Patterns of incidence and characteristics of youth with new-onset diabetes mellitus in the COVID era

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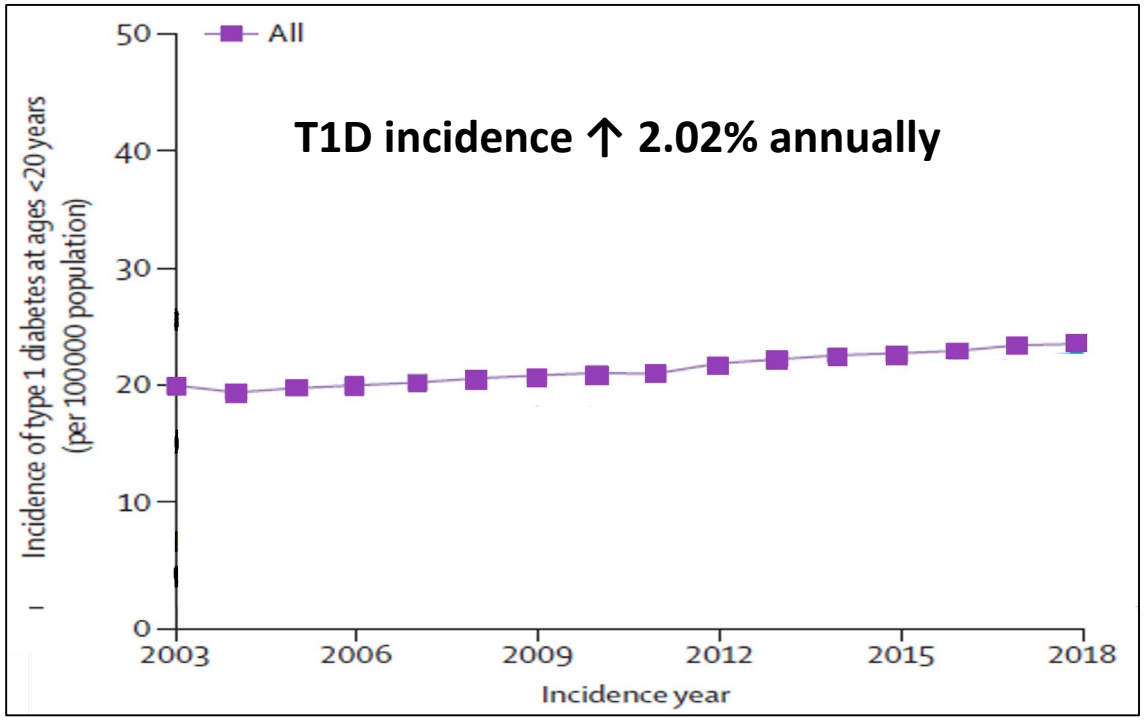
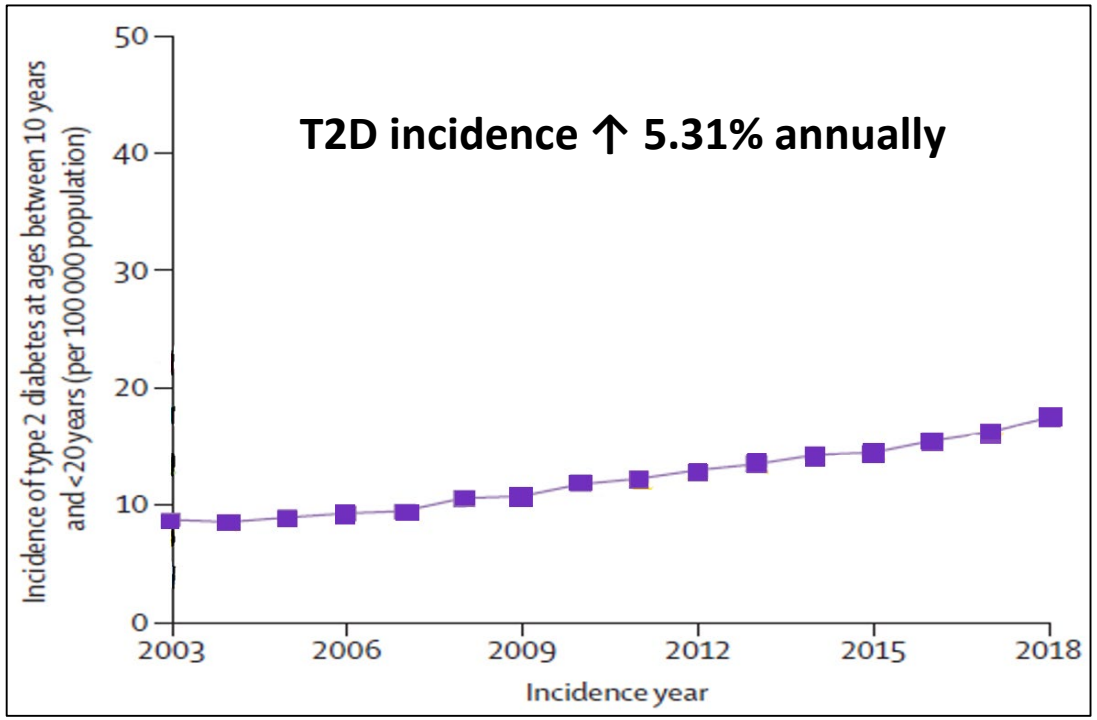
Diabetes in Youth in the Pre-COVID Era





Figures from Wagenknecht, L.E., et al., *Trends in incidence of youth-onset type 1 and type 2 diabetes in the USA, 2002-18: results from the population-based SEARCH for Diabetes in Youth study.* Lancet Diabetes Endocrinol, 2023. **11**(4): p. 242-250. Adapted for this presentation

Norton Children's

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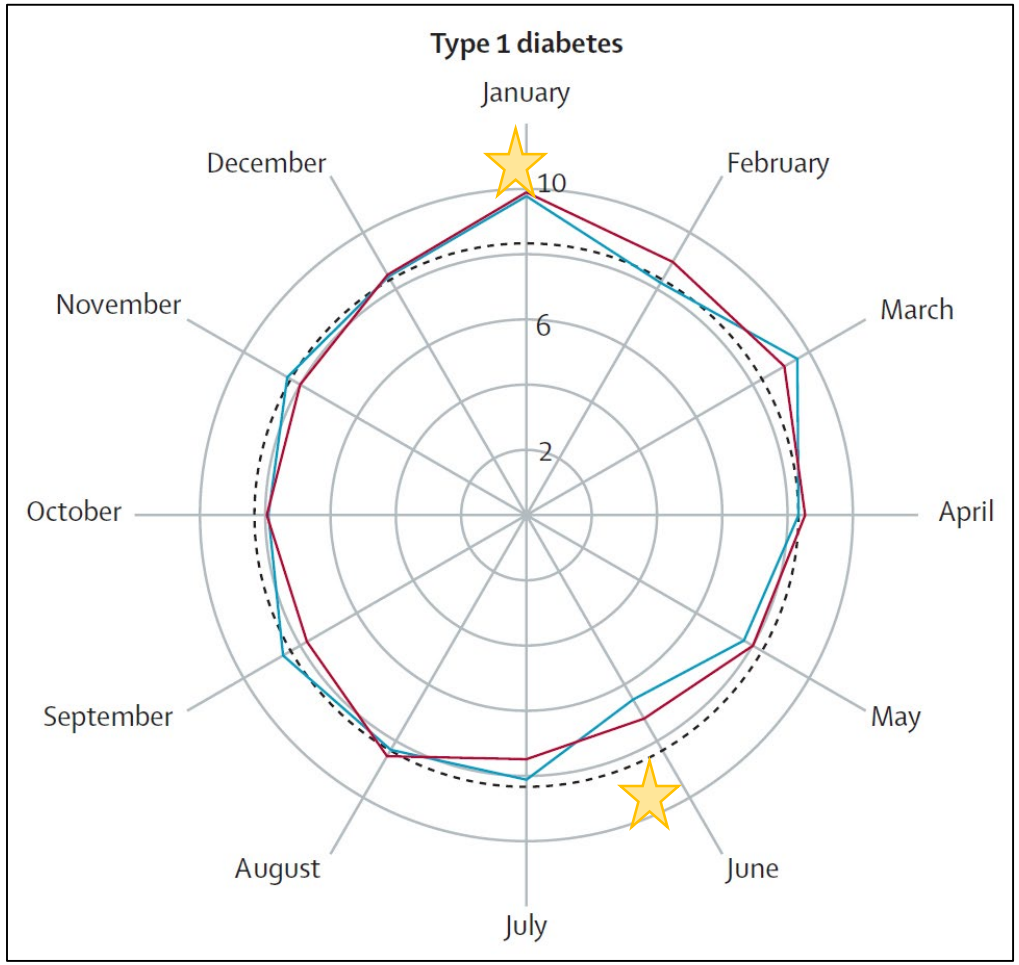
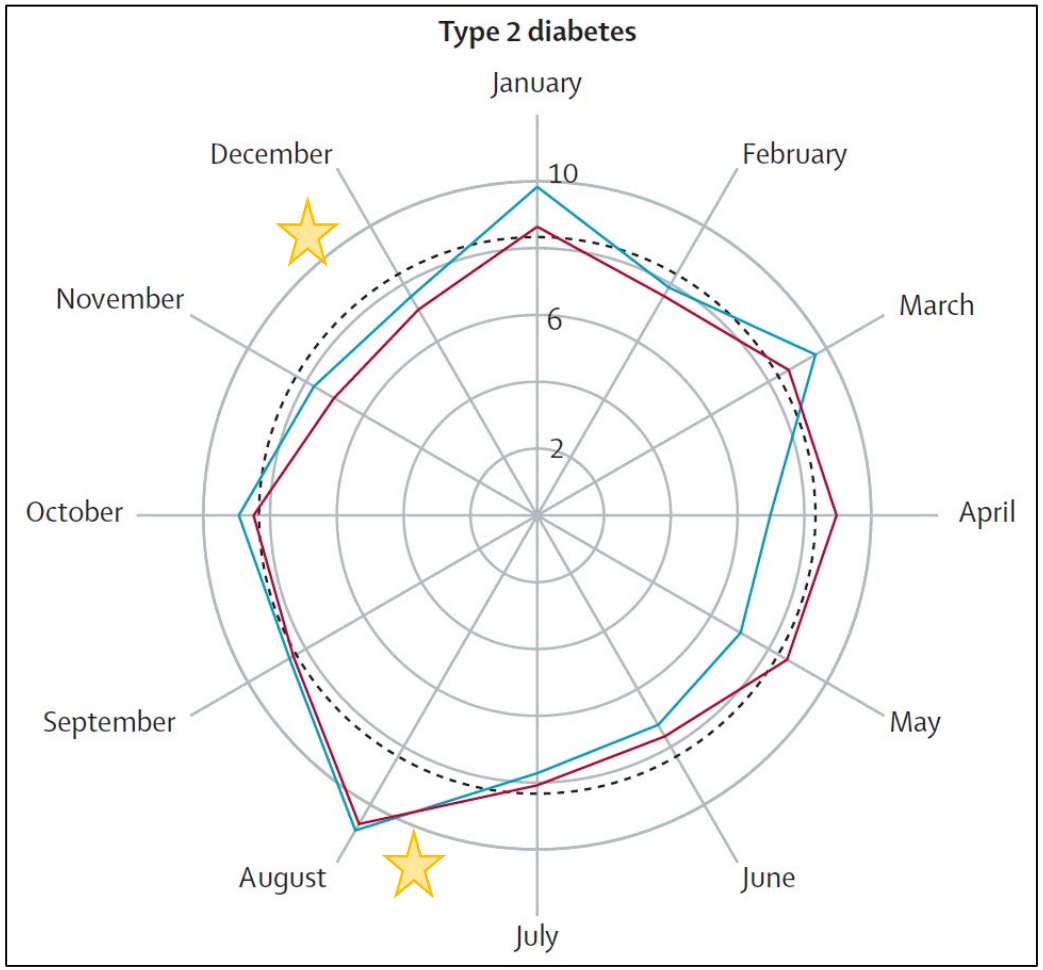
UofL School of Medicine





