

IMPACT OF THE COVID-19 PANDEMIC ON GLYCEMIC CONTROL IN CHILDHOOD TYPE 1 DM PATIENTS

Toni Kurniawan¹, Eka Agustia Rini², Asrawati³

^{1,2,3} Department of Child Health, Faculty of Medicine Universitas Andalas

Dr M Djamil General Hospital, Padang, Indonesia

Email: doktertonikurniawan@gmail.com, rini_ea@yahoo.co.id, asrawati1@yahoo.com

ABSTRACT

There has been an increase in cases of diabetic ketoacidosis in children aged 1-14 years from 73% in 2019 to 83% in 2020 during the COVID-19 pandemic. An increase in acute complications of type-1 DM can occur due to lack of compliance with glycemic control and activity restrictions which have the impact of reducing the level of glycemic control in children with type-1 DM. Based on these findings, researchers wanted to know the impact of restrictions on community activities during pandemic on the glycemic control of children with type 1 DM. The aims of this study is to determine the impact of the COVID-19 pandemic on glycemic control through HbA1c parameters in children with type 1 DM. Methods of this research is a cross sectional study with a sample size of 26 patients. Results are The average age of respondents was 15.58 years. More than half of respondents were female (73.1%). The average duration of suffering from type 1 DM was 4.77 years. More than half of the respondents had a history of diabetic ketoacidosis, 53.8%, and all respondents were Health Insurance (BPJS) participants (100%). There was a decrease in HbA1c levels during the pandemic compared to before the pandemic, namely 12.17 ± 2.60 to 10.32 ± 2.21 . Statistically, this decrease means that there is an impact of the COVID-19 pandemic on glycemic control through the HbA1c parameter in children with type 1 DM ($p < 0.05$). There was a decrease in HbA1c levels during the pandemic compared to before the pandemic.

KEYWORDS Type-1 DM, children, HbA1c, COVID-19, pandemic



This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was first identified in an outbreak that occurred in Wuhan, People's Republic of China, in early December 2019 (Zhao et al., 2020). Transmission of COVID-19 occurs directly through

Kurniawan. T et al. (2024). Impact Of The Covid-19 Pandemic On Glycemic Control In Childhood Type 1 DM Patients. *Journal Eduvest*. 4 (3): 1033-1043
E-ISSN: 2775-3727
Published by: <https://greenpublisher.id/>

droplet or aerosol transmission by infected individuals, and indirectly through contact with impermeable surfaces for up to 3 days. Presymptomatic transmission can occur approximately 1 to 3 days before the onset of symptoms. Several symptoms of COVID-19 include fever (51%), cough (41%), vomiting (33%), sore throat (16%), rhinorrhea (14%), nasal congestion (17%), myalgia (12%), and hypoxemia (3%). Asymptomatic cases of COVID-19 in children are found to be 20%-60%, which can serve as a source of SARS-CoV-2 transmission to the children's surrounding environment (Kachru Shriya & Kaul Dinesh, 2020).

The total number of COVID-19 cases worldwide was 188,556,234 as of July 13, 2021. The total number of positive COVID-19 cases in Indonesia as of June 2, 2021, was 2,256,851 (*COVID Live Update: 188,556,234 Cases and 4,064,985 Deaths from the Coronavirus - Worldometer*, 2021). The Indonesian Pediatric Society (IDAI) reported 2,712 confirmed cases of COVID-19 in children with 51 deaths recorded from March 17, 2020, to July 20, 2020. Research by Dewi et al. on mortality among children confirmed with SARS-CoV-2 found that 40% of patients died, with the most common causes being acute respiratory distress syndrome and septic shock (Dewi et al., 2021).

Type 1 diabetes mellitus (T1DM) accounts for more than 85% of cases in patients under 20 years old worldwide. Research by Aman B. Pulungan et al. showed that the prevalence of T1DM reached 1,220 children in 2018. Its incidence in Indonesia is not precisely known. Data from 2009 showed that 60% of girls and 28.6% of boys aged 10-14 years had T1DM. Cases of diabetic ketoacidosis (DKA) as a complication of T1DM increased during the COVID-19 pandemic from 63% in 2016 to 73% in 2019 and 83% in 2020 in Indonesia (Pulungan et al., 2019). According to a retrospective cohort study by Alaqeel et al. during the pandemic lockdown, there was an increase in acute complications of T1DM due to poor glycemic control adherence and activity restrictions leading to decreased glycemic control levels in children with T1DM during the COVID-19 pandemic (Alaqeel et al., 2021).

