authentic experience, active participation, feedback, reflection, and repeated performance (29). Accordingly, mere presence in clinical environments may be insufficient. Students need opportunities to perform skills under supervision, receive observation-based feedback, reflect on their performance, and repeat activities to improve. A staged curriculum may introduce growth concepts early, provide skills-laboratory practice, use case analysis during pediatric rotations, and enable supervised application in well-child clinics or primary-care settings.

4-3. Students' Skill-Related and Educational Needs

The second objective was to examine students' educational and skill-related needs in anthropometric measurement, plotting and interpreting growth charts, analyzing growth trajectories, and communicating with parents. These needs can be considered across three interconnected domains: practical and technical skills; cognitive and clinical-reasoning skills; and communication and family-centered counselling skills.

At the practical level, accurate anthropometric measurement is the foundation of valid growth assessment. Errors in weighing, measuring recumbent length or standing height, measuring head circumference, using uncalibrated equipment, recording age inaccurately, or plotting data incorrectly may alter a child's apparent position on a growth chart and lead to inappropriate clinical decisions (2, 11, 22). Anthropometric measurement should therefore be regarded as an observable clinical skill requiring standardized instruction, repeated supervised practice, direct assessment, and corrective feedback.

Gupta et al. found that improving growth assessment in a pediatric hospital required a multifaceted quality-improvement approach involving staff education, standardized procedures, appropriate equipment, and ongoing feedback (22). Although this study involved health-care staff rather than medical students, it has relevant implications for medical education. Classroom instruction or informal observation alone may not ensure proficiency. Students may benefit from repeated measurement practice, checklist-based direct observation, and targeted feedback on technical errors and strategies for improvement.

Appropriate selection of the growth chart and indicator is also a core component of competence. Students need to understand that chart selection depends on the child's age, sex, clinical context, and the growth reference used. Differences between WHO and CDC growth charts, methods of age calculation, use of recumbent length in younger children, use of standing height in older children, and changes in percentile classification when transitioning between growth references may affect interpretation (2, 11, 19–21). Therefore, teaching should include varied scenarios, such as children younger than 2 years, children born preterm, children with chronic illness, and children with overweight or obesity.

The central cognitive need is a transition from cross-sectional to longitudinal and context-sensitive interpretation. A child's low or high percentile alone is not sufficient to classify growth as normal or abnormal. Students should consider the direction and slope of the growth curve, growth velocity, percentile crossing, consistency across multiple anthropometric indicators, nutritional status, chronic disease, birth history, developmental status, and familial growth patterns (2, 11, 21, 26).

For example, a child who consistently tracks along a low percentile may have a familial or constitutional growth variant rather than pathological growth. Conversely, a sustained downward change in growth trajectory across serial measurements may warrant further assessment, particularly when supported by relevant clinical, nutritional, developmental, or psychosocial concerns.

Alterations in growth trajectory may also be clinically relevant in the early recognition of endocrine conditions, including disorders of pubertal timing. Accordingly, students should be encouraged to interpret growth patterns in conjunction with relevant clinical signs, pubertal development, medical history, and developmental history (41).

Scherdel et al. showed that the performance of growth-failure screening approaches is influenced by the indicator selected, the number and timing of measurements, and the referral threshold applied (26). Thus, teaching should not be confined to memorizing cut-off values. It should strengthen students' ability to interpret uncertainty, compare serial measurements, recognize potentially concerning changes in growth trajectory, and make contextually appropriate clinical decisions.

Communication and counselling skills represent a third essential domain. Interpreting growth charts in clinical practice is incomplete without the ability to discuss findings effectively with parents or caregivers. Parents may experience anxiety about growth percentiles, misunderstand growth trajectories, or express concern about their child's body size (25).

In the national survey by Ben-Joseph et al., many parents had difficulty interpreting plotted data and the meaning of percentiles, despite prior exposure to growth charts (25). Students should learn to communicate growth information clearly, avoid excessive technical jargon, elicit parental concerns, explain what the growth trajectory indicates, and provide practical nutritional and developmental guidance (11, 25). Rather than simply reporting a percentile or Z-score, students should explain the child's growth trajectory, the basis for reassurance or concern, relevant modifiable factors, and the follow-up plan.

Family-centered communication also requires avoiding premature labelling based on a single measurement. For example, describing a child as "short" or "obese" without contextual interpretation may increase parental anxiety and may not accurately reflect the child's growth pattern. Discussions should focus on longitudinal growth patterns, family concerns, feasible actions, and shared follow-up decisions. Role-play, standardized parents, and OSCE-based assessments may be useful approaches for developing these skills (12, 25). Structured feedback should accompany these activities and should be specific, constructive, balanced, and focused on the gap between the student's observed performance and the expected standard (33).