2002–09 2010–18 Constant

Figures from Wagenknecht, L.E., et al., *Trends in incidence of youth-onset type 1 and type 2 diabetes in the USA, 2002-18: results from the population-based SEARCH for Diabetes in Youth study.* Lancet Diabetes Endocrinol, 2023. **11**(4): p. 242-250. Adapted for this presentation

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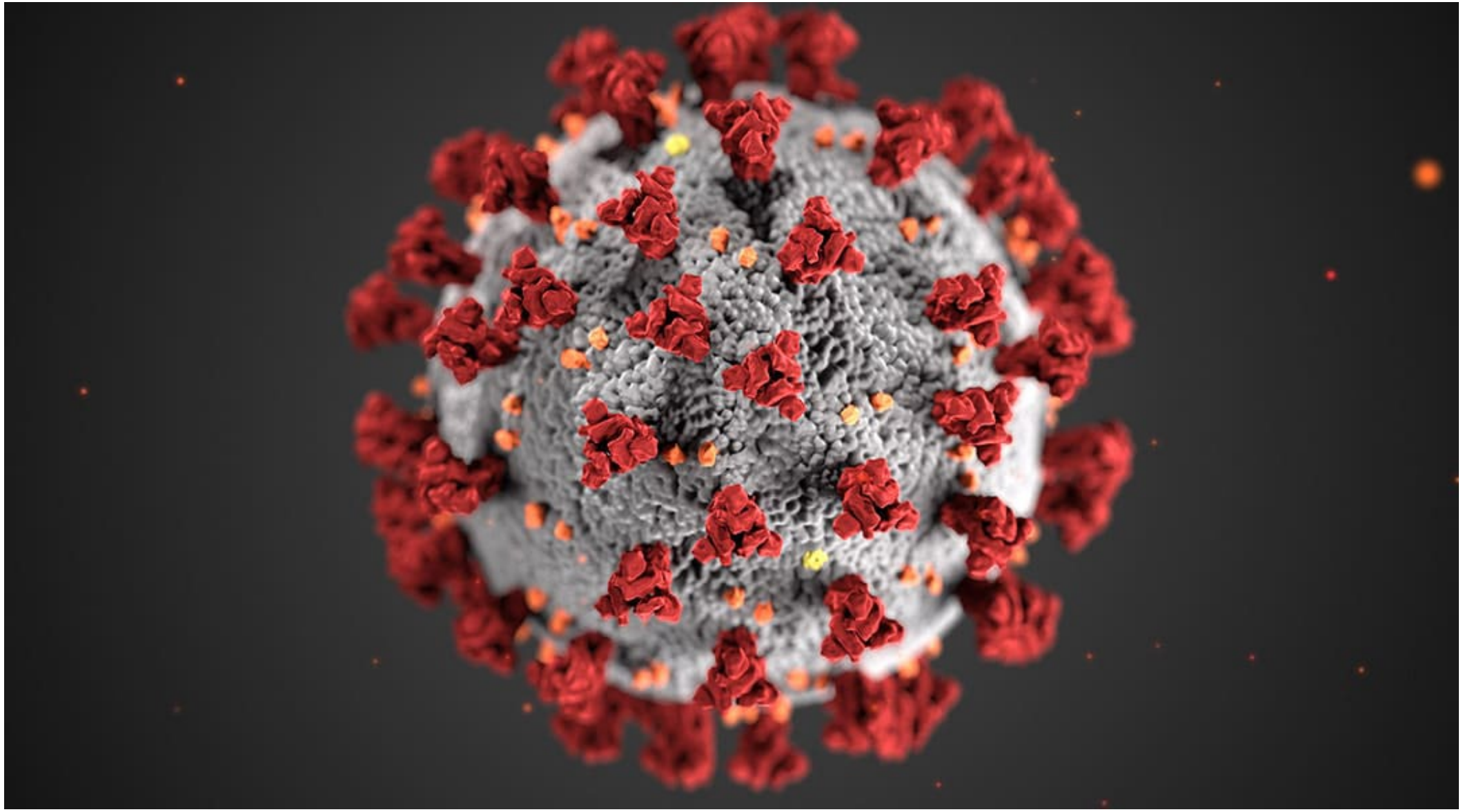


COVID & T1D: Lit Review

Incidence

First wave of pandemic ↑ vs ↓

Fall 2020 – 2021:↑

Greater than predicted? Country dependent

Presentation

DKA, HHS, and Mixed

- More than pre-pandemic?
- Debated and location dependent.

Seasonal Pattern

Europe: shifted in 2020, returned in 2021

US and Germany: shifted in 2020 and 2021

No 2022 data

Patient Characteristics

HbA1c, BMI %ile, Age, Sex

Different regions with different trends.

COVID & T2D: Lit Review

Incidence

- ↑ during COVID era (USA, Germany)
  - Greater than predicted

Presentation

- Varied reports of DKA, HHS, DKA/HHS at dx vs pre-COVID era

Obesity pattern

- USA: ↑ rates of obesity during pandemic, *younger population

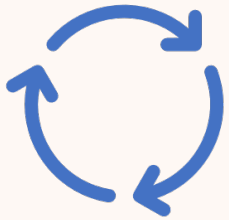
Patient characteristics

- No universal consensus
  - HbA1c
  - Age
  - BMI %ile
  - Socio-econ status

COVID + T1D + T2D: Literature Gaps

Why increase in pediatric DM incidence during pandemic?

Many hypotheses, but no clear mechanism; definitely multifactorial



What happened after 2021?

Very limited data reported for 2022, and that has been limited to Spring 2022

Methods

Objective:

Determine the incidence of diabetes mellitus, and its subtypes, at the WNDI/NCH during the 3 years pre-COVID-19 pandemic (2017-2019) and the first 3 years of the COVID-19 pandemic (2020-2022).

Specific Aims and Measures

1. Assess for **difference in seasonality and temporal pattern** of new onset diabetes mellitus when comparing the 3 years prior to the COVID-19 pandemic (2017-2019) and the first 3 years of the pandemic (2020-2022), as well as within the first 3 years of the COVID-19 pandemic (2020 vs 2021 vs 2022).

2. Describe the **incidence of diabetes mellitus by type and antibody profile at the time of diagnosis**. **Compare the incidence** of each type during the pre-pandemic and pandemic time periods.

3. Evaluate for **differences in clinical characteristics by diabetes type** for the 3 years of the COVID-19 pandemic versus those diagnosed in the first 3 years during the COVID-19 pandemic, and within the first 3 years of the COVID-19 pandemic (2020 vs 2021 vs 2022)

4. Evaluate **regional trends in incidence** of diabetes during the study period. Specifically, evaluate the **association of socioeconomic deprivation on the incidence of diabetes.**

Inclusion/Exclusion Criteria

Inclusion criteria

Males and Females

1 – 21 years of age at dx

New diagnosis of DM at WNDI/NCH:

1/1/17 – 12/31/22*

Exclusion criteria

Patients who do not meet the American Diabetes Association diagnostic criteria

Cystic Fibrosis related Diabetes mellitus

Patients with MODY diagnosis

Medication induced hyperglycemia and/or medication induced diabetes mellitus

Patients who did not receive new onset diabetes care at Norton Children's Hospital or Wendy Novak Diabetes Institute.

*Part 2 submitted and extended through 12/31/23

Results

Our population

1139 charts reviewed

969 patients included

Pre-COVID: 408 new DM dx

COVID Era: 561 new DM dx

↑ **38%**

Of those diagnosed with DM during pandemic period, only 97 were tested for COVID and 8 were positive.