Based on a cross-sectional study in the United States conducted by Melissa et al., Between March 1, 2018, and December 31, 2020, a total of 321 children and adolescents aged 0 to <18 years who were admitted to pediatric hospitals with new-onset diabetes experienced DKA at that time (Chambers et al., 2022). Among those admitted for new-onset diabetes, the prevalence of DKA was 48% (193/401) before the pandemic and 60% (128/214) after the pandemic, meaning the pandemic was associated with an increased prevalence of DKA in the studied diabetes patients. Bethany et al. also conducted a similar study and observed a significant increase in the frequency of DKA at the time of T1DM diagnosis during the COVID-19 pandemic in Toronto, Canada, with 93 out of 187 patients (49.7%) increasing from 261 out of 641 patients (40.7%) in the previous 5 years (Carballo et al., 2020).

A meta-analysis by Masoud et al. stated that, in total, of 26 studies, 21 experienced an increase in the number of DKA cases and 6 studies experienced an increase in blood glucose and HbA1c levels in newly diagnosed T1DM children compared to the period before COVID-19. The number of visits by T1DM pediatric patients to the pediatric clinic of Dr. M. Djamil Padang Hospital in 2020 decreased compared to 2019, coinciding with the increase in the number of positive COVID-

19 patients in West Sumatra province. Glycemic control underwent significant changes after these activity restrictions, marked by an increase in HbA1c levels (Verma et al., 2020).

This study aims to evaluate the differences in glycemic control in children with type 1 diabetes before and during the COVID-19 pandemic at the Pediatric Clinic of Dr. M. Djamil Padang Hospital. The general objective is to understand the impact of the COVID-19 pandemic on glycemic control, measured through the HbA1C parameter, in children with type 1 diabetes. The specific objectives are to evaluate glycemic control before and during the pandemic, as well as to evaluate the pandemic's impact on glycemic control through the HbA1C parameter. The benefits of this research include improving the literature on the effects of activity restrictions during the pandemic on glycemic control in children with type 1 diabetes, increasing awareness of the risk of ketoacidosis in children with this condition amid the pandemic, and also raising public awareness of the importance of adherence to glycemic control in children with type 1 diabetes.

Literature Review

Type 1 Diabetes Mellitus

Diabetes mellitus (DM) is an endocrine disorder caused by insulin abnormalities, affecting carbohydrate and lipid metabolism. DM is divided into several types, including type 1, type 2, gestational, and others. Type 1, also known as juvenile-onset diabetes or insulin-dependent diabetes mellitus (IDDM), occurs due to absolute insulin deficiency caused by autoimmune destruction of pancreatic beta cells.

The prevalence of type 1 DM varies worldwide, typically onset in childhood but can also occur in infants or young adults. The incidence of type 1 DM is quite high in some countries, but its incidence in Indonesia is not precisely known due to lack of awareness and medical monitoring. The pathogenesis of type 1 DM involves interactions between genetic and environmental factors, with key roles played by genes such as HLA and CTLA-4. Viral infections and exposure to toxins can also trigger pancreatic beta cell-damaging autoimmunity.

Diagnosis of DM is based on clinical symptoms such as polydipsia, polyuria, polyphagia, weight loss, as well as plasma blood sugar and HbA1c tests. These examinations may also include oral glucose tolerance tests and autoantibody tests. Management of type 1 DM in children and adolescents requires a different approach than in adults, focusing on education, insulin therapy, dietary regulation, physical activity, and self-monitoring. Comprehensive education by a multidisciplinary team is essential to achieve good glycemic control and prevent complications.

HbA1c testing is an important indicator for monitoring long-term glycemic control in diabetic patients, with results reflecting the average blood sugar levels over the past few months. This test is also used for diabetes diagnosis and evaluating therapy response. HbA1c analysis methods include hemoglobin fraction separation and chemical methods, both of which provide accurate and beneficial results in diabetes management.

