

Case-Based Curriculum for Pediatric Residents in Diabetes Fundamentals

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Abstract

Introduction: Pediatricians are at the front line to diagnose new-onset diabetes and treat acute diabetes complications in children. Pediatric residents need a strong foundation in recognizing and managing pediatric diabetes, imposing a demand for a structured, comprehensive pediatric-specific diabetes curriculum. **Methods:** This three-module case-based curriculum focused on diabetes fundamentals relevant to pediatricians in the outpatient and inpatient settings. Each module covered an independent topic within pediatric diabetes. Topics included diabetic ketoacidosis, new-onset diabetes management, and acute complications of diabetes. The modules were focused, short, and flexible to accommodate learners' demanding clinical duties and time limitations. We delivered the curriculum to pediatric residents rotating in the inpatient endocrinology department over 3 separate days. Pre- and posttests assessed learners' knowledge and confidence in diabetes care. **Results:** We tested the curriculum for 7 months in 10 individual cycles, with 11 learners participating. We noted an increase in learners' scores on diabetes knowledge assessment of 16% (95% CI, 5-28; $p = .01$) after completing the curriculum. The residents' confidence in performing diabetes clinical care skills also improved, with the majority going from reporting low or neutral confidence before instruction to reporting high confidence after instruction. Learners reported 100% extreme satisfaction with the curriculum. **Discussion:** This case-based curriculum exposed residents to pediatric diabetes using authentic, clinically relevant, engaging scenarios. The curriculum enabled learners to actively rationalize their thought process and slow down learning. Short and focused, the curriculum was suitable for mitigating the cognitive load and the time constraints in busy clinical environments.

Keywords

Pediatric Diabetes, Pediatric Endocrinology, Pediatrics, Physician, Case-Based Learning, Editor's Choice

Educational Objectives

By the end of this activity, learners will be able to:

1. Analyze clinical data to diagnose new-onset diabetes or diabetic ketoacidosis (DKA).
2. Recognize risks and clinical features of acute DKA complications (electrolyte disturbances and cerebral edema).
3. Choose an appropriate inpatient therapy plan for DKA and its related acute complications.
4. Differentiate clinical features of type 1 diabetes compared to type 2 diabetes.
5. Select appropriate subcutaneous insulin regimen for children with new-onset diabetes.
6. Critique blood glucose trends in relation to insulin regimen and adjust insulin doses accordingly.

7. Recognize risks for acute complications of diabetes (ketosis, hyperglycemia, and hypoglycemia).

Introduction

There is a rising prevalence of diabetes in children, with a growing incidence of type 1 diabetes (T1D) by 1.4% annually and type 2 diabetes by 7.1% annually.^{1,2} Pediatricians, emergency room physicians, and pediatric hospitalists/intensivists are at the front line to diagnose new-onset diabetes and treat acute diabetes complications in children. Moreover, the shortage of and limited access to pediatric endocrinologists impose a need for pediatric residents to have a strong foundation in recognizing and managing pediatric diabetes, whether they pursue general practice or subspecialty.³⁻⁵

Limited but increasing evidence shows an association between dedicated diabetes educational curricula and positive outcomes in advancing knowledge and confidence in diabetes care among internal medicine residents, as well as in improving patient care by reducing medical errors.⁶⁻⁹ However, there is a paucity of published educational tools that provide a comprehensive

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review of pediatric diabetes. The majority of available resources are focused on adults. A review of available pediatric-specific diabetes curricula in *MedEdPORTAL* and other publications revealed various limitations, including that these publications focus on limited or outpatient aspects of diabetes management, are embedded within a general overall endocrinology curriculum, involve specific educational techniques (e.g., team-based learning, simulation) that may preclude implementation in clinical teaching settings, or are self-directed with limited engagement and learner completion rates.^{6,10-14} To bridge these limitations and facilitate teaching residents the intricacies of pediatric diabetes fundamentals, we designed a structured pediatric-specific curriculum that is learner centered and comprehensive and provides an engaging educational delivery method flexible to several learning environments.