Our population: T1D

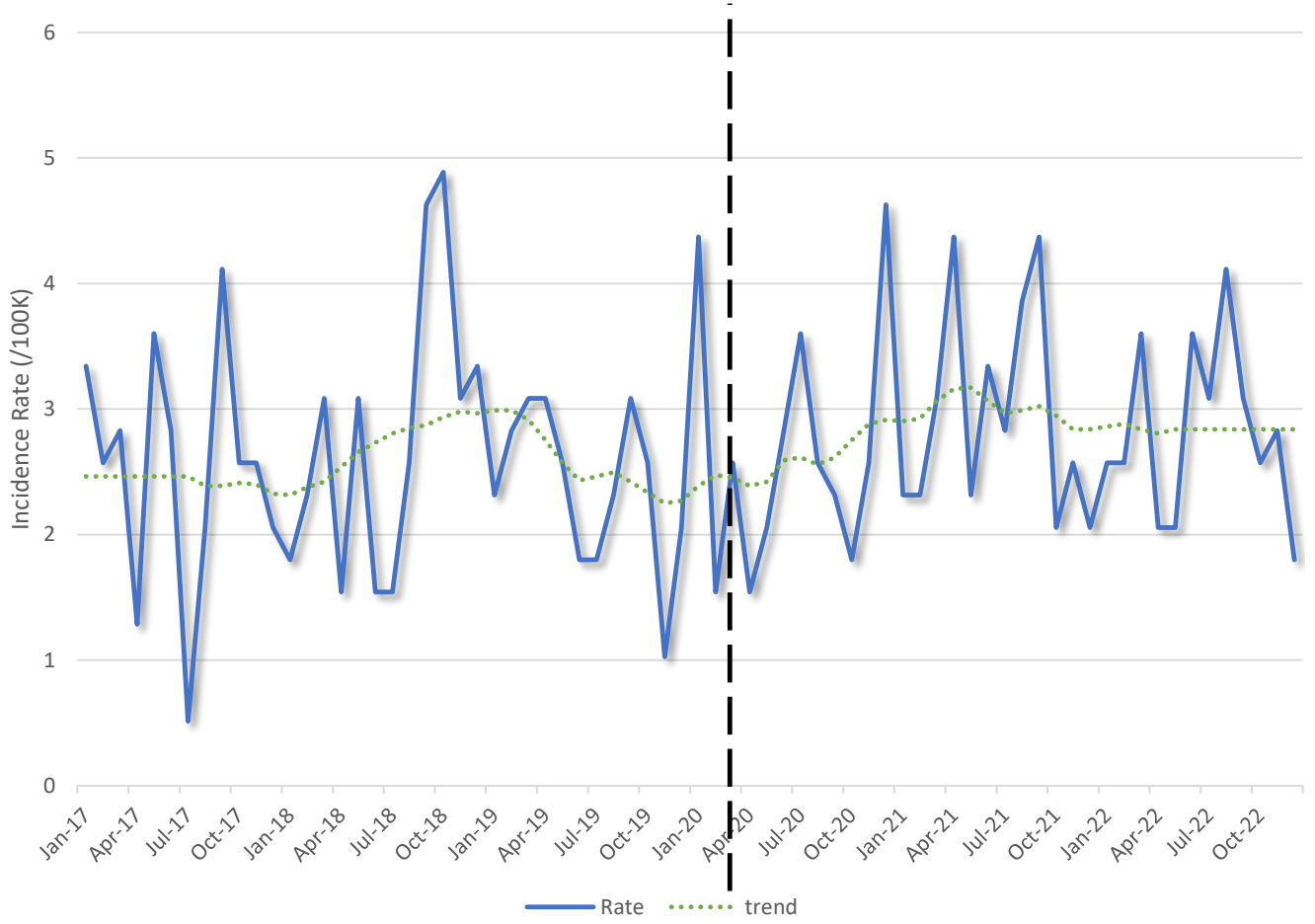
New Onset T1D: Incidence

Pre-COVID: 361

COVID: 402

↑ 11% incidence

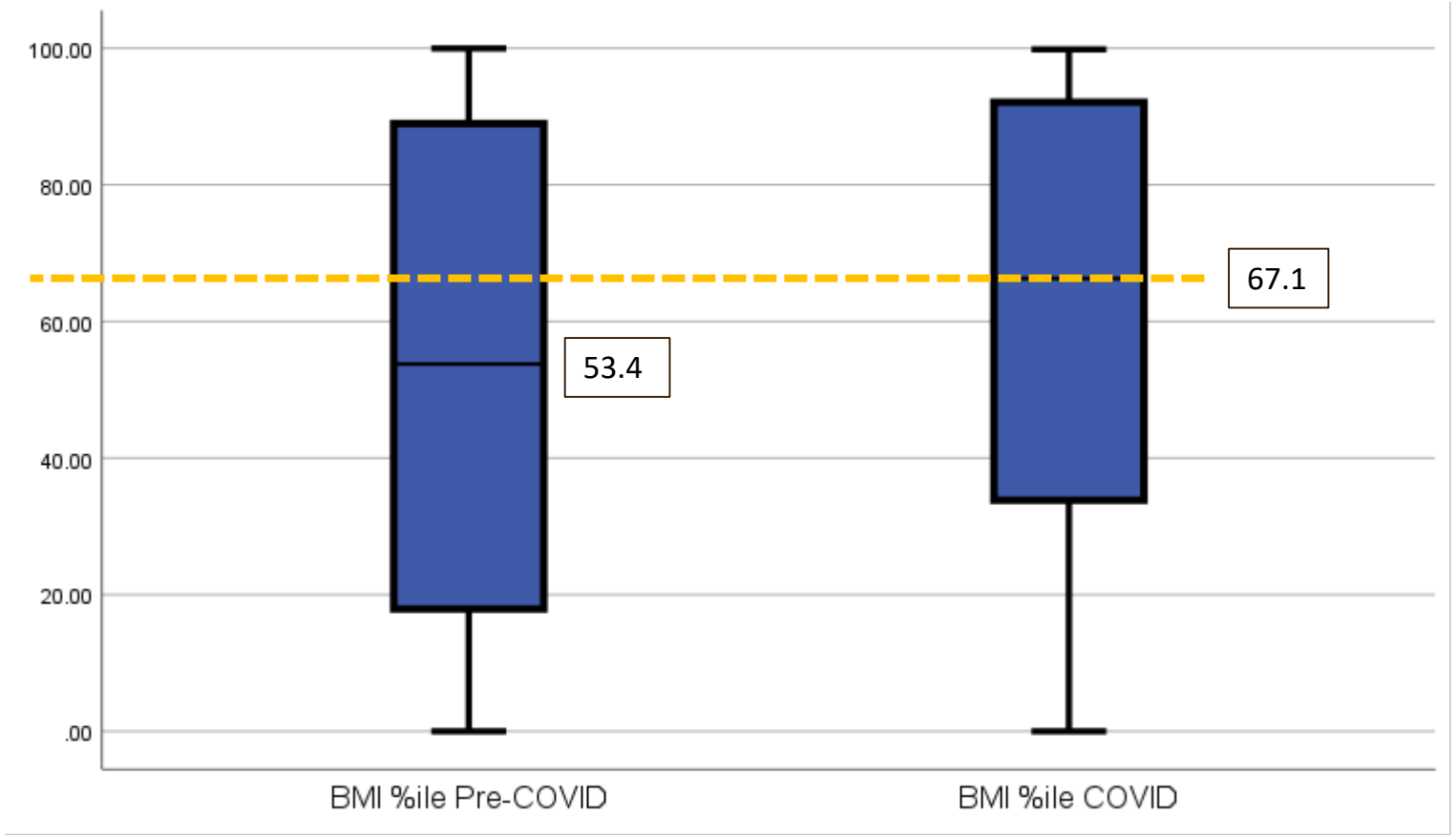
(IRR 1.11, 95%CI 1.01-1.23)



Characteristic	Pre-Pandemic 2017-2019	Pandemic Era 2020-2022	Univariate Analysis *p*-Value
Total, N (%)	361 (47.3)	402 (52.7)	
Sex, N (%)			0.554 [a]
Female	162 (44.9)	189 (47.0)	
Male	199 (55.1)	213 (53.0)	
Race, N (%)			0.215 [a]
White	289 (80.1)	327 (81.3)	
AA	41 (11.4)	41 (10.2)	
Hispanic	8 (2.2)	7 (1.7)	
Other	7 (1.9)	1 (0.2)	
Two or more race	14 (3.9)	18 (4.5)	
			0.685 [a]
Age group, N (%)			
0-7	87 (24.1)	110 (27.4)	
7-9	51 (14.1)	49 (12.2)	
9-11	64 (17.7)	60 (14.9)	
11-13	54 (15.0)	58 (14.4)	
13-15	50 (13.9)	51 (12.7)	
15-17	34 (9.4)	42 (10.4)	
17-21	21 (5.8)	32 (8.0)	
	Median (Q1-Q3)	**Median (Q1-Q3)**	
Median C-peptide	0.6 (0.3 - 0.9)	0.5 (0.3 - 1.0)	0.765 [c]
Median BMI Percentile	53.4 (17.9 - 89.0)	67.1 (32.1 - 91.8)	0.012 [c]
Median Household Income [d]	$64,283 ($46,781 - $83,333)	$66,062 ($46,620 - $85,498)	0.618 [c]
Social Vulnerability Index	0.5 (0.3 - 0.7)	0.4 (0.3 - 0.7)	0.489 [c]
Education level percent [d]			
High school or less	47.9 (34.5 - 57.9)	48.8 (34.5 - 59.0)	0.656 [c]
Some college or more	52.2 (42.1 - 65.5)	51.2 (41.0 - 65.5)	0.656 [c]
< 9th grade	3.4 (1.6 - 5.8)	3.4 (1.8 - 5.8)	0.650 [c]
9-12th grade, no diploma	7.4 (4.3 - 10.8)	7.5 (4.4 - 10.4)	0.976 [c]
High school graduate	35.5 (27.1 - 41.2)	36.1 (26.6 - 41.6)	0.688 [c]
Some college, no degree	21.8 (18.2 - 25.6)	21.1 (18.2 - 24.5)	0.122 [c]
Associate degree	8.6 (6.8 - 10.3)	8.4 (6.7 - 9.9)	0.427 [c]
Bachelor degree	11.6 (7.9 - 18.4)	11.1 (7.9 - 20.3)	0.930 [c]
Graduate or Prof degree	7.1 (4.4 - 12.2)	7.6 (4.8 - 12.6)	0.459 [c]

[a] P-value of Chi Square test;
[b] P-value of Fisher's Exact test;
[c] P-value of Wilcoxon Rank Sum test.
[d] U.S. Census Bureau (2017) by census tract level.

T1D: ↑ BMI %ile



P = 0.012 (Wilcoxon Rank Sum test)

T1D: Severity @ Presentation

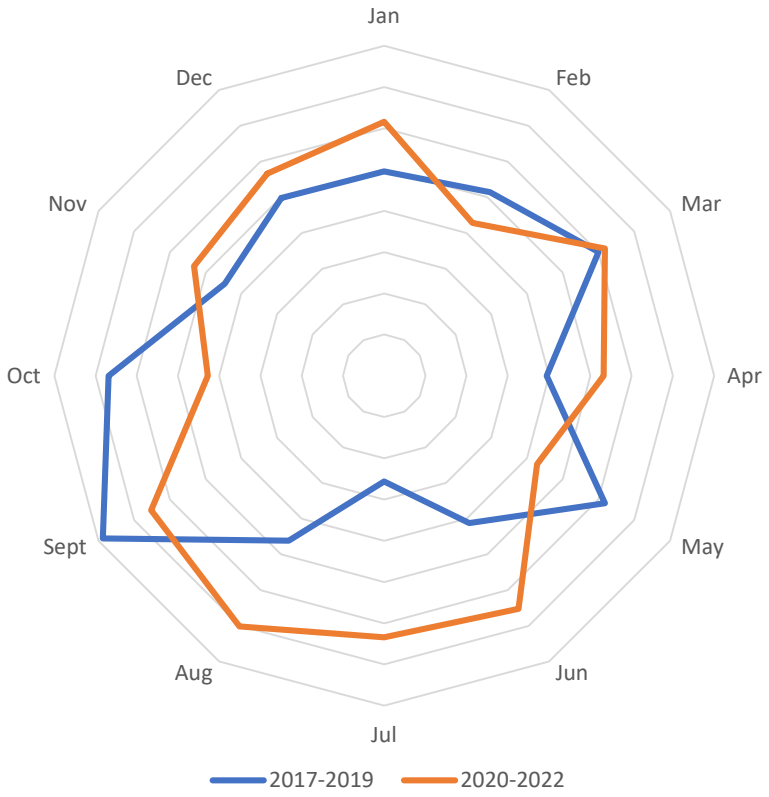
Pandemic: overall rate of DKA @dx was not significantly different vs pre-pandemic

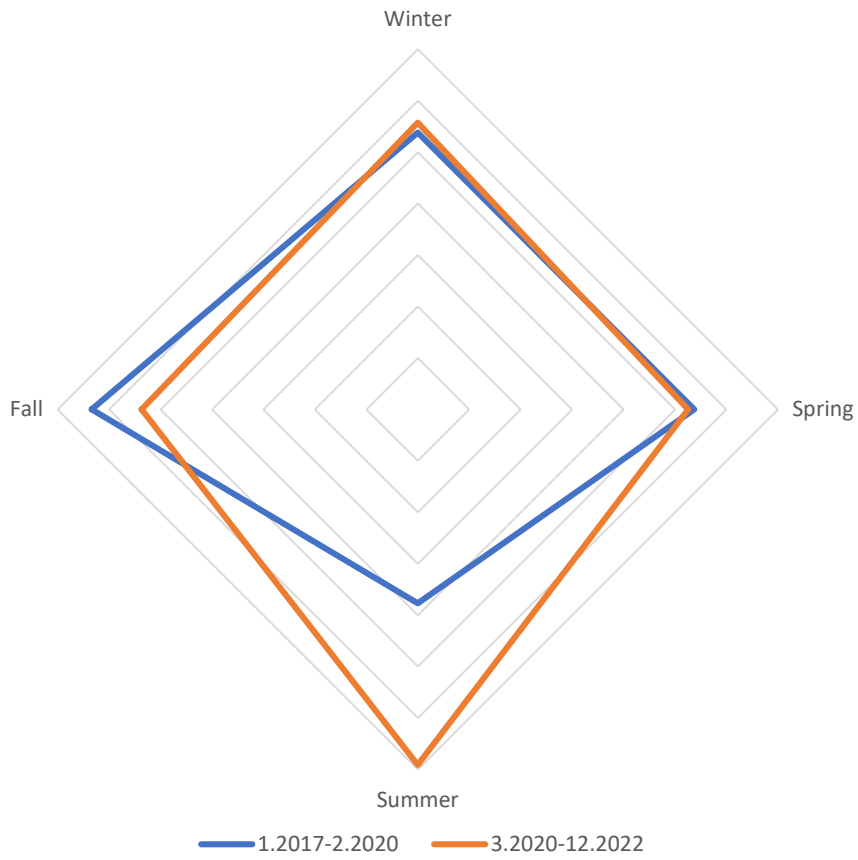
BUT….