Impact of the COVID-19 Pandemic on Glycemic Control in Children with Type 1 Diabetes

The Indonesian government's policy in handling the COVID-19 pandemic involves imposing activity restrictions on non-essential and critical sectors. Essential sectors such as finance and banking, and government. Critical sectors include energy, health, security, logistics, food and beverage industry, projects, basic utilities, and meeting the basic needs of the community. This was implemented in COVID-19 red zone areas.

Activity restrictions have been in place since March 30, 2020, in accordance with Government Regulation Number 21 of 2020 concerning Large-Scale Social Restrictions in Accelerating the Handling of Corona Virus Disease 2019 (COVID-19) (Pembatasan Sosial Berskala Besar Dalam Rangka Percepatan Penanganan Corona Virus Disease 2019 (Covid-19), 2020). In West Sumatra, official activity restrictions began on April 22, 2020, in accordance with Governor's Decision Number 180-297-2020 concerning the Implementation of Large-Scale Social Restrictions in West Sumatra Province in Accelerating the Handling of Corona Virus Disease 2019 (COVID-2019) (Perpanjangan Pemberlakuan Pembatasan Sosial Berskala Di Wilayah Provinsi Sumatera Barat Dalam Rangka Penanganan Corona Virus Disease 2019 (Covid-19), 2020). Activity restrictions have impacted access to healthcare for patients with chronic diseases requiring regular monitoring. Felicia et al. stated in a cross-sectional study that there was a decrease in immunization visits for children under 12 months at Wangaya Regional Public Hospital during the COVID-19 period (Arrieta et al., 2008).

Activity restrictions during the COVID-19 pandemic may affect glycemic control in patients with type 1 DM. Activity restrictions will change physical activity habits, dietary patterns, and the psychological status of children with type 1 DM. Several studies have shown short-term and long-term effects on glycemic parameters in disaster cases. Hurricane Katrina in the New Orleans area disrupted insulin supplies and treatment, varied food intake accompanied by decreased physical activity. These sudden changes resulted in patients experiencing acute complications of severe hyperglycemia or hypoglycemia. Fonseca et al. showed an increase in the average HbA1c after Hurricane Katrina disaster to 8.3% ($p < 0.001$) (Fonseca et al., 2009).

Verma et al. conducted a cross-sectional study on the effects of activity restrictions during the COVID-19 pandemic on glycemic control in type 1 DM. The results showed an increase in the average HbA1C to $10 + 1.5\%$ ($p < 0.05$). Another study by Onmez et al. also found reduced glycemic control due to activity restrictions during the COVID-19 pandemic. Incidents of DM complications such as hyperglycemia and hypoglycemia were also found to increase. Alaqeel et al. conducted a retrospective cohort study in children aged 1-14 years on the incidence of diabetic ketoacidosis in children with type 1 diabetes during the COVID-19 pandemic lockdown and found an increase in diabetic ketoacidosis cases to 83% in 2020 compared to 73% in 2019.

Factors causing poor glycemic control in children with type 1 DM occur due to decreased access to healthcare, changes in dietary patterns, psychological changes in patients and families, and difficulty accessing insulin and glucose strips during the pandemic. Daily home activities cause changes in sleep patterns and decreased adherence to food and physical activity. This can be seen during school

holidays when children experience sedentary behavior changes. Monitoring of low blood sugar in children is a cause of increased acute complications of type 1 DM during the pandemic. The difference between HbA1c levels before and after activity restrictions indicates uncontrolled glucose levels for at least the past 3 months.

During the COVID-19 pandemic, research by Telford et al. found a decrease in exercise in children with type 1 DM. Physical activity is a key factor in the success of management in patients with type 1 DM, which helps reduce/slow down complications, improve metabolic profiles (lower average glucose levels, and fewer episodes of hyperglycemia) (Telford et al., 2021).