This curriculum was unique in that it utilized a case-based learning approach, which is an inquiry-based teaching method. It was centered around authentic, realistic cases and was structured to allow learners to think critically by promoting discussion using open-ended questions with well-defined learning goals. We chose the case-based approach because of its several advantages, which include (1) providing an enjoyable learning experience for both the learner and teacher by engaging and motivating adult learners; (2) mirroring the clinical reasoning process and thus matching the learning context to the performance context; (3) being feasible to implement in several settings (clinical teaching, small-group discussions, or large groups); (4) being associated with enhanced clinical knowledge and skills, improved practice behavior, and improved patient outcomes; and (5) integrating provocative questions aimed to enhance clinical reasoning.¹⁵⁻¹⁸ The instructional goal of this resource was to educate pediatric residents about relevant pediatric diabetes fundamentals and demonstrate their ability to (1) diagnose, classify, and manage new-onset diabetes; and (2) identify and manage acute complications of T1D, including diabetic ketoacidosis (DKA), hyperglycemia, ketosis, and hypoglycemia.

Methods

Learners and Learning Context

The curriculum targeted pediatric residents. At our institution, learners rotated through a combined inpatient and outpatient diabetes and endocrinology rotation for 4 weeks (one to three learners per month). Learners included residents in a categorical pediatric program or combined pediatric-specialty programs (e.g., pediatric-medicine, pediatric-genetics, or pediatric-neurology programs). The majority of rotating learners were interns

(first-year trainees), with a few participating senior residents (second or third/final year). Before we implemented this curriculum, rotating residents received 1-hour traditional lectures (one to three times per week) addressing multiple endocrinology topics without a structured sequence. Residents did not necessarily attend a diabetes didactic session during their rotation. Our learners had frequent clinical exposure to diabetes in children, as the training center was a tertiary referral pediatric hospital in a large urban city with a specialized pediatric diabetes inpatient unit having a six-pediatric-bed capacity to treat uncomplicated DKA (the average number of new-onset diabetes was one to five patients per week). However, similar to most residency training centers, opportunities to learn the intricacies of diabetes care relied heavily on self-study and clinical teaching exposure (e.g., whether residents had the chance to treat patients with DKA). We offered rotating residents the opportunity to enroll in this nonmandatory educational activity. All the residents we approached were eager and motivated to participate and completed the educational modules during their rotation. The Baylor College of Medicine Institutional Review Board approved this educational study.

Instructional Strategy

We delivered the curriculum during inpatient weeks, during which residents actively practiced caring for hospitalized children with diabetes of variable complexity and at variable volumes. We designed the instructional method to be focused, short, and flexible to accommodate learners' demanding clinical duties and time limitations. The curriculum can be implemented in any setting. During the COVID-19 pandemic, two participants received instruction remotely during their outpatient week using videoconferencing software with a shared screen option to project the educational material during six remote learning sessions.

The curriculum consisted of three case-based modules delivered on 3 separate days. Each module focused on independent in-depth learning goals and objectives with an individualized instructor guide: (1) the DKA module (Appendices A and B), (2) the new-onset diabetes management module (classification, insulin therapy, and glycemic goals; Appendices C and D), and (3) the acute complications of diabetes module (ketosis, sick day management, hypoglycemia; Appendices E and F). We sequentially delivered the modules; however, each module can be given as a stand-alone activity and in any order. There was no required preactivity preparation. The duration of each educational session was an average of 30 minutes (ranging from 15 to 45 minutes).

We designed our instructional modules using the Dick and Carey Model.¹⁹ We developed the cases based on the American Board of Pediatrics General Pediatrics Content Outline²⁰ and focused on topics relevant to the general pediatrician and designed to resemble real-life situations. We focused on scenarios that pediatricians often face during outpatient and inpatient care of children with T1D. We minimized topics out of the pediatrician care scope, which would typically require endocrinologists to screen and manage (e.g., chronic complications of T1D). Residents did not require prior knowledge outside of what they had learned during their basic science and clinical years of medical school. We scripted the case questions to enable learners to actively rationalize their thought process, identify and explore misconceptions, slow down learning, and make thinking explicit.

We delivered the education in a small-group setting in the afternoon in a hospital conference room to limit distractions. Our average facilitator to learner ratio was 1:1 or 1:2 in each case session, as we only had one to two residents at a time working the morning shift. However, we believe the case-based sessions can be generalizable to a larger number of small-group participants without modification.

Facilitators

One pediatric endocrinology fellow delivered the curriculum. We developed an instructor guide with considerable details and clear learning points to facilitate the generalizability of instruction to pediatric hospitalists, intensivists, general pediatricians, or endocrinologists. Each module had a specific facilitator guide (Appendices A, C, and E) with a first page detailing the module overview, learning objectives, instructional strategy, and facilitator role. We recommend that facilitators use this guide to prepare for and implement each module.