During pandemic, if presented in DKA @ dx, more likely to be severe DKA

- OR 2.03, 95%CI 1.12-3.68, $p = 0.019$

T1D: Incidence Pattern





Sneak Peek

Brand New Data

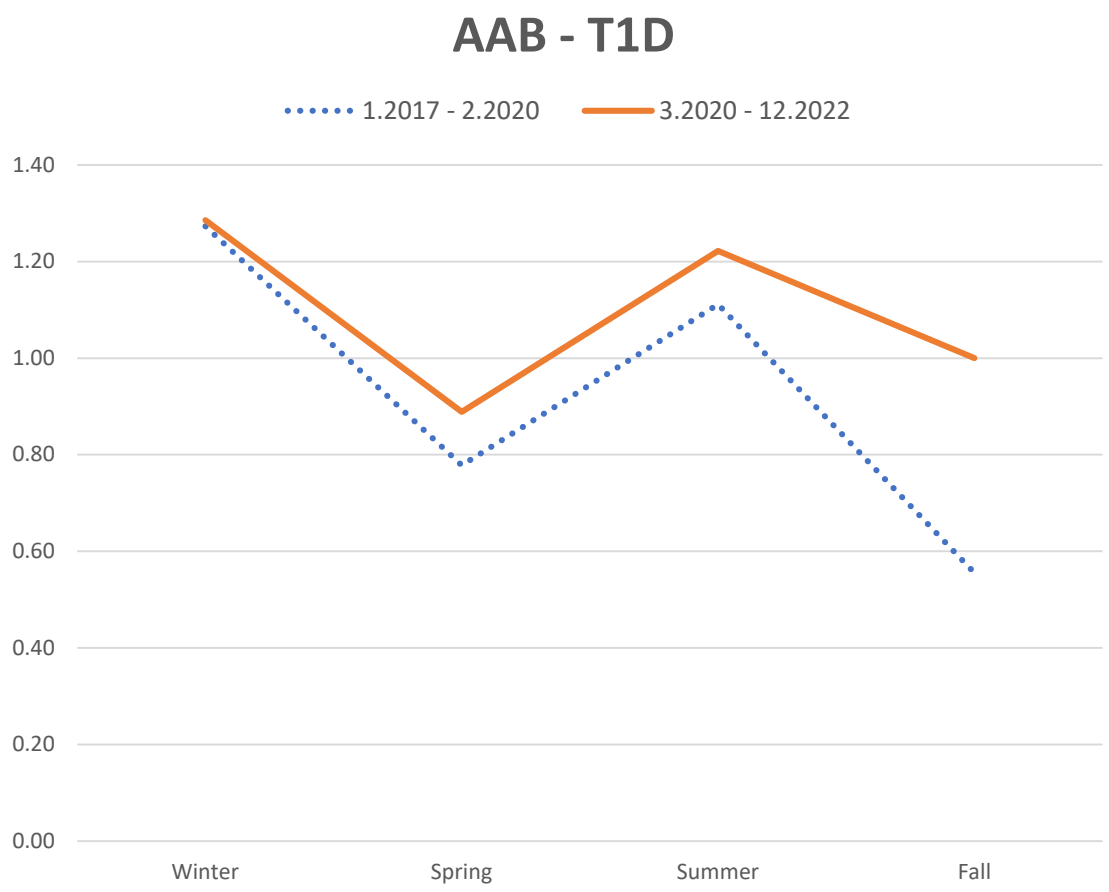
T1D: Autoantibodies & Screening

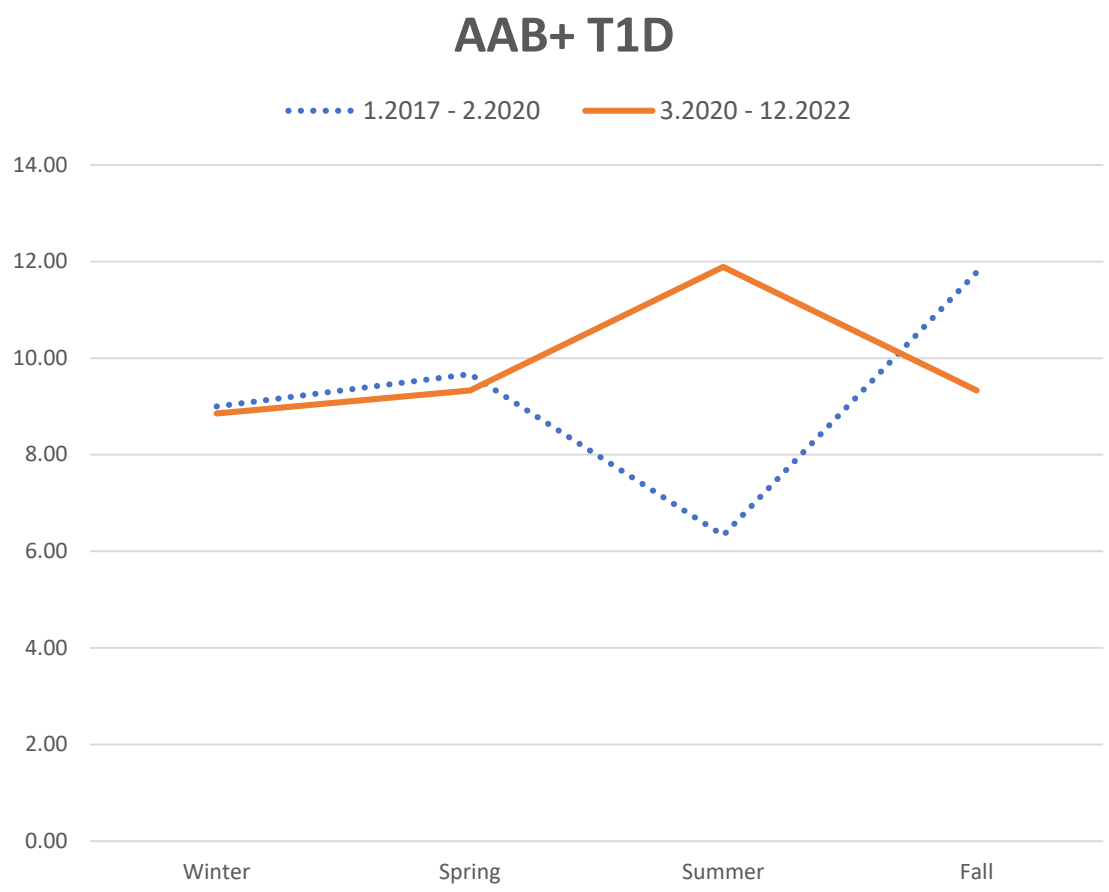
AAB - 1.2017-2.2020 vs 3.2020-12.2022				
	Pre-COVID	**COVID Era**	***p*-Value**	
Antibody	N (%)	N (%)		
All GAD+	295/385 (76.7%)	300/377 (79.6%)	0.172 [a]	↑
All IA2+	279/385 (**72.5%**)	241/377 (**63.9%**)	**<0.001** [a]	**↓***
All IAA+	108/385 (28.1%)	118/377 (31.3%)	0.167 [a]	↑
Thyroglobulin Ab	37/378 (9.8%)	20/367 (5.5%)	0.005[a]	**↓***
Thyroid Peroxidase Ab	60/378 (15.9%)	45/366 (12.3%)	0.061[a]	↓
Hashimoto's Thyroiditis	18.7%	13.9%	0.552[a]	↓
Celiac Screen	26/352 **(7.4%)**	42/356 **(11.8%)**	**<0.001** [a]	**↑***

*This pattern persisted in 2023.

[a] P-value of Chi Square test

T1D and Aab status: Seasonal Pattern



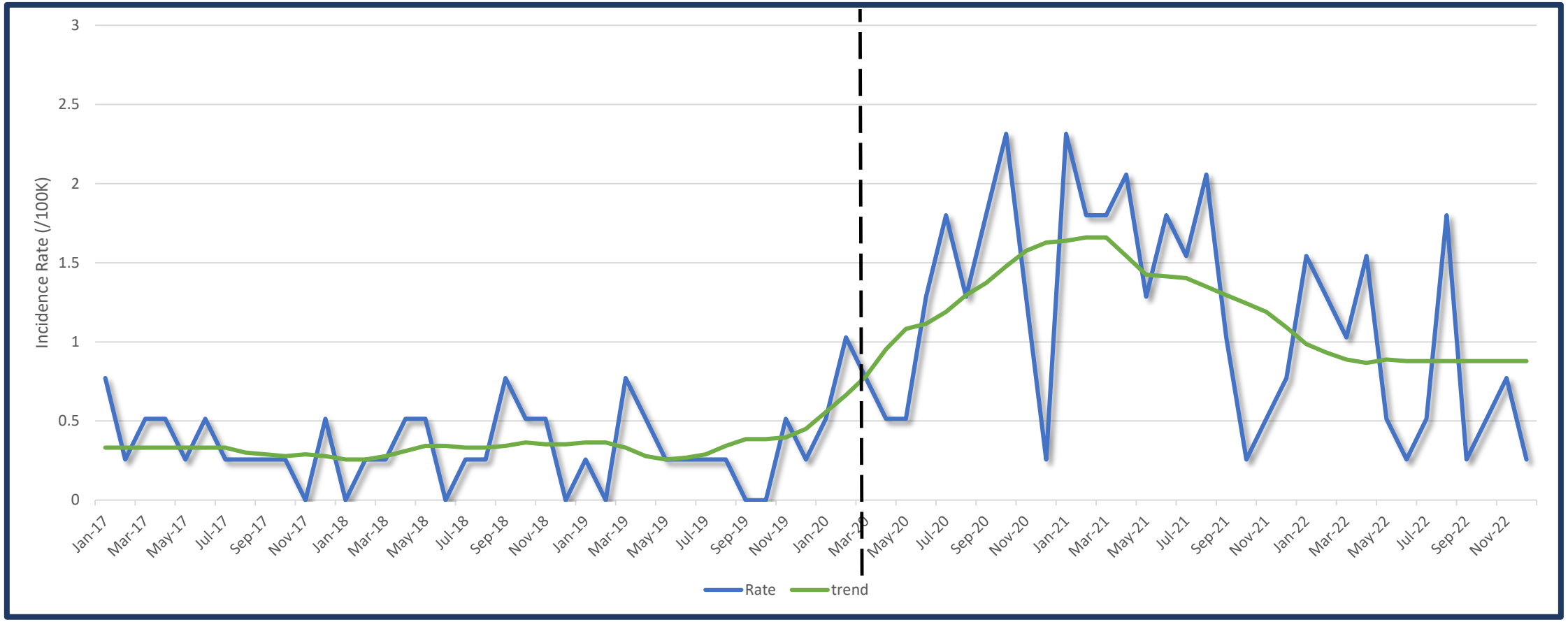


T1D: COVID Era Summary

- **Incidence ↑ 11%**
- **↑ BMI Percentile**
- **DKA: more likely to be severe**
- **Age remained the same**
- **Autoantibodies: ↓IA2 , ↓ Hashimoto , ↑ Celiac**
- **Summer!**