RESEARCH METHOD

This study is a cross-sectional study conducted at the Pediatric Clinic of Dr. M. Djamil Padang General Hospital during an 8-month period from May 01, 2023, to December 31, 2023. The study population included children with type 1 diabetes undergoing treatment at Dr. M. Djamil Padang General Hospital from January 01, 2019, to August 31, 2021. The sample was selected based on inclusion criteria, including children with clinical and laboratory confirmation of type 1 diabetes and undergoing routine follow-up at the Pediatric Endocrine Clinic of Dr. M. Djamil Padang General Hospital, with parental consent. Exclusion criteria included patients with comorbidities affecting glycemic control or currently experiencing severe infections. Sampling was performed using consecutive sampling method with a minimum sample size of 25. Study variables included glycemic control with HbA1c parameter as the dependent variable, and compliance with follow-up at the Pediatric Endocrine Clinic during the COVID-19 pandemic as the independent variable. Research procedures included obtaining ethical approval, sample selection, data collection through medical records, and data analysis using appropriate statistical tests.

RESULT AND DISCUSSION

Research on the impact of the COVID-19 pandemic on glycemic control through HbA1c parameters in children with type-1 DM has been conducted at the children's polyclinic of Dr. M. Djamil Padang Hospital with 26 respondents.

Characteristics of Respondents

The characteristics of research respondents can be seen as follows.

Table 1 Characteristics of Respondents

Characteristic	Mean ± SD	Frequency (%)
Age (years), mean±SD	15,58±3,04	
Gender, f (%)		
Male		7 (26,9)
Female		19 (73,1)

Long suffering from type 1 DM (years), mean±SD	4,77±1,53
Ketoasidosis Diabetikum, f (%)	
None	12 (46,2)
Available	14 (53,8)
Health Insurance, f (%)	
Yes	26 (100)
No	0 (0)

Based on table 1, the average age of respondents is 15.58 years. More than half of the respondents were female (73.1%). The average length of suffering from type 1 DM is 4.77 years. More than half of the respondents had a history of diabetic ketoacidosis 53.8%, and all respondents were participants in health insurance (BPJS) (100%).

Data Normality Test

The data normality test in this study was carried out using the Shapiro-wilk test, it can be seen as follows.

Table 2 Data Normality Test

Time	p-value
Before the Pandemic	0,146
Pandemic Time	0,906

Based on table 2 that HbA1c levels before and during the pandemic were normally distributed ($p > 0.05$). So proceed with hypothesis testing using parametric statistics using the *Paired sample T test*.

Impact of COVID-19 Pandemic on Glycemic Control through HbA1c Parameters in Children with Type-1 DM

The impact of the COVID-19 pandemic on glycemic control through HbA1c parameters in children with type-1 DM can be seen as follows.

Table 3 Impact of COVID-19 Pandemic on Glycemic Control through HbA1c Parameter in Children with Type-1 DM

Time	HbA1c Mean±SD	p-value
Before the Pandemic	12,17±2,60	<0,001
Pandemic Time	10,32±2,21	

Based on table 5.4, there was a decrease in HbA1c levels during the pandemic compared to before the pandemic, namely 12.17±2.60 to 10.32±2.21. Statistically,

this decrease means that there is an influence of the COVID-19 pandemic on glycemic control through the HbA1c parameter in children with type-1 DM ($p < 0.05$).

Discussion

Subject Characteristics

This study was conducted on 26 respondents, with a mean age of 15.58 years, and more than half of the subjects were female (73.1%), while males accounted for 26.9%. These findings are consistent with a study by Jessica C.G. Bak et al. in the Netherlands in 2023, which involved 7,549 outpatient subjects with type 1 diabetes between 2016 and 2021, where females comprised 54.7%, and males comprised 45.3%. Similar results were also found in a study conducted by Shah et al., where out of 77 child samples, 58.4% were female and 41.6% were male. This study found a mean duration of 4.77 years for subjects suffering from type 1 diabetes. Among the 26 research subjects, more than half had a history of diabetic ketoacidosis, accounting for 53.8%.

Impact of the COVID-19 Pandemic on Glycemic Control through the Parameter of HbA1C in Children with Type-1 Diabetes

The research results showed a decrease in HbA1c levels during the pandemic compared to before the pandemic, which was 1.85%. Based on the statistical test results using the Paired Sample T-test, it was found that the COVID-19 pandemic had an influence on glycemic control through the parameter of HbA1c in children with type-1 diabetes ($p < 0.05$). This is contrary to the hypothesis that there would be an increase in HbA1c levels in glycemic control of children with type-1 diabetes during the COVID-19 pandemic, which was derived from the study by Verma et al.

