ANNOTATION

Dissertation work of Akmaral Baimatovna Tashmanova
«Optimizing the treatment and management of children and adolescents with type 1 diabetes mellitus», submitted for the degree of Doctor of Philosophy (PhD) in the specialty "6D110100-Medicine"

Scientific consultants:
Berkinbaev S.F., Doctor of Medical Sciences, Professor
Bolshakova S.V., Ph.D., associate professor
Foreign scientific consultant:
Rakhimova G.N., Doctor of Medical Sciences, Professor

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Relevance of the research topic

In recent years, a steady increase in the prevalence and incidence of type 1 diabetes mellitus (T1DM) among children and adolescents has been observed, placing this condition among the priority public health problems. Individuals with disease onset in childhood have an increased risk of early disability and premature mortality due to acute and chronic complications, which often develop already during the pediatric stage of follow-up. The growing clinical and economic burden on the healthcare system is driven by the need for long-term monitoring, frequent hospitalizations, costly interventions, and rehabilitation measures.

International and national clinical practice relies on the concept of therapeutic patient education, consistently promoted by the World Health Organization. Systematic education of patients and their legal representatives includes the development of self-monitoring skills, rational nutrition, insulin dose calculation, as well as behavioral algorithms for managing hypo- and hyperglycemia. Effective mastery of these components is directly associated with achieving stable glycemic control and preventing complications in children and adolescents with T1DM.

Modern studies demonstrate that the integration of educational programs into standard therapy improves metabolic control and enhances treatment adherence. For the pediatric population, particular importance is attached to the repetitiveness and adaptability of education: the content and methods of delivery should take into account age, disease duration, baseline knowledge and motivation, as well as the degree of family involvement in the treatment process.

The primary goal of T1DM therapy is to maintain glycemic parameters within the target range. The most widely used approach is intensified insulin therapy with short-acting and long-acting insulin preparations. Individual dose selection is based on body weight, age, disease duration, and glycemic dynamics. The dose of rapid-acting insulin is calculated with consideration of carbohydrate intake, daily activity patterns, time of day, and postprandial glucose levels. Insulin administration is performed via injections or insulin pump therapy, which provides a more physiological simulation of the basal-bolus insulin secretion profile.

The diet should ensure an even distribution of carbohydrates throughout the day in accordance with age- and sex-specific requirements. Errors in the assessment of carbohydrate load lead to inaccurate bolus dose calculation and impaired postprandial glycemic control; elevated postprandial glucose levels are regarded as one of the significant factors in the progression of chronic T1DM complications.

To standardize the assessment of carbohydrate intake, the carbohydrate exchange system (bread units, BU) is used, where 1 BU corresponds to approximately 10–12 g of digestible carbohydrates. The availability of convenient BU tables facilitates

the planning of a balanced diet and adjustment of bolus insulin doses. However, the majority of existing reference materials are primarily oriented toward European culinary traditions and do not provide comprehensive data on traditional Kazakh cuisine (such as flatbreads, baursak, shelpek, beshbarmak, manty, kumys, kozhe, etc.). The lack of such information complicates self-management education in patients using insulin pump therapy and limits the accuracy of dose calculations for different bolus types.

In view of the above, there is a clear need to develop and evaluate the effectiveness of an adapted educational program that takes into account national dietary characteristics and modern treatment technologies (continuous subcutaneous insulin infusion and continuous glucose monitoring). It is expected that such an intervention will increase the proportion of time in range (TIR) while simultaneously reducing time below range (TBR) and decreasing the frequency of acute decompensation events.

Aim of the Study: To develop a new modified educational program tailored to national and cultural characteristics for children and adolescents with type 1 diabetes mellitus undergoing insulin pump therapy.

Research objectives:

1. To study the prevalence and incidence of type 1 diabetes among children and adolescents in Almaty.
2. To conduct a comparative analysis of the effectiveness of the modified versus traditional education programs among children and adolescents using insulin pump therapy — both with and without CGM.
3. To evaluate the frequency of achieving target HbA1c and Time-in-Range (TIR) in children and adolescents with T1DM using the modified education program versus the traditional one.
4. To assess the incidence of acute complications in T1DM among children and adolescents receiving the modified education compared to traditional education.
5. To assess quality of life (QoL) using the ADDQoL questionnaire among children and adolescents with T1DM participating in the modified versus traditional programs.