Our population: T2D

T2D: Incidence



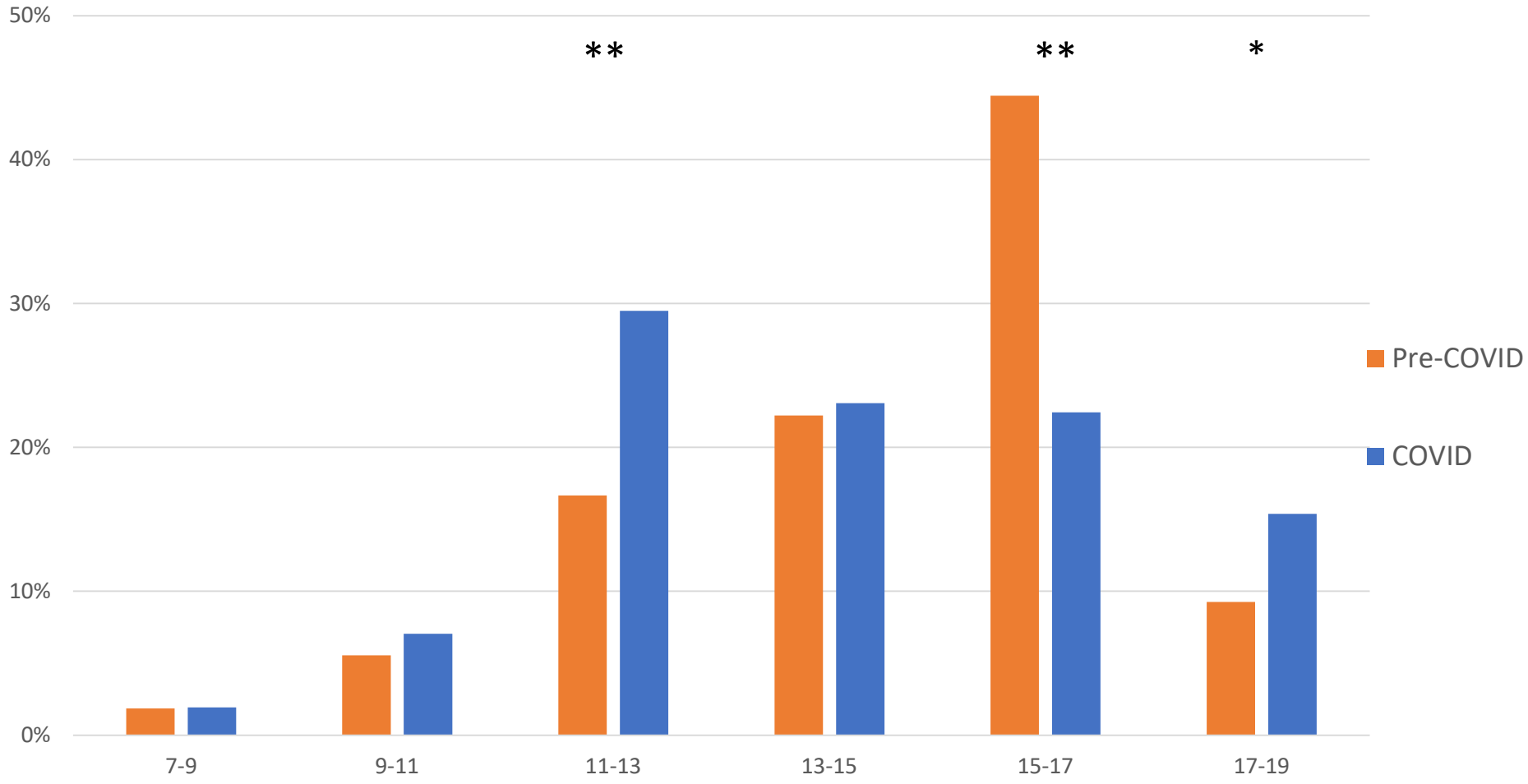
New Dx: **Pre-COVID: 47** **COVID Era: 159** **↑ 238% incidence**

(IRR 3.38, 95%CI 2.17-5.28)

Characteristic	Pre-Pandemic 2017-2019	Pandemic 2020-2022	Univariate Analysis *p*-Value
Total, N (%)	47 (22.8)	159 (77.2)	
Sex, N (%)			0.868 [a]
Female	24 (51.1)	79 (49.7)	
Male	23 (48.9)	80 (50.3)	
Race, N (%)			0.397[b]
White	**19 (40.4)**	**41 (25.8)**	
AA	**19 (40.4)**	**75 (47.2)**	
Hispanic	**5 (10.6)**	**24 (15.1)**	
Other	0 (0.0)	2 (1.3)	
2 or more races	4 (8.5)	10 (6.3)	
Age group (years), N (%)			**0.015 [b]**
0-7	0 (0.0)	1 (0.6)	
7-9	1 (2.1)	2 (1.3)	
9-11	2 (4.3)	14 (8.8)	
11-13	**8 (17.0)**	**43 (27.0)**	
13-15	**7 (14.9)**	**40 (25.2)**	
15-17	**24 (51.1)**	**32 (22.0)**	
17-21	5 (10.6)	24 (15.1)	
	Median (Q1-Q3)	**Median (Q1-Q3)**	
Median C-peptide	3.8 (2.6-6.6)	4.3 (2.5-6.8)	0.947 [c]
Median BMI pct	99.4 (98.5-99.7)	99.3 (98.6-99.6)	0.930 [c]
Median household income [d]	$49,688 ($35,345-$60,068)	$47,110 ($34,476-$64,117)	0.924 [c]
Social Vulnerability Index (SVI)	0.7 (0.5-0.8)	0.6 (0.4-0.9)	0.771 [c]
Education level percent [d]			
High school or less	54.0 (50.0 - 59.3)	53.2 (43.1 - 59.5)	0.313 [c]
Some college or more	46.0 (40.7 - 50.0)	46.8 (40.5 - 56.9)	0.313 [c]
Less than 9th grade	**5.4 (4.3-7.9)**	**4.6 (2.5-6.2)**	**0.017 [c]**
High school, no diploma	10.1 (7.9-13.1)	8.9 (6.5-13.1)	0.262 [c]
High school graduate or GED	37.6 (30.1-41.2)	36.0 (31.3-40.5)	0.656 [c]
Some college, no degree	23.4 (19.8-24.9)	22.5 (19.7-27.0)	0.957 [c]
Associate degree	7.9 (6.3-9.7)	**8.3 (6.3-10.5)**	0.340 [c]
Bachelor degree	7.9 (5.8-11.7)	**9.3 (5.9-13.8)**	0.349 [c]
Grad/Prof degree	4.9 (3.3-7.7)	**5.8 (2.9-8.5)**	0.333 [c]

[a] P-value of Chi Square test
[b] P-value of Fisher's Exact test
[c] P-value of Wilcoxon Rank Sum test
[d] U.S. Census Bureau (2017) by census tract level

T2D: Age at Diagnosis



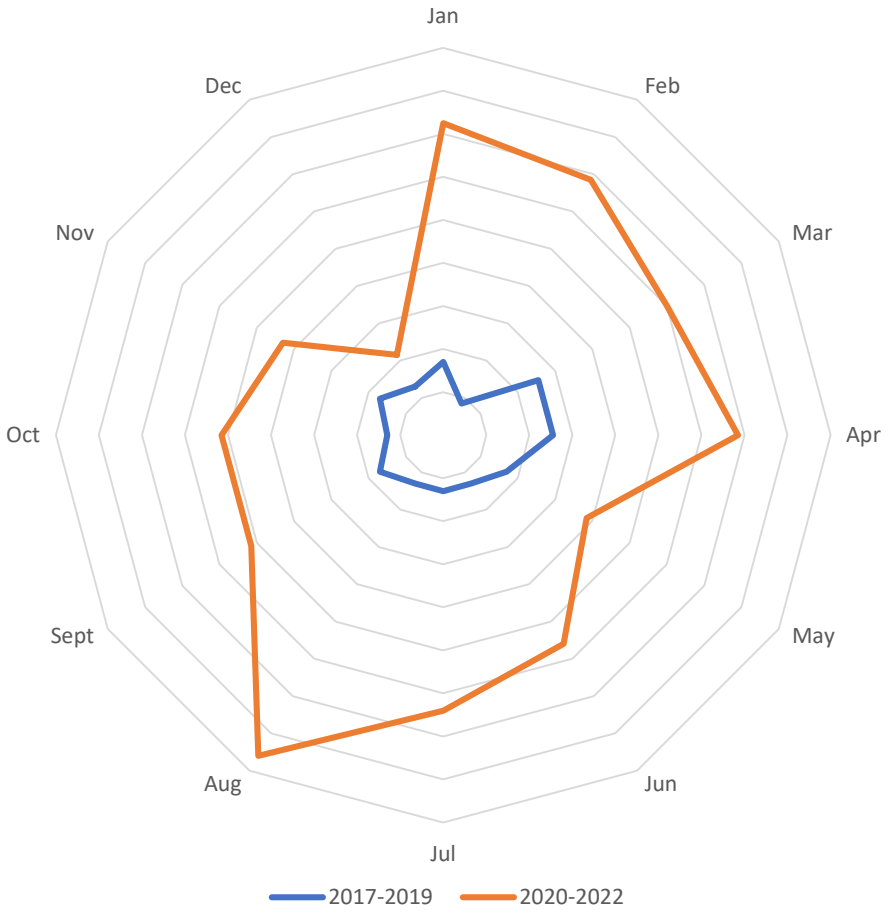
* p = 0.01 ** p <0.001

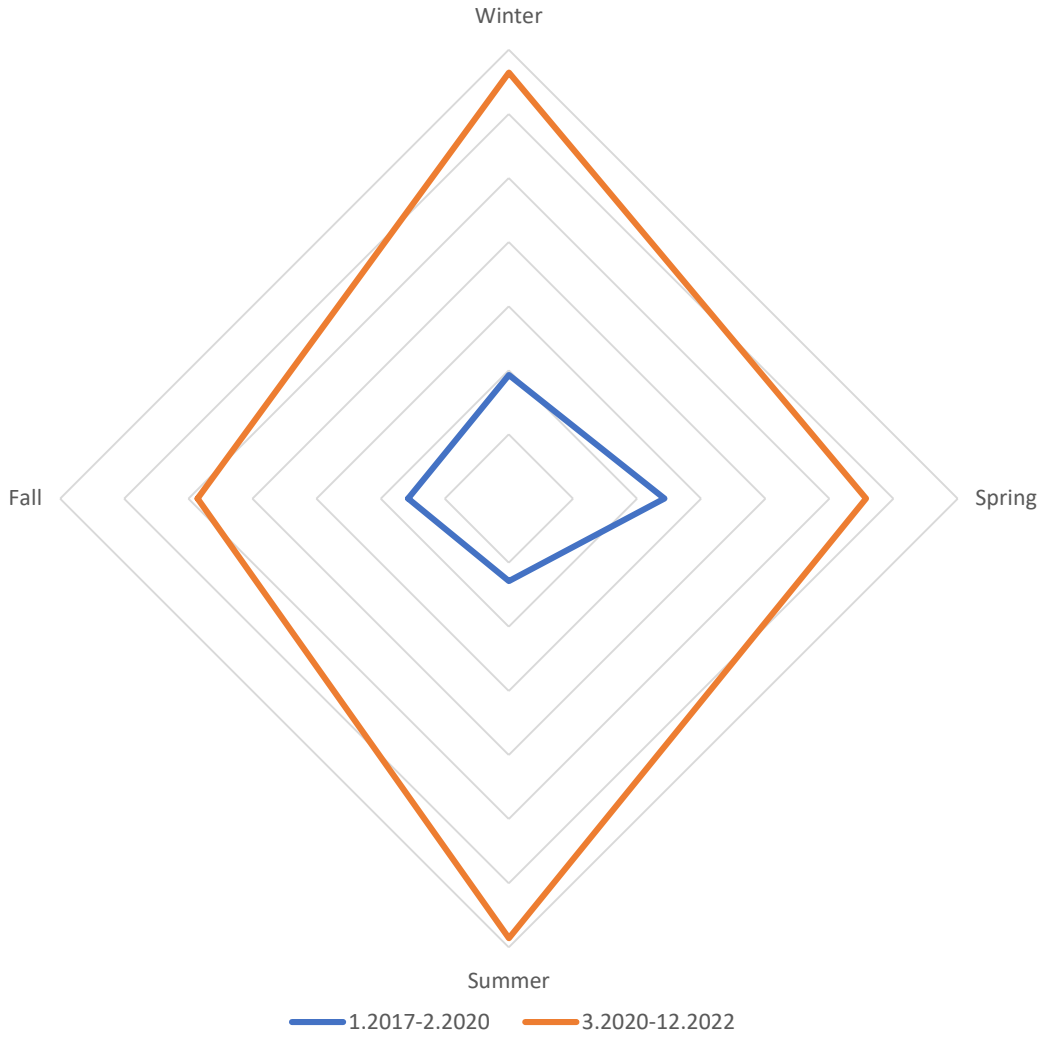
T2D: Severity at Presentation

The percentage of patients who did not have DKA or HHS at presentation was about the same: 86% Pre-COVID vs 87% COVID

The percentage of patients who presented with Mixed DKA/HHS was slightly higher in the COVID era at 7% vs 2% during Pre-COVID era, but not statistically significant

T2D: Incidence Pattern





T2D: COVID Era Summary

- Incidence ↑ 238%
- ↓ Age at diagnosis
- BMI Percentile unchanged
- Severity at presentation not significantly different