The cross-sectional study conducted by Verma et al. on the effect of activity restriction during the COVID-19 pandemic on glycemic control in type-1 diabetes found an increase in the mean HbA1c to $10 + 1.5\%$ ($p < 0.05$). Another study by Onmez et al. also found a decrease in glycemic control due to activity restriction during the COVID-19 pandemic. These differing results could be due to differences in the samples taken. In Verma et al.'s study, the sample consisted of inpatients, while in this study, the sample consisted of outpatients.

The results of this study indicate a decrease in HbA1c levels during the pandemic, which is consistent with the report by Tornese in 2020 that glycemic control of type 1 diabetes in adolescents using a hybrid closed-loop system did not worsen during COVID-19 restrictions, and they were still able to continue physical activities during quarantine (Tornese et al., 2020). It was also explained that during quarantine, concerns about relapse, and the presence of parents/guardians at home increased self-care and supervision of diabetes control. This is also consistent with clinical research and reviews conducted by Anoop Misra in 2021, reporting that patients with well-controlled blood sugar experienced minimal changes in their glycemic status (Misra et al., 2021). These patients could self-manage at home

according to their previous diabetes management. A study conducted at the Children's Health Center in Italy reported a decrease in diabetes cases in 2020 compared to 2019 by 23%. Although the HbA1c results obtained show a decrease during the pandemic examination, HbA1c levels are still high above the normal value of $>7\%$. Only 1 out of 26 patients (3.8%) had HbA1c levels below the normal value (Hashemipour et al., 2021).

The improvement in glycemic control as evidenced by the decrease in HbA1c levels during the COVID-19 pandemic is consistent with the study conducted by Shah et al. in India. An observational study by Shah et al. on children and adolescents in India with type 1 diabetes showed that the COVID-19 lockdown resulted in much better or not worse glycemic control in children in their study group. Interestingly, children from lower and lower-middle socioeconomic classes showed better glycemic control during lockdown, while children from higher socioeconomic classes had unchanged post-lockdown glycemic control. Additionally, children whose parents did not work and stayed at home during lockdown showed improved glycemic control compared to children whose parents worked during lockdown. Social restrictions or lockdown positively affected glycemic control in children with type 1 diabetes. Similar findings have been reported in studies on adults with type 1 diabetes by Capaldo et al., Bonora et al., Dover et al., and Fernandez et al. The above studies link better glycemic control with better stability in daily routines, healthier and regular diets, and more time for treatment adjustments (Shah et al., 2021).

The improved glycemic control during the COVID-19 pandemic may be due to the fact that all the research samples in this study were covered by national health insurance, BPJS, providing free insulin. This is consistent with research conducted by Shah et al. in developing countries like India, where one of the main reasons for suboptimal glycemic control is poor compliance, mainly due to the cost of insulin and glucose strips as shown in a study by Varma et al. This is different from the findings of the study by Shah et al. The main reason for this difference is that barriers such as affordability and the availability of insulin and glucose strips were facilitated in this study; as indicated by Shah et al., patients in the lower-income group were given free insulin and glucose strips so that families with low income could be one reason for the improvement in glycemic control in this group.

Another reason for the improved glycemic control during the COVID-19 pandemic, as suggested by Shah et al., is the stronger family support system (as both parents were at home during lockdown). In this group, almost 50% of parents who worked before lockdown were at home during the lockdown period. Because no parent actually lost their source of income and because free insulin was provided to low-income families, Shah et al. hypothesized that having both parents at home led to more attention and discipline toward the child, including regular and consistent meal times and dedicated time for some form of exercise at home, all of which contribute to better glycemic control. A stronger family support system leads to

better problem-solving skills and disciplined lifestyles known to affect glycemic control.