4-4. Objective 3: Educational Strategies and Performance-Based Assessment

The third objective was to examine relevant educational strategies and performance-based assessment methods. The findings suggest that sustained competence in child growth monitoring is unlikely to result from a single intervention. A staged and integrated approach combining focused instruction, practical skills training, case-based learning, simulation, authentic clinical experience, direct feedback, and multimethod assessment may be more suitable.

Iranian studies suggest that IMCI training and workshops on child growth and nutrition can improve medical interns' knowledge (7, 9). Such interventions may establish foundational knowledge and introduce growth-monitoring principles. However, because most available studies assessed short-term knowledge outcomes, higher post-test scores should not be interpreted as sufficient evidence that learners can accurately measure, plot, interpret serial growth charts, or counsel parents in routine clinical practice. These activities may be more useful when embedded within a longitudinal educational programme that includes supervised performance practice and structured feedback.

Case-based learning is well suited to moving students from factual recall toward clinical reasoning. It enables students to work with real or simulated child cases containing serial anthropometric measurements, growth charts, nutritional information, clinical history, and parental concerns. Students can interpret the available data, identify risk factors, consider possible explanations, and decide on counselling, follow-up, investigation, or referral. A BEME systematic review found that case-based learning may support diverse learning outcomes in health-professional education, although the quality and implementation of the included studies were variable (38).

In growth education, case-based scenarios should use serial rather than isolated growth data. For instance, a case may describe a child whose weight-gain velocity has declined across three visits while weight-for-age remains within the reference range. Students should recognize that this downward trajectory may warrant exploration of feeding history, intercurrent illness, family circumstances, and an appropriate follow-up plan, even if a single measurement does not fall outside the reference range. Such cases may help learners move beyond single-point interpretation and practice trajectory-based decision-making.

Simulation may be useful for teaching anthropometric measurement, chart plotting, complex case interpretation, and communication with parents. Students may practice measuring length, height, weight, and head circumference using mannequins or standardized equipment; subsequently plot the data on growth charts; and explain findings to a standardized parent. Simulation may offer a safe environment for repeated practice, immediate feedback, and correction of errors before application in clinical settings.

Elamin et al. reported that the introduction of simulation-based learning into a pediatric curriculum was associated with improved written, clinical, and continuous-assessment performance among 2,251 fifth-year medical students over a 12-year period (32). Although the study did not focus specifically on growth monitoring or growth-chart interpretation, it provides indirect support for incorporating simulation into pediatric education. Similarly, a recent review concluded that simulation-based training may improve learners' knowledge, practical skills, and clinical performance, although its effectiveness may vary according to the type of simulation, the educational setting, the learners' level of training, and the assessment methods used (39).

However, simulation should complement rather than replace learning in authentic clinical environments. Growth monitoring is preventive, longitudinal, and family-centered; therefore, its practice is particularly relevant in well-child clinics, comprehensive health service centers, and family medicine settings (1, 5, 7, 10). Outpatient training allows students to perform measurements in real conditions, compare results with previous visits, explore nutritional and social contributors to growth, respond to parents' questions, and participate in follow-up planning. This form of learning is consistent with experiential-learning principles and may facilitate the transfer of skills from simulated to clinical practice (29).

Longitudinal records and portfolios can reinforce outpatient learning. Students may document the growth of one or more children over repeated visits, plot and interpret measurements, record their clinical reasoning, reflect on decisions, and receive feedback from faculty members or clinical supervisors. Driessen et al. found that portfolios are more likely to support competence development when integrated into the curriculum, accompanied by clear objectives, mentor support, and regular feedback (34). Thus, a growth-monitoring portfolio should go beyond completed forms and include reflection, interpretation of longitudinal patterns, response to feedback, and an action plan for improvement.

The findings also support multimethod assessment. Written examinations may assess conceptual knowledge of indicators, chart selection, and interpretation principles, whereas practical and communication skills require performance-based assessment (11, 12, 31). OSCEs may assess students' ability to select appropriate equipment, perform measurements, plot data, interpret growth trajectories, and counsel a standardized parent. Direct observation, DOPS, and mini-CEX may be better suited to evaluating performance in authentic clinical settings and providing immediate educational feedback (35).

The educational value of workplace-based assessment depends on repeated observations, a range of clinical contexts, high-quality feedback, and the use of assessment information to guide subsequent learning (36). A single observation of a student measuring or interpreting child growth is unlikely to be sufficient to judge overall competence. Moonen-van Loon et al. found that combining data from multiple workplace-based assessment tools within a portfolio can improve the reliability of competence judgments compared with relying on a single assessment tool (37).