At each session, the facilitator handed out a printed learner version of the case-based module to the residents (Appendices B, D, and F) and pointed out the introductory instructions aimed at setting up the learning expectations (e.g., describing the flow of the modules and acknowledging the safe learning environment with a think-aloud approach). The facilitator then followed the scripted instruction detailed in the facilitator guide of each case-based module. Based on learners' feedback, we designed a handout to give to learners at the end of each session summarizing the learning points (Appendix G).

Assessment

We designed a multiple-choice test about diabetes fundamentals. We mapped the test questions around the learning objectives

of all three modules. We used two versions of the test, a seven-question test (administered to three learners) that we revised and expanded into an 18-question test (administered to eight learners). Furthermore, we included five questions assessing residents' confidence level in specific diabetes care aspects based on a 5-point Likert scale (1 = *extremely disagree*, 5 = *extremely agree*). Learners completed this assessment before the first instruction during the first week of the rotation (pretest) and at the end of their rotation (posttest), using either a paper or an electronic format. The time to complete the assessment varied between 5 and 15 minutes. The assessment (Appendix H) can be used to assess the effectiveness of the three modules collectively. We also expanded the answer key to include clinical pearls that can be provided as feedback to learners to reflect on the correct answers (Appendix H).

Learners also received formative feedback during case discussions around the specific learning objectives of each case-based module. The facilitator explored learners' reasoning as they rationalized their decisions aloud while answering the structured multistep questions. These facilitated discussions were centered around the learning objectives and provoked higher-order thinking and problem-solving discussions to reinforce appropriate responses or correct misconceptions. The facilitator guides provided explanations and discussion prompts to facilitate feedback for learners when they recommended either appropriate or inappropriate answers and expanded on each specific learning objective.

We evaluated the educational activity by the end of the rotation by asking the learners to anonymously report their satisfaction with the overall learning activity rated on a 5-point Likert scale (1 = *extremely dissatisfied*, 5 = *extremely satisfied*) using an electronic or paper-based evaluation. We also elicited a qualitative evaluation of the learning activity by asking learners to write down what they liked most about the learning activity and what they would like to change or improve in it.

Results

We tested the curriculum for 7 months (January 2020-July 2020) in 10 individual educational delivery cycles (each cycle had three case-based learning sessions). The total sample size was 11 pediatric residents with variable characteristics (Table 1).

Assessment of Knowledge and Confidence in Diabetes Skills
Of the 11 participants, 100% completed the pretest, and 91% completed the posttest. We calculated the percentage of correct answers for the pre- and posttests and compared the mean scores using a paired sample *t* test. We found a notable increase

Table 1. Learners Participating in the Case-Based Curriculum (N = 11)

Learner Characteristics	No. (%)
Resident level	
Interns (PGY 1)	10 (90)
Senior residents (PGY 2-4)	1 (10)
Residency program	
Categorical pediatric program	8 (73)
Combined pediatric-medicine program	1 (9)
Combined pediatric-other program	2 (18)
Exposure to pediatric endocrinology rotation	
No prior exposure	11 (100)
Number of residents per educational session	
1:1 facilitator to learner	9 (82)
1:2 facilitator to learner	2 (18)

in learners' scores by 16% that was statistically significant (95% CI, 5-28; paired $t = 3.1$; $p = .01$; Figure).

We found that residents increased their confidence in performing diabetes clinical care tasks after completing our educational curriculum. Before instruction, the majority of residents had low or neutral confidence in the acute management of pediatric DKA (64%), the identification or management of acute diabetes complications (91%), and their basic knowledge of diabetes fundamentals (64%). We noted an increase in their confidence postinstruction, with around 90%-100% of residents reporting high confidence across all aspects of diabetes clinical care skills (Table 2).