During the collection of child patients with type 1 diabetes data, 26 patients with type 1 diabetes were included in the study, where of these 26 patients, there were 14 patients with diabetic ketoacidosis, and 2 of them died. This is in line with research conducted by Ivanna in 2020, where an increase in the severity of type 1 diabetes patients during COVID-19 was found. However, this study could not prove the relationship between an increase in the severity of type 1 diabetes symptoms such as diabetic ketoacidosis.

Limitations of the Study

This study did not examine the factors that cause poor glycemic control in children with type 1 diabetes, such as dietary patterns, physical activity, and therapy compliance. However, during the pandemic, all children undergoing type 1 diabetes treatment at Dr. M. Djamil Padang Hospital, along with their parents, were well and intensively educated via WhatsApp by pediatric specialists about the importance of maintaining dietary patterns, physical activity, and therapy compliance to achieve good glycemic control, thus fostering emotional bonds between pediatric specialists, patients, and patient families.

CONCLUSION

Based on the results and discussion above, the following conclusions can be drawn: 1. The average glycemic control before the pandemic was found to be 12.17%. 2. The average glycemic control during the pandemic was found to be 10.32%. 3. There was a decrease in HbA1c levels during the pandemic compared to before the pandemic. Statistically, this decrease signifies the influence of the COVID-19 pandemic on glycemic control through the parameter of HbA1c in children with type 1 diabetes.

For further research, it is suggested to include data on parental occupation and family socioeconomic status to support the patients' ability to obtain medication and glucose testing strips. Subsequent studies should be conducted on a larger sample size and compare samples with and without national health insurance coverage.

REFERENCES

- Alaqeel, A., Aljuraibah, F., Alsuhaibani, M., Huneif, M., Alsaheel, A., Dubayee, M. Al, Alsaedi, A., Bakkar, A., Alnahari, A., Taha, A., Alharbi, K., Alanazi, Y., Almadhi, S., & Khalifah, R. Al. (2021). The Impact of COVID-19 Pandemic Lockdown on the Incidence of New-Onset Type 1 Diabetes and Ketoacidosis Among Saudi Children. *Frontiers in Endocrinology*, 12. <https://doi.org/10.3389/fendo.2021.669302>
- Arrieta, M. I., Foreman, R. D., Crook, E. D., & Icenogle, M. L. (2008). Insuring continuity of care for chronic disease patients after a disaster: Key

- preparedness elements. *American Journal of the Medical Sciences*, 336(2), 128–133. <https://doi.org/10.1097/MAJ.0b013e318180f209>
- Carballo, J. J., Llorente, C., Kehrmann, L., Flamarique, I., Zuddas, A., Purper-Ouakil, D., Hoekstra, P. J., Coghill, D., Schulze, U. M. E., Dittmann, R. W., Buitelaar, J. K., Castro-Fornieles, J., Lievesley, K., Santosh, P., Arango, C., Sutcliffe, A., Curran, S., Selema, L., Flanagan, R., ... Aitchison, K. (2020). Psychosocial risk factors for suicidality in children and adolescents. In *European Child and Adolescent Psychiatry* (Vol. 29, Issue 6, pp. 759–776). Springer. <https://doi.org/10.1007/s00787-018-01270-9>
- Chambers, M. A., Mecham, C., Arreola, E. V., & Sinha, M. (2022). Increase in the Number of Pediatric New-Onset Diabetes and Diabetic Ketoacidosis Cases During the COVID-19 Pandemic. *Endocrine Practice*, 28(5), 479–485. <https://doi.org/10.1016/j.eprac.2022.02.005>
- COVID Live Update: 188,556,234 Cases and 4,064,985 Deaths from the Coronavirus - Worldometer. (2021, July 14). <https://www.worldometers.info/coronavirus/>
- Dewi, R., Kaswandani, N., Karyanti, M. R., Setyanto, D. B., Pudjiadi, A. H., Hendaro, A., Djer, M. M., Prayitno, A., Yuniar, I., Indawati, W., Prawira, Y., Handryastuti, S., Sjakti, H. A., Hidayati, E. L., Muktiarti, D., Soebadi, A., Puspaningtyas, N. W., Muhaimin, R., Rahmadhany, A., ... Putri, N. D. (2021). Mortality in children with positive SARS-CoV-2 polymerase chain reaction test: Lessons learned from a tertiary referral hospital in Indonesia. *International Journal of Infectious Diseases*, 107, 78–85. <https://doi.org/10.1016/j.ijid.2021.04.019>
- Fonseca, V. A., Smith, H., Kuhadiya, N., Leger, S. M., Yau, C. L., Reynolds, K., Shi, L., McDuffie, R. H., Thethi, T., & John-Kalarickal, J. (2009). Impact of a natural disaster on diabetes: Exacerbation of disparities and long-term consequences. *Diabetes Care*, 32(9), 1632–1638. <https://doi.org/10.2337/dc09-0670>
- Hashemipour, M., Hovsepian, S., Mozafarian, N., Motaghi, Z., Izadikhah, E., & Maracy, M. R. (2021). Factors related to glycemic control in children and adolescents with type 1 diabetes mellitus in Isfahan, Iran. *Journal of Diabetes and Metabolic Disorders*, 20(2), 1281–1288. <https://doi.org/10.1007/s40200-021-00854-8>
- Kachru Shriya, & Kaul Dinesh. (2020). COVID-19 manifestations in children. *Current Medicine Research and Practice*, 186–188. <https://doi.org/10.1016/j.eclinm.2020.100433>
- Misra, A., Ghosh, A., & Gupta, R. (2021). Heterogeneity in presentation of hyperglycaemia during COVID-19 pandemic: A proposed classification. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 15(1), 403–406. <https://doi.org/10.1016/j.dsx.2021.01.018>
- Pembatasan Sosial Berskala Besar Dalam Rangka Percepatan Penanganan Corona Wrus Disease 2019 (Covid-19), Pub. L. No. Nomor 21, Peraturan Pemerintah Republik Indonesia (2020).
- Perpanjangan Pemberlakuan Pembatasan Sosial Berskala Di Wilayah Provinsi Sumatera Barat Dalam Rangka Penanganan Corona Virus Disease 2019