Structured feedback provides an important connection between teaching and assessment. Feedback is most useful when it is specific, constructive, balanced, behaviorally anchored, and clearly identifies the gap between observed and expected performance (33). In growth-monitoring education, feedback should identify what the student performed correctly and what requires improvement, for example, child positioning during length measurement, chart selection, age recording, reliance on a single percentile, or clarity of explanation to parents. Learners should then have a further opportunity to repeat the task and demonstrate improvement.

4-5. Educational and Practical Implications

The findings of this review have several implications for medical curriculum design:

- Child growth monitoring may be incorporated as a longitudinal and staged curricular theme. Core concepts and indicators can be introduced during the pre-clinical phase; anthropometric skills can be practiced in clinical skills laboratories; longitudinal case interpretation can be developed during pediatric and family medicine rotations; and authentic performance can be supported during internship and primary-care placements.
- Teaching may need to shift beyond numerical values and isolated percentile positions towards interpretation of growth trajectories, growth velocity, changes across visits, and relevant clinical and social contexts. Students

should be able to distinguish between a low but stable growth pattern and a clinically relevant deviation from an established growth trajectory.

- Well-child clinics, comprehensive health service centers, and family medicine settings can function as active learning environments. In Iran, these locations may strengthen alignment between undergraduate medical education and the preventive, nutritional, and child-growth services delivered in primary care (5, 6, 8, 40).
- Communication with parents should be considered an explicit educational outcome. Learners should be able to explain growth findings without unnecessary alarm, respond to family concerns, offer recommendations suited to the child's and family's circumstances, and confirm parental understanding.
- Assessment should align with the intended learning outcomes. If the intended outcome is that graduates can accurately measure, interpret, and communicate child growth findings, written examinations alone are unlikely to be sufficient. OSCEs, direct observation, DOPS, mini-CEX, portfolios, and structured feedback can complement written assessment (11, 12, 31, 33, 34, 35, 37).

4-6. Strengths and Limitations

This review has several strengths. It organized the evidence around three pre-specified objectives, applied a structured narrative-synthesis approach, addressed curriculum challenges, student skill needs, and educational strategies together, and linked medical education with primary health-care requirements. The inclusion of Iranian studies alongside international evidence and child-growth standards also supported the formulation of contextually relevant educational implications.

Several limitations should be considered. Heterogeneity in study designs, participant groups, educational settings, interventions, and outcome measures limited direct comparison and precluded meta-analysis. Many educational interventions used single-group pre-test–post-test designs and focused on short-term outcomes, especially knowledge or self-reported confidence. Therefore, conclusions regarding sustained skill development and transfer of learning to real primary-care practice should be interpreted cautiously.

In addition, some evidence concerning difficulties with growth-chart use and interpretation was derived from health-care professionals or parents rather than medical students. Although these sources identify potential challenges in measurement, interpretation, and family communication, their results cannot be directly generalized to medical students. Future research should evaluate longitudinal, controlled, multicenter educational programs using validated performance outcomes and assess whether learning transfers to authentic primary-care settings.

5- CONCLUSION

This structured narrative review indicates that teaching child growth monitoring and growth-chart interpretation to medical students should extend beyond theoretical instruction on percentiles, Z-scores, and anthropometric indicators. Competence in this area requires the integration of accurate anthropometric measurement, appropriate selection and plotting of growth charts, longitudinal interpretation of growth trajectories, clinical reasoning informed by nutritional, medical, and family contexts, and clear, family-centered communication.

The main challenges identified were fragmented curricular content, predominantly hospital-based clinical training, limited exposure to well-child and primary-care settings, insufficient opportunities for repeated skills practice, cross-sectional rather than trajectory-based interpretation of growth data, and limited access to structured observation and feedback.

Accordingly, education in child growth monitoring may benefit from a longitudinal, integrated, and competency-based approach. Core concepts can be introduced during the pre-clinical phase, reinforced through clinical skills laboratory sessions and pediatric clerkships, and consolidated through supervised practice in well-child clinics, comprehensive health service centers, and family medicine settings. A staged educational approach that combines structured modules, case-based learning, simulation, repeated supervised practice, longitudinal growth records or portfolios, direct feedback, and performance-based assessment may strengthen students' technical accuracy, clinical reasoning, communication skills, and readiness to provide preventive, evidence-informed, and family-centered child health care.

6- AUTHORS' CONTRIBUTIONS

Study conception and design: HK and SP. Data analysis and initial manuscript drafting: SP and HK. Critical revision of the manuscript: SP. Supervision of the research: HK and SP. Final approval of the version to be published: HK and SP.

7- CONFLICT OF INTEREST: None.

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