Research Methods:

Epidemiological Method: The prevalence and incidence of type 1 diabetes among children and adolescents were analyzed using data from the Almaty City Diabetes Registry and reports from the Republican Center for Health Development (RCHD), with district-level differentiation. Indicators were studied over the period 2018–2022.

Clinical and Anthropometric Method: Patient examination and education were conducted at the Children's Clinical Hospital No. 2 and the A. Syzganov National Research Institute, in both outpatient and inpatient settings between 2018 and 2023. The follow-up period was 60 months. Clinical evaluation included history taking, assessment of complaints, and evaluation of physical and sexual development according to WHO growth and weight standards.

Laboratory and Instrumental Method: Carbohydrate metabolism compensation was assessed by measuring fasting and postprandial glucose levels (via glucometer and glucose oxidase laboratory method), using different types of sensors, and by determining glycated hemoglobin (HbA1c) through an immunochemical assay on the DCA Vantage automatic analyzer. Proficiency in insulin pump management and adequacy of device settings were assessed using CareLink Professional ver. 3.3 (Medtronic B.V., USA): monthly in the modified-education group and at baseline and study completion in the control group.

Questionnaire Method: A newly developed modified educational program was implemented, distinguished by the inclusion of Kazakh national dishes calculated in bread units (BU) for dietary planning in children and adolescents with T1DM. To evaluate the program's effectiveness, participants underwent pre- and post-training testing assessing diabetes self-management knowledge, laboratory HbA1c, and sensor-based glucose monitoring data. Knowledge levels of children, adolescents, and parents regarding independent diabetes management were assessed using a validated, culturally adapted questionnaire for T1DM patients. Surveys were conducted in printed and online forms (Google Forms) in both Kazakh and Russian languages.

Statistical Method: Data analysis was performed using Statistica 8.0 (StatSoft Inc., USA). Descriptive statistics were presented as median and interquartile range (Me [25; 75]) and percentages (%).For non-normally distributed data, nonparametric tests were used, such as the Mann–Whitney U-test for independent samples. Group differences were analyzed using the χ^2 test.Correlation analysis employed Spearman's rank correlation coefficient. The mean ± standard deviation (M ± SD) was used to describe the frequency of hypoglycemic episodes, frequency of self-monitoring, use of corrective boluses, glycemic variability, and some QoL questionnaire results. Statistical significance was considered at $p < 0.05$.

Object of the Study:

The study included 125 children and adolescents with type 1 diabetes mellitus.

The group with the modified training program consisted of 68 patients who received education annually at the "Type 1 Diabetes School for Pump Therapy," attending 2–3 courses per year during the period from 2018 to 2022 in outpatient and inpatient settings.The control group included 57 children and adolescents with type 1 diabetes mellitus who received outpatient and inpatient treatment and were followed up in various clinics where the education was conducted by the traditional method.

Subject of the Study:

To achieve the established goals and objectives, a modified structured training program was created for patients with type 1 diabetes mellitus receiving insulin pump therapy, in two languages — Kazakh and Russian. All study participants underwent testing based on a questionnaire that included 30 key questions on self-monitoring during insulin pump therapy and on bread units, before and after training.

The questions were provided to patients in electronic form and via a Google Form link in both Kazakh and Russian.Epidemiological data were studied based on the Almaty City Register and RCHD reports.

Main Provisions Submitted for Defense

1. The incidence and prevalence rates of type 1 diabetes mellitus among children and adolescents in Almaty showed an increasing trend during the period from 2018 to 2021.
2. Traditional methods of therapeutic training for children and adolescents with type 1 diabetes mellitus undergoing insulin pump therapy are limited in effectiveness and cannot ensure stable and long-term achievement of target treatment levels.
3. The developed modified training program for children and adolescents with type 1 diabetes mellitus is a vivid example of the introduction into clinical practice of a "personalized (individualized) approach" and the concept of "lifelong learning" for patients with diabetes mellitus, which made it possible to achieve safe and long-term attainment of target treatment levels among children and adolescents receiving insulin pump therapy.
4. The indicators of time in range (TIR, TAR, TBR) obtained using professional continuous glucose monitoring and the calculated indicators (dTIR, dTAR, dTBR) determined by self-monitoring of glycemia showed statistically significant positive correlations. This fact confirms the comparability of these parameters regardless of the glucose measurement method used and indicates the expansion of possibilities for clinical application of new integral indicators of glycemic control in routine endocrinological practice.