- (Covid-19), Keputusan Gubernur Sumatera Barat Nomor: 180 - 331- 2020 (2020).
- Pulungan, A. B., Annisa, D., & Imada, S. (2019). Diabetes melitus tipe-1 pada anak: situasi di Indonesia dan tata laksana Diabetes Melitus Tipe-1 pada Anak : Situasi di Indonesia dan Tata Laksana. In *Sari Pediatri* (Vol. 20, Issue 6).
- Shah, N., Karguppikar, M., Bhor, S., Ladkat, D., Khadilkar, V., & Khadilkar, A. (2021). Impact of lockdown for COVID-19 pandemic in Indian children and youth with type 1 diabetes from different socio-economic classes. *Journal of Pediatric Endocrinology and Metabolism*, 34(2), 217–223. <https://doi.org/10.1515/jpem-2020-0460>
- Telford, D. M., Signal, D. M., Hofman, P. L., & Gusso, S. (2021). Physical activity in adolescents with and without type 1 diabetes during the new zealand covid-19 pandemic lockdown of 2020. *International Journal of Environmental Research and Public Health*, 18(9). <https://doi.org/10.3390/ijerph18094475>
- Tornese, G., Ceconi, V., Monasta, L., Carletti, C., Faleschini, E., & Barbi, E. (2020). Glycemic Control in Type 1 Diabetes Mellitus During COVID-19 Quarantine and the Role of In-Home Physical Activity. *Diabetes Technology and Therapeutics*, 22(6), 462–467. <https://doi.org/10.1089/dia.2020.0169>
- Verma, A., Rajput, R., Verma, S., Balania, V. K. B., & Jangra, B. (2020). Impact of lockdown in COVID 19 on glycemic control in patients with type 1 Diabetes Mellitus. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 14(5), 1213–1216. <https://doi.org/10.1016/j.dsx.2020.07.016>
- Zhao, Y. miao, Shang, Y. min, Song, W. bin, Li, Q. quan, Xie, H., Xu, Q. fu, Jia, J. li, Li, L. ming, Mao, H. li, Zhou, X. man, Luo, H., Gao, Y. feng, & Xu, A. guo. (2020). Follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors three months after recovery. *EClinicalMedicine*, 25. <https://doi.org/10.1016/j.eclinm.2020.100463>