Diabetes Mellitus

Socioeconomic status
&
Incidence Trends

Socioeconomic Status

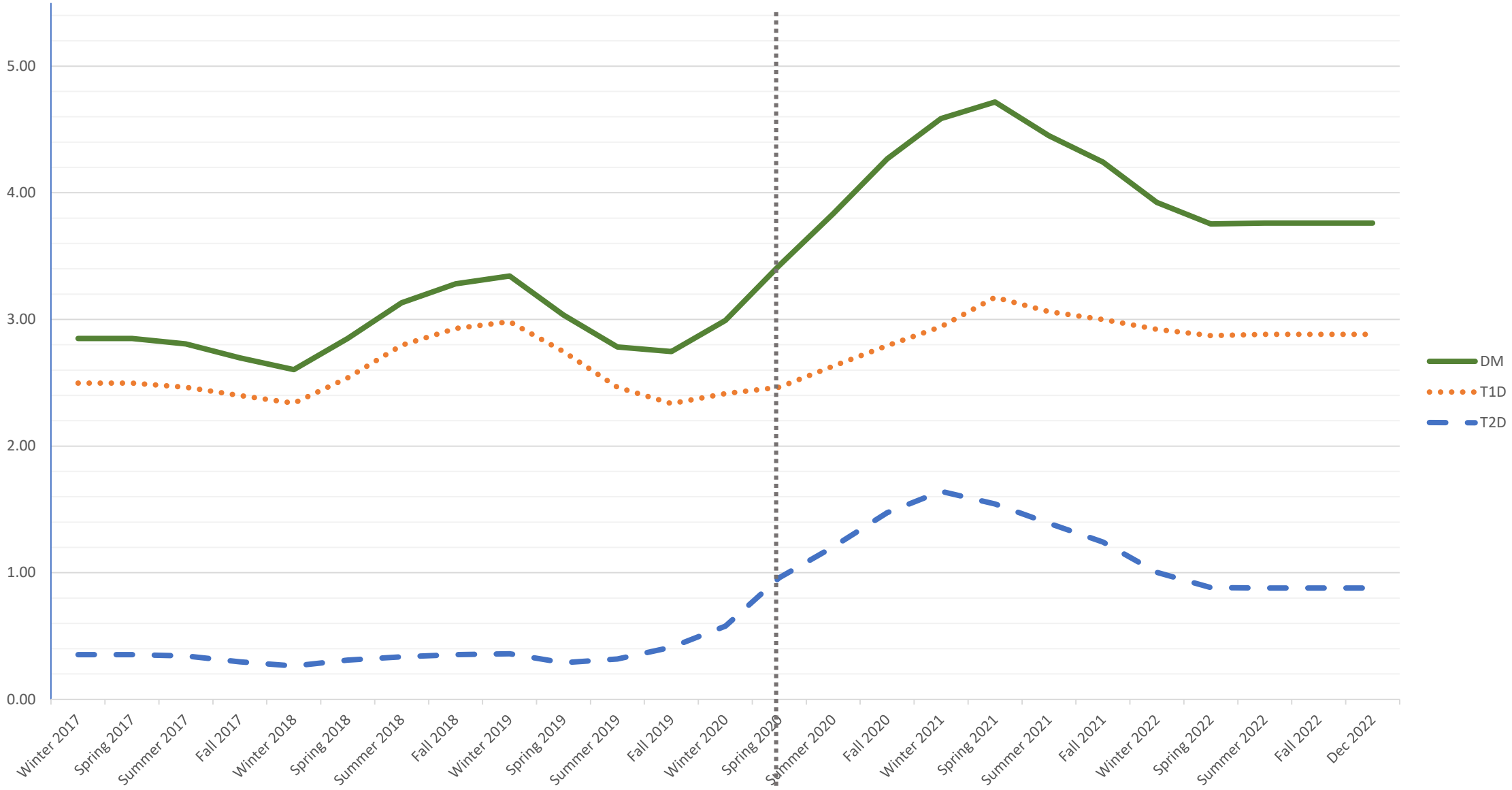
The **socioeconomic status for our population: T2D < T1D for all time periods**.

No change in socioeconomic status for T1D when compared pandemic to pre-pandemic.

No difference in SVI, race, or income level for patients diagnosed with T2D b/w time periods

For patients diagnosed with T2D during the pandemic, the proportion of adults with < 9th grade education in their community ↓ and the proportion of those with an associate degree or higher ↑.

DM: Seasonal Incidence Trend



Discussion

Severity at Diagnosis

Varying reports for T1D and T2D globally and in the US

WNDI/NCH

T1D: Overall rate of DKA stable, but more likely to have severe DKA in pandemic.

T2D: Increase in DKA/HHS in pandemic, but not stat sig (7% vs 2%)

T1D:
Seasonal Pattern

PRE-COVID (2017-2019):

- **Global** (Europe, USA): WINTER >>> SUMMER
- **WNDI/NCH**: FALL > Spring > Winter > SUMMER

COVID (2020-2022):

- **WNDI/NCH: SUMMER** > Fall > Winter > Spring
- **2020: SUMMER!**
  - Europe + USA + WNDI/NCH
- **2021**
  - **Europe: WINTER** >>> SUMMER
  - **USA + Germany + WNDI/NCH: SUMMER!**
- **2022**
  - **WNDI/NCH: SUMMER!**

↑ Incidence:

Greater than predicted?

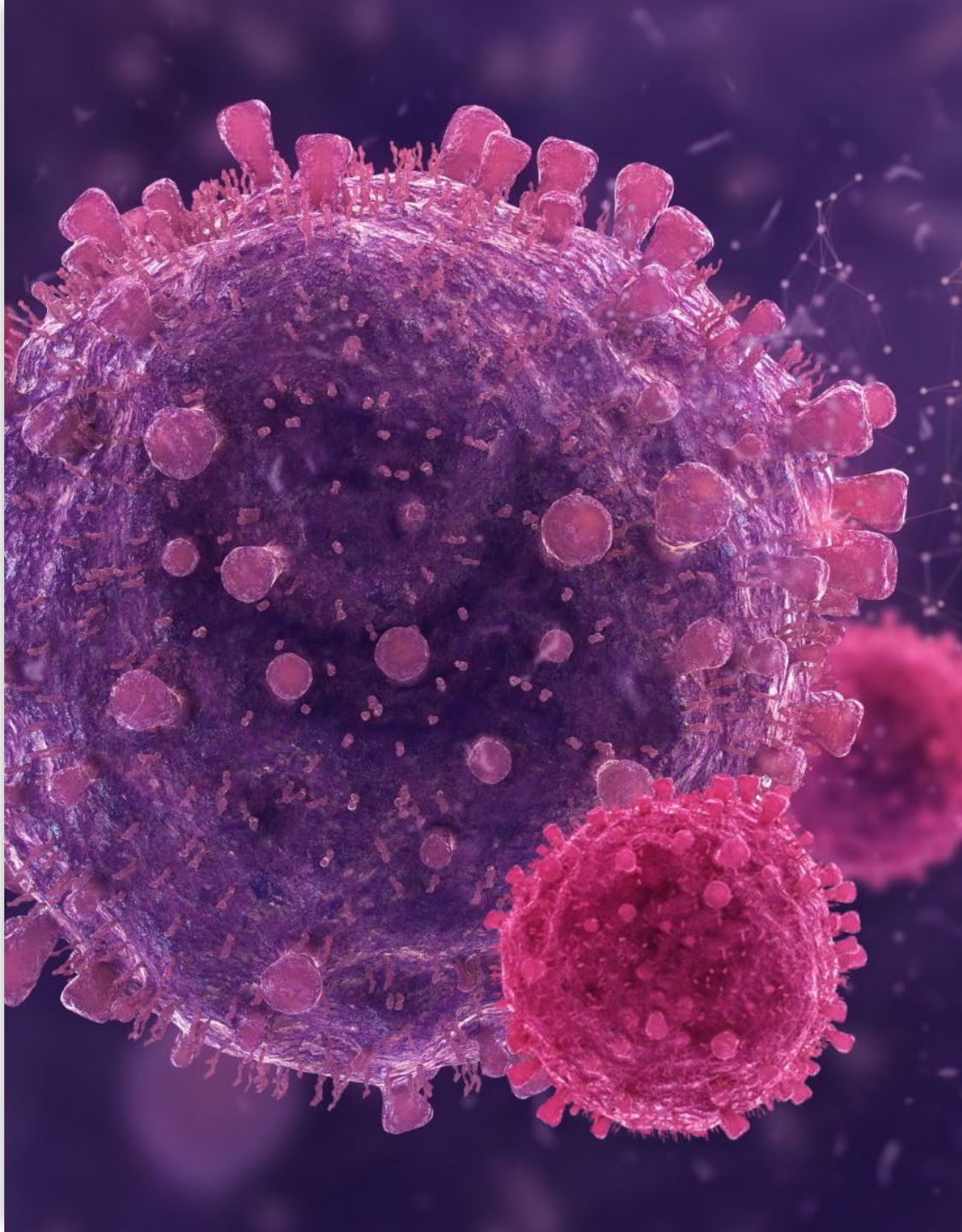
- **T1D**
  - WNDI/NCH: 3-yr increase: 11%
  - Predicted annual increase: 2.02%
- **T2D:**
  - WNDI/NCH: 3-yr increase: 238%
  - Predicted annual increase: 5.31%

WHY?

- SARS-CoV2 virus can infect the pancreas [51, 54-57]
  - **Which cells is up for debate**

- **Controversy:** Potential for **direct viral destruction** of the beta cells?

- **Agreement:** indirect effect of viral infection on the immunologic activity → worsen immune cell invasion → more rapid loss of beta cells in those who were predisposed [9, 22, 23, 50, 56]



….Interesting

The studies that evaluated for COVID infection in their patients with new onset diabetes mellitus, showed **very low rates** of COVID infection at time of diagnosis or prior to diagnosis [23, 27-30, 52, 53]

Our population: <20% of new onsets during the pandemic were tested for COVID, hence no data analysis performed on our group. Very few (<10% of those tested) were COVID+ at DM dx

The theory of direct viral destruction of the pancreas and indirect immunological effects on the beta cells caused by COVID infection has likely contributed to the development of diabetes mellitus during the pandemic, BUT most patients who developed diabetes mellitus during the pandemic were not positive for COVID co-infection or prior COVID infection…***so there must be something else***

What about…

Immunologic and downstream metabolic effects of stress (psychologic and physiologic) related to the drastic environmental changes put in place to prevent the spread of COVID → ↑ DM? [2, 9, 23, 50, 54]

Lockdown measures →

↑ social isolation ↓ physical activity ↑ sedentary lifestyle

Start of virtual school and loss of structured environments.