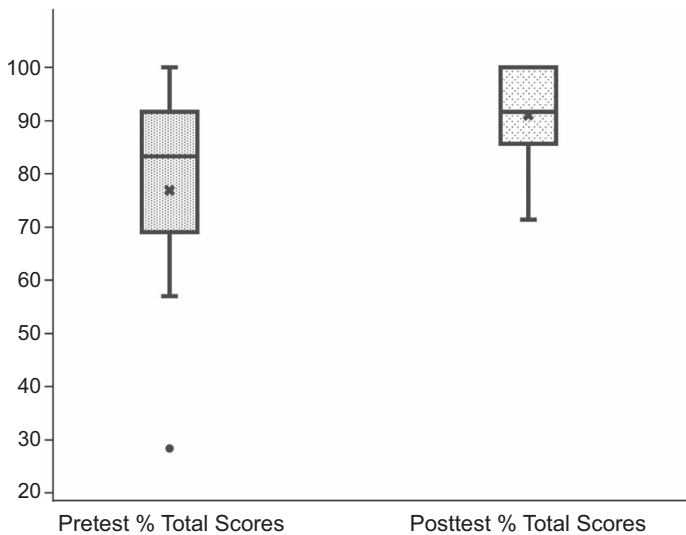


Figure. Diabetes knowledge test results. The Figure shows box plots of the pretest and posttest scores, as calculated from the percentage of correct answers. The x within each box represents the mean, and the horizontal bar within each box represents the median. The lower and upper boundaries of each box represent the 25th and 75th percentiles, respectively. Whiskers below and above each box represent the minimum and maximum scores, respectively. The dot denotes an outlier observation.

Evaluation of Satisfaction

Learners reported 100% extreme satisfaction with the overall learning activity. Furthermore, qualitative assessment of the learning activity demonstrated positive reactions to the case-based instructional method. Collective written comments organized by simple themes about the educational curriculum are summarized below.

Favorable qualitative feedback from different learners:

- Active engagement in thinking aloud:
 - “I liked that I was encouraged to vocalize my thought process through the prompts before the explanation, and the next steps were explained.”
 - “I really appreciated being encouraged to talk through my thought process out loud.”
 - “I liked the interactive nature of the cases and the talking out loud while thinking through answers.”
- Mirroring of the clinical reasoning process:
 - “I liked that it is case-based and that it prompted me to make clinical decisions in a stepwise manner. The exercise mimicked the idea of mental modeling that is much appreciated from the experts—i.e., fellows, attendings.”
- Clinical relevance:
 - “The clinically relevant scenarios made the material easier to remember.”
- Fostering interactive discussions:
 - “Cases were helpful and often not straightforward. It prompted stimulating discussions.”
 - “I liked that it is short, interactive, and made me think about the [why’s] in management.”
- Positive educational experience compared to traditional didactics:
 - “I would rather have this instead of daily lectures.”
 - “We should do this daily, in place of our part (or all) of the didactic lecture sessions.”

Points to change or improve on provided by several learners:

- Timing the curriculum at the beginning of the rotation:
 - “Would love to have these earlier in the rotation because I think they would have been really helpful to have prior to diabetes week.”
 - “I would make it as a mandatory/scheduled seminar at the beginning of endocrinology rotation.”
- Provide supplemental educational material:
 - “Provide some kind of physical handout to take/keep with pertinent information.”
 - “Maybe color pictures or short video explanations.”

Table 2. Diabetes Clinical Skills Confidence Level

Clinical Skill	Confidence Level No. (%) ^a					
	Preinstruction ^b			Postinstruction ^c		
	Low Confidence ^d	Neutral	High Confidence ^e	Low Confidence ^d	Neutral	High Confidence ^e
Recognizing the signs and symptoms of diabetes in children.	0 (0)	3 (27)	8 (73)	0 (0)	0 (0)	10 (100)
Acute management of diabetes ketoacidosis in children.	4 (36)	3 (27)	4 (36)	0 (0)	0 (0)	10 (100)
Identification of diabetes acute complications in children.	5 (46)	5 (46)	1 (9)	0 (0)	0 (0)	10 (100)
Management of diabetes acute complications in children.	7 (64)	3 (27)	1 (9)	0 (0)	1 (10)	9 (90)
Basic fundamental knowledge about diabetes in children.	1 (9)	6 (55)	4 (36)	0 (0)	0 (0)	10 (100)

^aRated on a 5-point Likert scale (1 = *extremely disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *extremely agree*).

^bN = 11.

^cN = 10.

^dLow confidence = *extremely disagree* or *disagree*.

^eHigh confidence = *agree* or *extremely agree*.

- Expand the content/practice:
 - “More sessions.”
 - “More content, i.e., common questions asked by parents of children with new-onset diabetes prior to discharge (if we can teach it, we can understand it).”
- Increase the small group size:
 - “I think possibly having a group element, maybe two to three, might be a nice addition, but the one-on-one nature made it really comfortable to work through the cases.”