Key findings of the study:

The first stage of the study was to examine the incidence and prevalence of type 1 diabetes mellitus in children and adolescents in Almaty from 2018 to 2022. The prevalence of type 1 diabetes mellitus among children has shown an upward trend, with an increase observed when comparing the figures for 2018 (8.24 per 100,000 children) and 2022 (9.28 per 100,000). The highest rates were recorded in 2021 (9.15) and 2022 (9.28 per 100,000 children). This period coincided with the COVID-19 pandemic and the spread of the Omicron strain, which is highly infectious, including among vaccinated individuals. Comparable dynamics were observed among adolescents, where the prevalence of type 1 diabetes increased from 14.6 per 100,000 in 2018 to 18.9 per 100,000 in 2022, with the highest rates observed in 2021 - 22.2 per 100,000 adolescents. According to data from the Almaty Republican Center for Health Protection, the incidence of T1DM is among children increased from 0.17 to 0.18 per 100,000 children in 2018–2022, while among adolescents a slight decrease was noted from 9.78 in 2018 to 9.29 per 100,000 in 2022, which is likely associated with higher vaccination coverage against COVID-19, as they were more susceptible to coronavirus vaccination.

When assessing the effectiveness of training using questionnaire-based testing, it was revealed that before training, children and adolescents in the modified training group with a mean diabetes duration of 6.7 [4; 14] years, correctly answered only 9-10 questions. At follow-up intervals of 6 months, a year, and 3 years, their performance improved substantially, with correct responses reaching 80-90%, in the group of children with modified training and CMG, which amounted to 28.4±3.1 ($p<0.001$) out of 30 key self-management questions related to insulin pump therapy.

In contrast, children and adolescents in the traditional training group, with a mean of 7.2 [5; 16] years of experience, low baseline knowledge, and motivation, were more likely to be admitted to the intensive care unit both before and after traditional training. Throughout the observation period, their correct responses remained low, ranging from 15 to 18 points.

The result showed that children and adolescents with T1DM who received insulin pump therapy in combination with a CGM and a modified education program demonstrated significant improvements in glycemic control and quality of life over a three-year follow-up period, irrespective of the glycemic control monitor (glucometer or real-time CGM). Moreover, the group with modified education and the use of a CGM showed a more significant reduction in HbA1c levels to 7.3 ± 0.9% ($p < 0.001$) compared to the traditional group using the same sensors (HbA1c - 9.1 ± 1.2%). Additionally, participants in the modified education group using self-monitoring with glucometers also recorded a statistically significant reduction in HbA1c levels to 8.8 ± 1.2%. In the modified training group, children and adolescents who used continuous blood glucose monitoring systems (CGM) achieved target glycemic control indicators to a greater extent (66.4%) than in the traditional training group (51.1%).

Analysis of the time in ranges(TIR) over three year follow up, in children and adolescents with T1DM, in the group of the modified training program with CGM, revealed a significant increase from 34.1% to 89.1%($P<0.001$) in comparison with the traditional training group who also used CGM, but the level TIR showed a modest increase from 35.8% to 54.2%($P<0.001$).

During long-term follow-up and ongoing regular motivational support for children, adolescents, and their parents, the frequency of severe hypoglycemia episodes decreased markedly. In the modified training group using CGM sensors, the rate significantly declined from 33.3% to 3% ($p < 0.01$). Similarly, in the modified group employing glucometer-based self-monitoring, the frequency of severe hypoglycemia also decreased—from 31.4% to 8.6% ($p < 0.05$). Moreover, the frequency of glucose measurements in the glucometer group ranged from 7 to 10 times per day. In contrast, CGM devices provide 200 to 300 measurements per day, offering more accurate and comprehensive information on glucose fluctuations. Weight gain is a well-known consequence of intensified insulin therapy, which hinders both patients and physicians from adequately adjusting the dose to achieve glycemic compensation. When analyzing the 3-year follow-up in the groups, we focused on the bolus to basal dose ratio, as global data show that this basal/bolus dose ratio ranged on average from 40% to 60%. In our study, as glycemia control improved, parents of children and adolescents in the modified educational group independently adjusted the insulin dose based on self-monitoring results supported by frequent attendance at diabetes school, consistent blood glucose monitoring using CGM sensors, and correct calculation of XE during dose adjustments for high blood glucose. As a result, after 3 years, the basal/bolus insulin dose ratio increased from the initial 8%/92% to 42/58%, demonstrating that adequate glycemic compensation reduced the need for high bolus doses.