↑↑ obesity rate [69]

– the highest rate occurred in the younger age groups: <u>5-11 & 12-15 year olds</u>

↑ obesity + ↑ stress + ↑ sedentary lifestyle + ↓ physical activity → ↑ insulin resistance in those at risk

****

WNDI/NCH: New onset T2D during pandemic were younger, new onset T1D during pandemic w/↑ BMI%ile

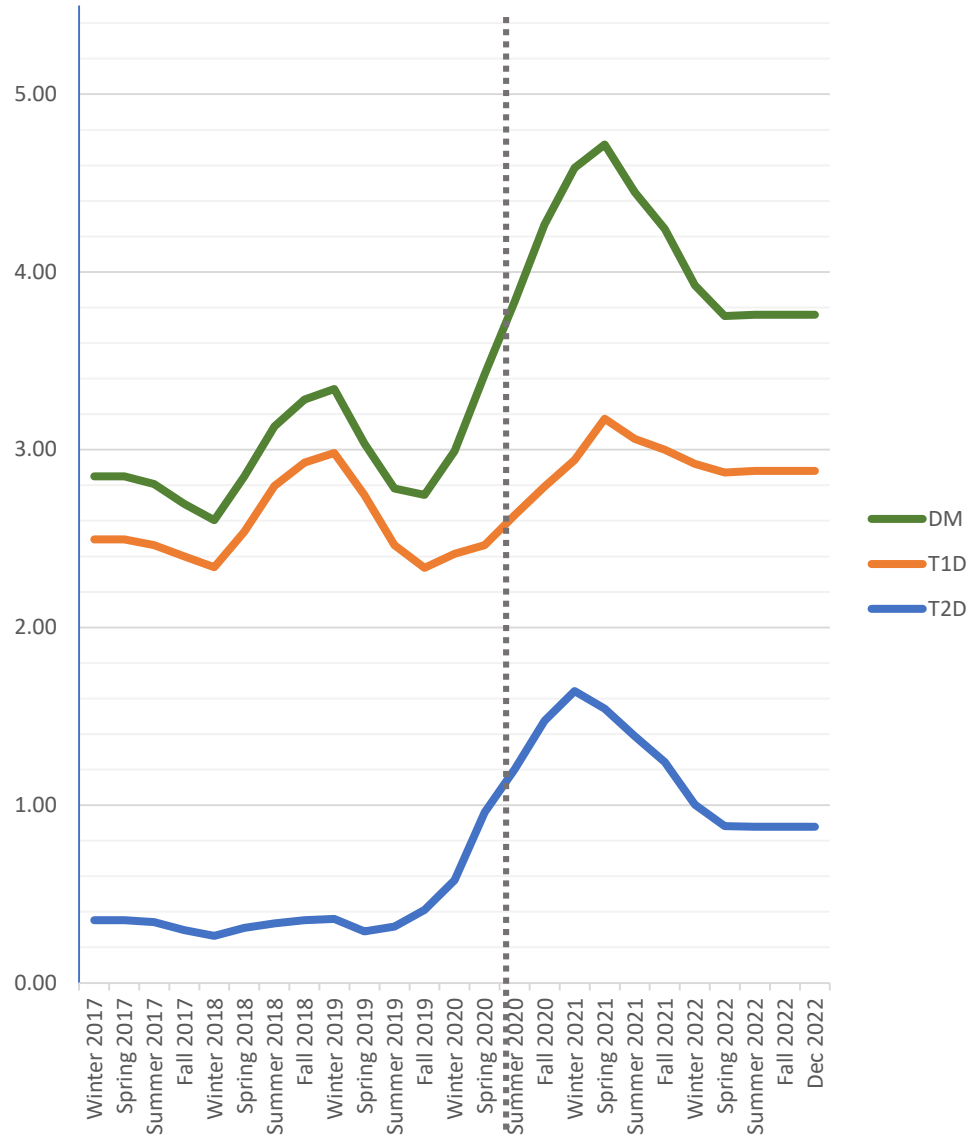
THE TREND

- Universal: ↑ new-onset diabetes mellitus incidence 2020-2021

- WNDI/NCH: ↑ incidence of T1D and T2D 2020-2022.
  - The monthly incidence trend peaked in spring 2021.
  - Gradually decreased until summer 2022 and then remained stable through December 2022*

  - **T2D:** stabilized at rate lower than pandemic peak but higher than pre-pandemic incidence

  - **T1D:** stabilized at rate lower than pandemic peak, higher than most pre-pandemic incidence (except winter 2018-19)



This is the first report of the stabilized incidence for T1D and T2D in 2022.

The Reasoning

The decrease and stabilization of the incidence of diabetes mellitus in pediatric patients during **the second half of 2021 and throughout 2022** was likely multifactorial.

The **return to in-person school and structured environments** with **increased physical activity** may have had positive effects on weight status and metabolic changes that occurred during the sedentary period.

In addition, the **decrease in rates of COVID infection and social isolation** likely led to some improvement in psychological stress.

It remains to be seen how this trend will evolve with the end of the pandemic as additional components of lifestyle and social environments continue to change.

Next…

- Extend to include 2023.
- Viral Patterns
- Autoantibody data

References

1.Cinek, O., et al., *Type 1 diabetes incidence increased during the COVID-19 pandemic years 2020-2021 in Czechia: Results from a large population-based pediatric register.* Pediatr Diabetes, 2022. **23**(7): p. 956-960.
2.Denzer, C., et al., *Is COVID-19 to Blame? Trends of Incidence and Sex Ratio in Youth-Onset Type 2 Diabetes in Germany.* Diabetes Care, 2023. **46**(7): p. 1379-1387.
3.Wagenknecht, L.E., et al., *Trends in incidence of youth-onset type 1 and type 2 diabetes in the USA, 2002-18: results from the population-based SEARCH for Diabetes in Youth study.* Lancet Diabetes Endocrinol, 2023. **11**(4): p. 242-250.
4.Gerasimidi Vazeou, A., et al., *Seasonality at the clinical onset of type 1 diabetes-Lessons from the SWEET database.* Pediatr Diabetes, 2016. **17 Suppl 23**: p. 32-37.
5.Gesuita, R., et al., *Trends and cyclic variation in the incidence of childhood type 1 diabetes in two Italian regions over 33 years and during the COVID-19 pandemic.* Diabetes Obes Metab, 2023. **25**(6): p. 1698-1703.
6.Lawrence, J.M., et al., *Trends in Prevalence of Type 1 and Type 2 Diabetes in Children and Adolescents in the US, 2001-2017.* JAMA, 2021. **326**(8): p. 717-727.
7.Tonnies, T., et al., *Estimating prevalence of type I and type II diabetes using incidence rates: the SEARCH for diabetes in youth study.* Ann Epidemiol, 2019. **37**: p. 37-42.
8.Perng, W., et al., *Youth-Onset Type 2 Diabetes: The Epidemiology of an Awakening Epidemic.* Diabetes Care, 2023. **46**(3): p. 490-499.
9.Reschke, F., et al., *The COVID-19 Pandemic Affects Seasonality, With Increasing Cases of New-Onset Type 1 Diabetes in Children, From the Worldwide SWEET Registry.* Diabetes Care, 2022. **45**(11): p. 2594-2601.
10.Mayer-Davis, E.J., et al., *Incidence Trends of Type 1 and Type 2 Diabetes among Youths, 2002-2012.* N Engl J Med, 2017. **376**(15): p. 1419-1429.
11.Divers, J., et al., *Trends in Incidence of Type 1 and Type 2 Diabetes Among Youths - Selected Counties and Indian Reservations, United States, 2002-2015.* MMWR Morb Mortal Wkly Rep, 2020. **69**(6): p. 161-165.
12.Kamrath, C., et al., *Incidence of COVID-19 and Risk of Diabetic Ketoacidosis in New-Onset Type 1 Diabetes.* Pediatrics, 2021. **148**(3).
13.Abdou, M., et al., *Presentations, Complications, and Challenges Encountered During Management of Type 1 Diabetes in Egyptian Children During COVID-19 Pandemic: A Single-Center Experience.* Front Endocrinol (Lausanne), 2022. **13**: p. 814991.
14.Ansar, A., et al., *Sharp Rise in New-Onset Pediatric Diabetes During the COVID-19 Pandemic.* WMJ, 2022. **121**(3): p. 177-180.
15.Baechle, C., et al., *Incidence and presentation of new-onset type 1 diabetes in children and adolescents from Germany during the COVID-19 pandemic 2020 and 2021: Current data from the DPV Registry.* Diabetes Res Clin Pract, 2023. **197**: p. 110559.
16.Barrett, C.E., et al., *Risk for Newly Diagnosed Diabetes >30 Days After SARS-CoV-2 Infection Among Persons Aged <18 Years - United States, March 1, 2020-June 28, 2021.* MMWR Morb Mortal Wkly Rep, 2022. **71**(2): p. 59-65.
17.D'Souza, D., et al., *Incidence of Diabetes in Children and Adolescents During the COVID-19 Pandemic: A Systematic Review and Meta-Analysis.* JAMA Netw Open, 2023. **6**(6): p. e2321281.
18.Delpeut, J., et al., *Variable incidence of ketoacidosis in youth with type 1 diabetes onset during COVID-19 pandemic peaks in France.* Diabetes Metab, 2022. **48**(2): p. 101322.
19.Dilek, S.O., et al., *Changes in the presentation of newly diagnosed type 1 diabetes in children during the COVID-19 pandemic in a tertiary center in Southern Turkey.* J Pediatr Endocrinol Metab, 2021. **34**(10): p. 1303-1309.
20.Farakla, I., et al., *Stress hyperglycemia, Diabetes mellitus and COVID-19 infection: The impact on newly diagnosed type 1 diabetes.* Front Clin Diabetes Healthc, 2022. **3**: p. 818945.
21.Gottesman, B.L., et al., *Incidence of New-Onset Type 1 Diabetes Among US Children During the COVID-19 Global Pandemic.* JAMA Pediatr, 2022. **176**(4): p. 414-415.
22.Guo, Y., et al., *Incidence Trends of New-Onset Diabetes in Children and Adolescents Before and During the COVID-19 Pandemic: Findings From Florida.* Diabetes, 2022. **71**(12): p. 2702-2706.
23.Kamrath, C., et al., *Incidence of Type 1 Diabetes in Children and Adolescents During the COVID-19 Pandemic in Germany: Results From the DPV Registry.* Diabetes Care, 2022.
24.Kaya, G., et al., *A Long-Term Comparison of Presenting Characteristics of Children with Newly Diagnosed Type 1 Diabetes Before and During the COVID-19 Pandemic.* J Clin Res Pediatr Endocrinol, 2022. **14**(3): p. 267-274.
25.Knip, M., et al., *SARS-CoV-2 and type 1 diabetes in children in Finland: an observational study.* Lancet Diabetes Endocrinol, 2023. **11**(4): p. 251-260.
26.Luciano, T.M., et al., *DKA and new-onset type 1 diabetes in Brazilian children and adolescents during the COVID-19 pandemic.* Arch Endocrinol Metab, 2022. **66**(1): p. 88-91.
27.Marks, B.E., et al., *Increase in the Diagnosis and Severity of Presentation of Pediatric Type 1 and Type 2 Diabetes during the COVID-19 Pandemic.* Horm Res Paediatr, 2021. **94**(7-8): p. 275-284.
28.McIntyre, T., et al., *Disrupted Pediatric Diabetes Trends in the Second Year of the COVID-19 Pandemic.* J Endocr Soc, 2023. **7**(8): p. bvad092.
29.Novoa-Medina, Y., et al., *Role of the SARS-CoV-2 virus in the appearance of new onset type 1 diabetes mellitus in children in Gran Canaria, Spain.* J Pediatr Endocrinol Metab, 2022. **35**(3): p. 393-397.
30.Salmi, H., et al., *New-onset type 1 diabetes in Finnish children during the COVID-19 pandemic.* Arch Dis Child, 2022. **107**(2): p. 180-185.
31.Neyman, A., et al., *Pediatric Type 2 Diabetes Presentation During the COVID-19 Pandemic.* Clin Pediatr (Phila), 2022. **61**(2): p. 133-136.
32.Schmitt, J.A., et al., *Changes in Type 2 diabetes trends in Children and Adolescents during the COVID-19 Pandemic.* J Clin Endocrinol Metab, 2022.
33.Unsworth, R., et al., *New-Onset Type 1 Diabetes in Children During COVID-19: Multicenter Regional Findings in the U.K.* Diabetes Care, 2020. **43**(11): p. e170-e171.
34.Kostopoulou, E., et al., *Impact of COVID-19 on new-onset type 1 diabetes mellitus - A one-year prospective study.* Eur Rev Med Pharmacol Sci, 2021. **25**(19): p. 5928-5935.
35.Vlad, A., et al., *Increased Incidence of Type 1 Diabetes during the COVID-19 Pandemic in Romanian Children.* Medicina (Kaunas), 2021. **57**(9).
36.Wolf, R.M., et al., *Increase in newly diagnosed type 1 diabetes in youth during the COVID-19 pandemic in the United States: A multi-center analysis.* Pediatr Diabetes, 2022. **23**(4): p. 433-438.
37.Boboc, A.A., et al., *SARS-CoV-2 Positive Serology and Islet Autoantibodies in Newly Diagnosed Pediatric Cases of Type 1 Diabetes Mellitus: A Single-Center Cohort Study.* Int J Mol Sci, 2023. **24**(10).
38.Chambers, M.A., et al., *Increase in the Number of Pediatric New-Onset Diabetes and Diabetic Ketoacidosis Cases During the COVID-19 Pandemic.* Endocr Pract, 2022. **28**(5): p. 479-485.
39.Chao, L.C., A.P. Vidmar, and S. Georgia, *Spike in Diabetic Ketoacidosis Rates in Pediatric Type 2 Diabetes During the COVID-19 Pandemic.* Diabetes Care, 2021. **44**(6): p. 1451-1453.
40.d'Annunzio, G., et al., *Increased Frequency of Diabetic Ketoacidosis: The Link With COVID-19 Pandemic.* Front Clin Diabetes Healthc, 2022. **3**: p. 846827.
41.Dzygalo, K., et al., *Increased frequency of severe diabetic ketoacidosis at type 1 diabetes onset among children during COVID-19 pandemic lockdown: an observational cohort study.* Pediatr Endocrinol Diabetes Metab, 2020. **26**(4): p. 167-175.
42.Goldman, S., et al., *Alarming increase in ketoacidosis in children and adolescents with newly diagnosed type 1 diabetes during the first wave of the COVID-19 pandemic in Israel.* Pediatr Diabetes, 2022. **23**(1): p. 10-18.
43.Ho, J., et al., *Diabetic ketoacidosis at type 1 diabetes diagnosis in children during the COVID-19 pandemic.* Pediatr Diabetes, 2021. **22**(4): p. 552-557.
44.Kamrath, C., et al., *Ketoacidosis in Children and Adolescents With Newly Diagnosed Type 1 Diabetes During the COVID-19 Pandemic in Germany.* JAMA, 2020. **324**(8): p. 801-804.
45.Lawrence, C., et al., *Increased paediatric presentations of severe diabetic ketoacidosis in an Australian tertiary centre during the COVID-19 pandemic.* Diabet Med, 2021. **38**(1): p. e14417.
46.Loh, C., et al., *Diabetic ketoacidosis in pediatric patients with type 1- and type 2 diabetes during the COVID-19 pandemic.* Metabolism, 2021. **122**: p. 154842.
47.Mastromauro, C., et al., *Peculiar characteristics of new-onset Type 1 Diabetes during COVID-19 pandemic.* Ital J Pediatr, 2022. **48**(1): p. 26.
48.McGlacken-Byrne, S.M., et al., *The SARS-CoV-2 pandemic is associated with increased severity of presentation of childhood onset type 1 diabetes mellitus: A multi-centre study of the first COVID-19 wave.* Diabet Med, 2021. **38**(9): p. e14640.
49.Denina, M., et al., *Increase in newly diagnosed type 1 diabetes and serological evidence of recent SARS-CoV-2 infection: Is there a connection?* Front Med (Lausanne), 2022. **9**: p. 927099.
50.Bombaci, B., et al., *Examining the associations between COVID-19 infection and pediatric type 1 diabetes.* Expert Rev Clin Immunol, 2023. **19**(5): p. 489-497.
51.Kusmartseva, I., et al., *Expression of SARS-CoV-2 Entry Factors in the Pancreas of Normal Organ Donors and Individuals with COVID-19.* Cell Metab, 2020. **32**(6): p. 1041-1051 e6.
52.Boboc, A.A., et al., *The Impact of SARS-CoV-2 Pandemic on the New Cases of T1DM in Children. A Single-Centre Cohort Study.* J Pers Med, 2021. **11**(6).
53.Messaaoui, A., L. Hajselova, and S. Tenoutasse, *Anti-SARS-CoV-2 antibodies in new-onset type 1 diabetes in children during pandemic in Belgium.* J Pediatr Endocrinol Metab, 2021. **34**(10): p. 1319-1322.
54.Anindya, R., G.A. Rutter, and G. Meur, *New-onset type 1 diabetes and severe acute respiratory syndrome coronavirus 2 infection.* Immunol Cell Biol, 2023. **101**(3): p. 191-203.
55.Yang, J.K., et al., *Binding of SARS coronavirus to its receptor damages islets and causes acute diabetes.* Acta Diabetol, 2010. **47**(3): p. 193-9.
56.Atkinson, M.A. and A.C. Powers, *Distinguishing the real from the hyperglycaemia: does COVID-19 induce diabetes?* Lancet Diabetes Endocrinol, 2021. **9**(6): p. 328-329.
57.Coate, K.C., et al., *SARS-CoV-2 Cell Entry Factors ACE2 and TMPRSS2 Are Expressed in the Microvasculature and Ducts of Human Pancreas but Are Not Enriched in beta Cells.* Cell Metab, 2020. **32**(6): p. 1028-1040 e4.
58.Rabbone, I., et al., *Has COVID-19 Delayed the Diagnosis and Worsened the Presentation of Type 1 Diabetes in Children?* Diabetes Care, 2020. **43**(11): p. 2870-2872.
59.Kamrath, C., et al., *Frequency of Autoantibody-Negative Type 1 Diabetes in Children, Adolescents, and Young Adults During the First Wave of the COVID-19 Pandemic in Germany.* Diabetes Care, 2021. **44**(7): p. 1540-1546.
60.Pillai, S.S., et al., *Delays in Presentation of New Onset Diabetes at the Start of the COVID-19 Pandemic.* R I Med J (2013), 2022. **105**(5): p. 46-50.
61.Bogale, K.T., et al., *The Impact of COVID-19 Pandemic on Prevalence of Diabetic Ketoacidosis at Diagnosis of Type 1 Diabetes: A Single-Centre Study in Central Pennsylvania.* Endocrinol Diabetes Metab, 2021. **4**(3): p. e00235.
62.Tittel, S.R., et al., *Did the COVID-19 Lockdown Affect the Incidence of Pediatric Type 1 Diabetes in Germany?* Diabetes Care, 2020. **43**(11): p. e172-e173.
63.Mariet, A.S., et al., *Incidence of new-onset type 1 diabetes during Covid-19 pandemic: A French nationwide population-based study.* Diabetes Metab, 2023. **49**(3): p. 101425.
64.Botelho, T.A., et al., *Ketoacidosis in new-onset type 1 diabetes: did the severity increase during the COVID-19 pandemic?* J Pediatr Endocrinol Metab, 2022. **35**(1): p. 73-77.
65.Sasidharan Pillai, S., et al., *Incidence, Severity, and Presentation of Type 2 Diabetes in Youth During the First and Second Year of the COVID-19 Pandemic.* Diabetes Care, 2023. **46**(5): p. 953-958.
66.*QuickStats: Number* of Youths Aged 2-19 Years and Adults Aged >/=20 Years with Obesity(dagger) or Severe Obesity(section sign) - National Health and Nutrition Examination Survey, 2015-2016.* MMWR Morb Mortal Wkly Rep, 2018. **67**(34): p. 966.
67.*QuickStats: Prevalence of Obesity* and Severe Obesity(dagger) Among Persons Aged 2-19 Years - National Health and Nutrition Examination Survey, 1999-2000 through 2017-2018.* MMWR Morb Mortal Wkly Rep, 2020. **69**(13): p. 390.
68.Hales, C.M., et al., *Trends in Obesity and Severe Obesity Prevalence in US Youth and Adults by Sex and Age, 2007-2008 to 2015-2016.* JAMA, 2018. **319**(16): p. 1723-1725.
69.Woolford, S.J., et al., *Changes in Body Mass Index Among Children and Adolescents During the COVID-19 Pandemic.* JAMA, 2021. **326**(14): p. 1434-1436.
70.Ogden, C.L., et al., *Trends in Obesity Prevalence by Race and Hispanic Origin-1999-2000 to 2017-2018.* JAMA, 2020. **324**(12): p. 1208-1210.
71.American Diabetes Association Professional Practice, C., *2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2022.* Diabetes Care, 2022. **45**(Suppl 1): p. S17-S38.
72.Shah, A.S., et al., *ISPAD Clinical Practice Consensus Guidelines 2022: Type 2 diabetes in children and adolescents.* Pediatr Diabetes, 2022. **23**(7): p. 872-902.
73.*Centers for Disease Control and Prevention/ Agency for Toxic Substances and Disease Registry/ Geospatial Research, Analysis, and Services Program. CDC/ATSDR Social Vulnerability Index*. 2020.