Discussion

We developed a learner-centered, comprehensive, pediatric-specific, case-based diabetes curriculum targeted to pediatric residents to address the gap of a simultaneous rise in diabetes prevalence and a need for structured diabetes didactics for pediatricians. The curriculum was feasible to implement in multiple settings, including a busy inpatient clinical environment. Our curriculum positively impacted learners’ knowledge by raising their performance scores by 16%. It also changed their perceived confidence across all pediatric diabetes clinical skills that were assessed as part of our curriculum. Residents enjoyed the curriculum, as shown by the 100% extreme satisfaction rate and the qualitative feedback promoting the course’s integration as part of the rotation.

Our educational materials has several strengths:

1. Case-based modules present authentic real-life scenarios that are clinically relevant to the learners and mimic the performance context.
2. The flexibility permits implementation in any clinical setting and adaptation of part/all of the modules.
3. The structured multistep questions ensure that all learning objectives have been met and guide the facilitator to

provoke higher-order thinking and problem-solving discussions.

4. The materials engage both the learner and facilitator, making the learning enjoyable and aligned with adult learning theories.
5. The modules are practical to impart pediatric diabetes clinical skills in rural or underserved areas where pediatric residents do not have access to endocrinologists and endocrinology-specific rotations.
6. The materials do not require advanced preparation by the learner; instead, they elicit prior basic knowledge through specific questions to allow learning and anchoring new information.
7. The modules are short and focused, suitable for mitigating the cognitive load and time constraints in busy clinical environments.

Our educational curriculum was readily adaptable when we shifted to remote learning for two participants during the COVID-19 pandemic restrictions (on outpatient rotation weeks). We noted active learner engagement and a positive instructional experience, where learners participated in lively discussions that exceeded the typical educational session duration (up to 1 hour). The learning environment difference may explain why instructional duration varied, as learners participated remotely from their homes compared to the busy-paced hospital.

Some of the challenges we faced with implementing our educational activity were finding the most feasible times to deliver the activity in a busy inpatient resident schedule. We trialed a nonstructured approach where the facilitator delivered the session depending on each day’s inpatient service flow. However, we found that the burden of documentation requirements and productivity obligations competed with

the learners' prioritization of learning and teaching. Thus, we switched to a structured approach in which the learners had a scheduled 30-minute slot for each session in the afternoon with a specified time and place planned at the beginning of the rotation. This approach was successful in setting expectations, prioritizing learning, and avoiding distractions. Another challenge included reviewing tedious or difficult concepts (e.g., insulin types and duration of action). We designed illustrations to navigate this challenge, which aided in simplifying concepts and capturing the learners' attention. We included the illustrations in a printable handout of pertinent information that was developed based on learners' feedback (Appendix G).

The educational activity has some limitations in generalizability. A single academic physician with endocrine expertise delivered all our sessions. We developed elaborate facilitator guides detailing the clinical pearls and references to assist facilitators from any background to utilize this resource. Furthermore, although the curriculum included major fundamental concepts, it was built on evidence-based studies subject to change with time. The facilitator guide highlighted references and dates of pertinent guidelines used (e.g., American Diabetes Association Standards of Clinical Care Guidelines²¹) to allow for easy review and access to any updates.

Conclusion

The interactive case-based learning modules showed positive effects on our learners' clinical knowledge and confidence in pediatric diabetes skills and their educational experience satisfaction. We were encouraged to integrate this activity as part of our resident rotation. In future studies, we would like to explore the effects of this educational method on advancing residents' clinical reasoning skills in diabetes care. Also, we would like to transform the educational delivery into an online remote learning tool. An online model would allow us to provide educational access to learners across the entire pediatric residency program and not exclusively to rotating pediatric endocrinology residents.

Appendices

- A. Diabetic Ketoacidosis Case - Facilitator Version.docx
- B. Diabetic Ketoacidosis Case - Learner Version.docx
- C. New-Onset Diabetes Management Case - Facilitator Version.docx
- D. New-Onset Diabetes Management Case - Learner Version.docx
- E. Acute Diabetes Complications Case - Facilitator Version.docx
- F. Acute Diabetes Complications Case - Learner Version.docx

G. Educational Handouts.docx

H. Assessment Tool and Answer Key.docx

All appendices are peer reviewed as integral parts of the Original Publication.

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Prior Presentations

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Al-Gadi I, Sisley S. Not another lecture! Engaging pediatric residents in a case-based curriculum. Abstract presented at: Pediatric Academic Societies 2021 Virtual Meeting; April 30-May 4, 2021.

Ethical Approval

The Baylor College of Medicine Institutional Review Board approved this study.

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