The average frequency of changing the infusion set depended on the type of training and type of insulin. Patients are required to rotate the infusion site every 3-4

days, which is a mandatory practice for all insulin pump users. When using different types of rapid-acting insulin, frequent infusion site changes occurred due to cannula kinking, insulin crystallization, and thrombosis. By the third to fourth day, blood glucose levels increased despite unchanged insulin doses. The mean number of infusion set changes was (4.9 ± 3.7) for Lisipro, (3.5 ± 2.1)for Aspart, and (4.6 ± 2.9) for Glulisine.

Diabetes-specific quality of life (QOL) was assessed using the Audit of Diabetes-Dependent Quality of Life (ADDQoL) questionnaire. The majority of children, adolescents, and their parents rated their QOL as "good," with scores ranging from 1 to 10. During the 3-year follow-up, the mean QOL score in the modified group with CGM training was significantly higher, at 9.6±0.5 points ($P < 0.001$), compared to the modified group training performing glucose-based self-monitoring (7.4±0.7). Patients also reported that diabetes has a negative impact on their lives. Thus, on the "Society's Reaction to Me" scale, the mean score was 2.1 ± 0.2 in the modified training with CGM, while in the group with modified training and self-monitoring of glycemia (SMBG), it was 5.1 ± 0.4. Based on the results of a three-year follow-up, participants who completed the modified educational program showed a significant improvement in all quality of life indicators, regardless of the method of glycemia assessment.

Scientific novelty

The epidemiological dynamics of prevalence and incidence of type 1 diabetes mellitus among children and adolescents were analyzed across different districts of Almaty during the period 2018–2022

For the first time in the Republic of Kazakhstan, a modified training program has been developed for children and adolescents with type 1 diabetes who are on insulin pump therapy, tailored to age, duration of diabetes, and level of knowledge, using CGM, based on the calculation of XE in Kazakh national dishes.

The newly modified educational program for children and adolescents with T1DM on insulin pump therapy and continuous glucose monitoring has been shown to promote the achievement of target glycemic levels (TIR), reduce the risk of hypoglycemia (TBR), and decrease the incidence and risk of acute ketoacidotic complications. Furthermore, the implementation of this program improves the quality of life of children and adolescents with T1DM in various life situations.

Practical recommendations

For practical healthcare, we propose a new cost-effective, personalized educational program for children, adolescents, and their parents with T1DM on insulin pump therapy. The program is aimed at improving glycemic control, reducing the risk of acute complications, and improving both quality of life and life expectancy.

In clinical practice, the modified educational program has been integrated into the clinical practice for children and adolescents with T1DM on insulin pump

therapy, taking into account Kazakh national cuisine, various bolus calculator modes, and the use of continuous glucose monitoring (CGM) sensors.

When switching to insulin pump therapy, throughout subsequent training in the "School of Insulin Pump Therapy", it's essential to pay special attention to mastering the bolus calculator. This includes learning various types of bolus and basal rate regimens, as well as basal profiles, all of which are essential for achieving optimal carbohydrate metabolism.

This study demonstrates that the proposed diabetes management model can significantly improve the effectiveness of outpatient monitoring and observation of children and adolescents with T1DM on insulin pump therapy. Moreover, it improves clinical outcomes and strengthens the overall safety of the treatment.

Personal contribution of the doctoral student: All results presented in this dissertation, which demonstrate scientific novelty, were obtained by the author personally. The author independently conducted patient testing using the new modified program during the observation period, installed CGM and insulin pumps for patients, and performed the complete statistical analysis of the collected data. The modified educational program was officially implemented in the A. Syzganov National Research Institute in both outpatient and inpatient settings (implementation certificate No. 2). The author also received the Author's Certificate No. 56331 for the "Modified structured training program for children and adolescents with type 1 diabetes mellitus on insulin pump therapy."