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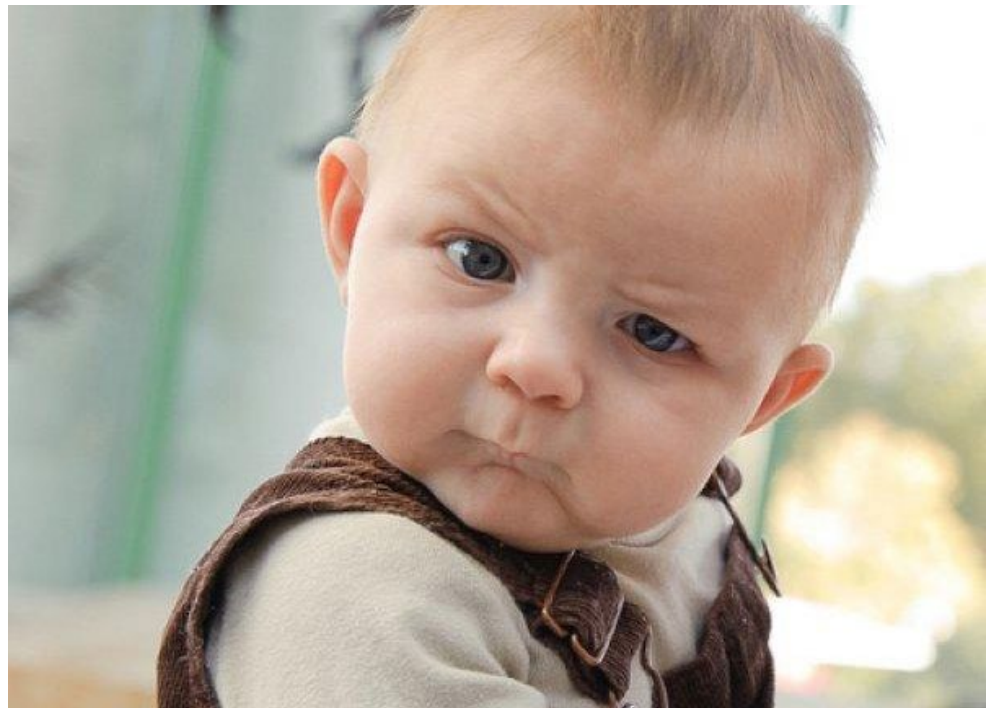
Questions?



Statistical Analysis

Patient characteristics

- Continuous variables analyzed using Wilcoxon Rank Sums Test
- Categorial variables compared using Chi-square and Fisher's exact test
- Comparing 2020 vs 2021 vs 2022: Kruskall Wallis and Fisher's Exact tests
- P <0.05 = significant
- Severity at presentation – pre-pandemic vs pandemic – Generalized multinomial logistic regression

Incidence of T1D and T2D

- Population of patients 1-21 y/o in the regions our patients live (per census tract) between 2017-2022. Incidence rate calculated /100K children.
- Incidence trend pre vs pandemic analyzed via time series analysis
- Incidence and season relationships were analyzed via Poisson regression models

Dr. Kahir Jawad, MD, PhD and Dr. Yana Fergin, PhD

SAS Software 9.4 (SAS institute, Cary, NC)

Definitions

- **Diabetes type** classified per ADA Guidelines

- **Diabetes Emergencies:** used International Society for Pediatric and Adolescent Diabetes (ISPAD) criteria to define DKA, HHS, Mixed DKA/HHS, and their severities

- **Social Vulnerability Index (SVI):** evaluates for factors that determine a community's ability to prevent human suffering and financial loss in a disaster. 16 total factors in the following categories: socioeconomic status (includes education), household composition and disability, minority status and language, housing type, and transportation
  - (0.0 lowest, 1.0 highest vulnerability)

- **Census tracts** were determined by home address and the associated SVI for each community was obtained. SVI, level of education, and income for each census tract were compared for pandemic and pre-pandemic periods.