Conclusions:

1. Based on the analysis of epidemiological data from 2018 to 2022, the prevalence of type 1 diabetes increased among children from 8.24 to 9.28 (per 100,000, +9.2%) and among adolescents from 14.6 to 18.9 (per 100,000, +29.4%). Similarly, the incidence of T1DM in children rose from 0.17 to 0.18 (+5.8%), while among adolescents it decreased from 9.78 to 9.29 per 100,000 (−5.0%), which is likely associated with higher COVID-19 vaccination coverage, as adolescents were more frequently vaccinated against the coronavirus.
2. In children and adolescents with T1DM receiving insulin pump therapy, those in the continuous modified training with CGM exhibited a significant reduction in the HbA1c over three years, reaching 7.3±0.9%, compared to 9.1 ±1.2% in the group receiving traditional training with CGM.
3. In children and adolescents with T1DM, over a 3-year follow-up, in the group with a modified training program with CGM, the time spent in the target TIR range significantly increased over the years from 34.1% to 89.1% compared to the group with traditional training with CGM, where the TIR level increased from 35.8% to only 54.2%.
4. The frequency of achieving target levels of HbA1c ≤ 7% in children and adolescents with T1DM over three years was 66.4% in the modified training group

with CGM, compared to 51.1% in the traditional group with CGM. When self-monitoring with a glucometer was employed, the corresponding rates were 60.5% vs. 46.2% respectively.

5. During the 3-year follow-up, the incidence of severe hypoglycemia episodes significantly declined in the modified training group with CGM from 33.3% to 3% compared to the group with traditional training with CGM from 31.4% to 8.6%.
6. The quality of life of children and adolescents with T1DM who participated in modified training and received insulin pump therapy was higher in indicators as "Freedom in eating" (9,9±1,1) p <0.001, "Family relationships" (9,9±1,1) p <0.001 and "Social activity" (9,9±1,1) p <0.001 compared with the group who underwent traditional training, according to the results of the ADDQoL questionnaire.

Testing the results of the dissertation.

The main provisions and results of the dissertation were presented at:

1. Oral Poster Presentation. Study on the efficacy of long-term education for achieving compensation type 1 diabetes mellitus in children Almaty region/ A. Tashmanova, G. Rakhimova, S. Berkinbayev, B. Raimkulov, L. Danyarova, G. Dzhunusbekova, M. Tundibayeva, SATynalieva. Oral poster presentation, International Diabetes Federation Congress 2019. Busan, Korea. 2 - 6 December.Abstract number: BU-02371, P 124.
2. Oral Poster Presentation. Achievement of therapeutic targets in children and adolescents with type 1 diabetes mellitus at the "Diabetes School"/ A. Tashmanova, G. Rakhimova, S. Berkinbayev, B. Raimkulov, L. Danyarova., Oral poster presentation. International Diabetes Federation Congress 2019. Busan, Korea. December 2 - 6. Abstract number: BU-02380, P 124.
3. Oral presentation. 12th Congress of Cardiologists of the Republic of Kazakhstan with international participation. Young scientists' competition "Intensified insulin therapy in patients with diabetes mellitus who have recovered from coronavirus." Almaty, November 19-20, 2020.

Publications:

Based on the results of the study, 13 scientific papers were published: - in journals recommended by the Committee for Quality Assurance in Education and Science of the Republic of Kazakhstan–4; in international peer-reviewed scientific journals with an impact factor according to Journal Citation Reports or indexed in the Web of Science Core Collection database, Science Citation Index Expanded or a SiteScore percentile indicator of at least the 25th percentile in the Scopus database – 3 articles, less than the 25th percentile–1 article;- in the proceedings of international conferences – 4. Copyright - 1.

1. «Epidemiological parameters and monitoring of analysis of treatment of children and adolescents with type 1 diabetes mellitus in insulin pump therapy with modified

educational program» Tashmanova Akmaral, Berkinbayev Salim, Rakhimova Gulnara, Mansurova Madina, Tyulepberdinova, Gulnur. Polski Merkuriusz Lekarski, 2024, Volume 52, Issue 1, Page. 23 – 29.DOI10.36740/Merkur202401104

2. «Prevalence of Impaired Fasting Glucose and Type 2 Diabetes in Kazakhstan: Findings from Large Study» Binur Razumkova, Alpamys Issanov, Kuralay Aageldiyeva, Salim Berkinbayev, Gulnara Junusbekova, Laura Danyarova, Zhanmedet Shyman, Akmaral Tashmanova and Antonio Sarria-Santamera. ORIGINAL RESEARCH article, Front. Public Health, 24 February 2022Sec. Clinical Diabetes. Volume 10 - 2022 |https://doi.org/10.3389/fpubh.2022.81015
3. «Therapy Goal Achievement in Children and Adolescents with Type 1 Diabetes Mellitus in Insulin Pump Therapy Depending on the Glucose Monitoring and Educational Programs». Akmaral B. Tashmanova, Gulnara N. Rakhimova, Salim F. Berkinbaev, Madina E. Mansurova, Kamilla B. Srailova. International Journal of Biomedicine 13(1) (2023) 41-46http://dx.doi.org/10.21103/Article13(1)_OA3
4. «Evaluation of the achievement of target glycemic levels in children and adolescents with type 1 diabetes mellitus with insulin pump therapy ccording to a modified training program». Tashmanova, A.B., Rakhimova, G.N., Berkinbaev, S.F. Miznarodnij Endokrinologicnij Zurnal, 17(4), стр 287–292, 2021. DOI: 10.22141/2224-0721.17.4.2021.
5. «Evaluation of the effectiveness of a new structured training program for children and adolescents with type 1 diabetes in the Almaty region». Tashmanova A.B., Berkinbaev S.F., Rakhimova G.N., Srailova K.B. Journal of KazNMU Bulletin No. 2, Almaty 2019, pp. 199-202.
6. «Study of the effectiveness of long-term training and the achievement of target levels of therapy for type 1 diabetes mellitus in children and adolescents.» Tashmanova A.B., Berkinbaev S.F., Rakhimova G.N. Journal of KazNMU Bulletin No. 4, Almaty 2019, pp. 199-202.
7. «Optimization of insulin pump therapy in children and adolescents with type 1 diabetes mellitus using a modified training program.» Tashmanova A.B., Berkinbaev S.F., Rakhimova G.N., Bolshakova S.V., Abylayuly Zh. Journal Bulletin of KazNMU No. 1, Almaty 2022, 478-485 pp.
8. «Achieving target levels of therapy and monitoring analysis of treatment of children and adolescents with type 1 diabetes mellitus using insulin pump therapy using a modified training program.» Tashmanova A.B., Berkinbaev S.F., Rakhimova G.N., Kodabaev A.T., Bolshakova S.V., Mansurova M.E., Tyulepberdinova G.A. Journal of Pharmacy of Kazakhstan No. 1, Almaty 2023, 91-98 pp. DOI 10.53511/PHARMKAZ.2023.19.98.013.
9. «Analysis of clinical data of patients with type 1 diabetes mellitus using insulin pump therapy with minimed 780g: the effectiveness of glycemic control.» Kyrykbaeva A.A., Tashmanova A.B., Baysalbaeva A.S., Abduakhasova G.K. V

(XXX) National Congress of Endocrinologists with international participation "Innovative technologies in endocrinology", Moscow, May 21-24, 2024, Collection of abstracts, 110 pages.

10. «Achievement of Therapy Targets in Children and Adolescents with Type 1 Diabetes Mellitus at the 'Diabetes School'.» Akmaral Tashmanova, Laura Danyarova, Gulnara Rakhimova. 57th Annual Conference of the European Society of Paediatric Endocrinology (ESPE 2018), September 27-29, 2018, Athens, Greece. Abstract number: P3-P077, P 254.
11. Oral Poster Presentation. Study on the efficacy of long-term education for achieving compensation type 1 diabetes mellitus in children Almaty region/ A. Tashmanova, G. Rakhimova, S. Berkinbayev, B. Raimkulov, L. Danyarova, G. Dzhunusbekova, M. Tundibayeva, SATynalieva. Oral poster presentation, International Diabetes Federation Congress 2019. Busan, Korea. 2 - 6 December.Abstract number: BU-02371, P 124.
12. Oral Poster Presentation. Achievement of therapeutic targets in children and adolescents with type 1 diabetes mellitus at the "Diabetes School"/ A. Tashmanova, G. Rakhimova, S. Berkinbayev, B. Raimkulov, L. Danyarova., Oral poster presentation. International Diabetes Federation Congress 2019. Busan, Korea. December 2 - 6. Abstract number: BU-02380, P 124.
13. Copyright. «Modified Structured Educational Program for Children and Adolescents with Type 1 Diabetes Mellitus Undergoing Insulin Pump Therapy» Tashmanova A.B., April 2, 2025. No. 56331.

Structure and Volume of the Dissertation

Structure and volume of the dissertation. The dissertation is presented on 143 pages of computer text. It consists of an introduction, a literature review, a description of the research materials and methods, the original research findings, a discussion, a conclusion, a reference list, and appendices. The dissertation is illustrated with 25 figures and 28 tables. The bibliography contains 189 references.