IDMVis:
Temporal Event Sequence Visualization for Type 1 Diabetes Treatment Decision Support

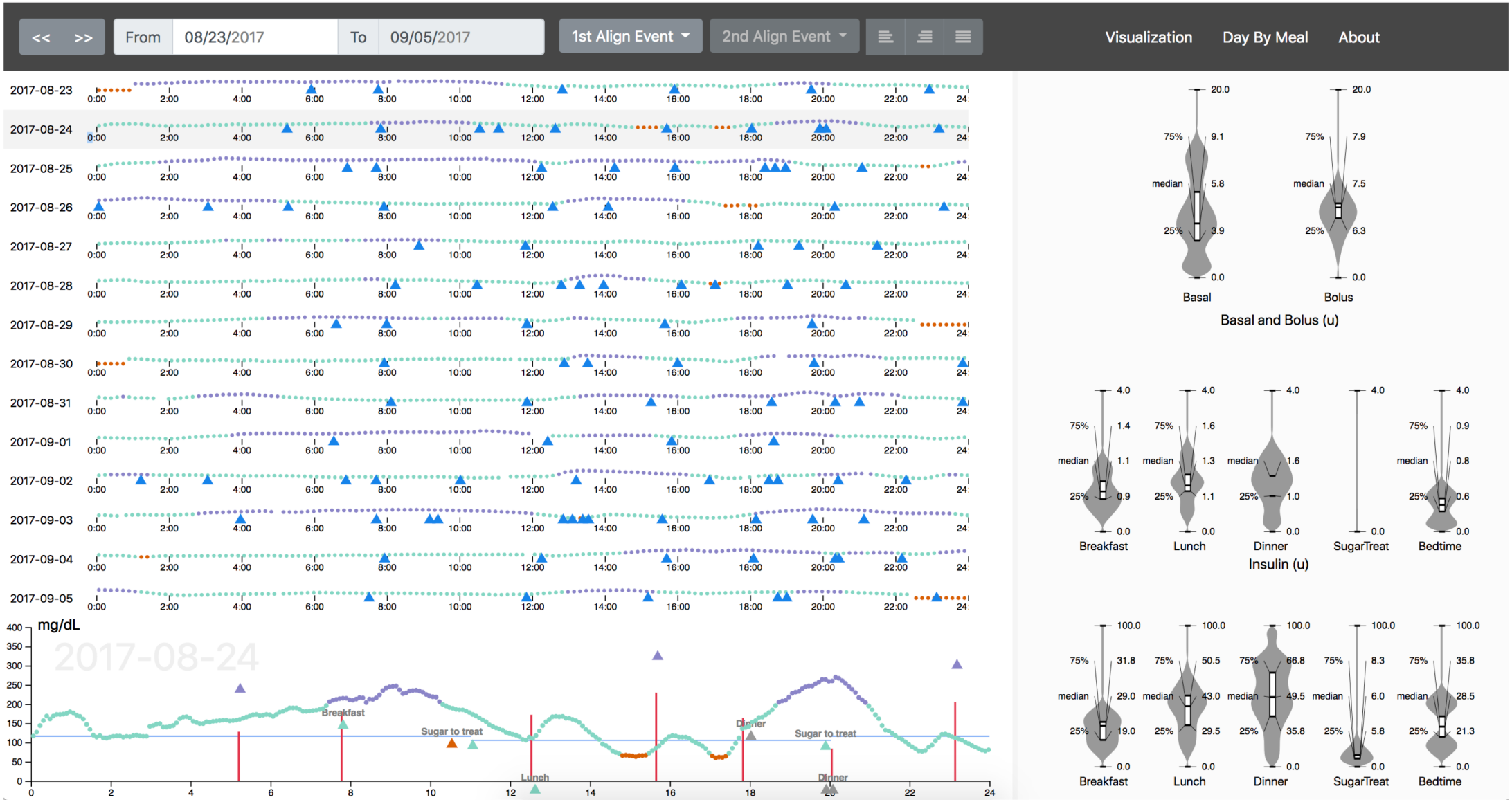

Yixuan (Janice) Zhang


Kartik Chanana


Cody Dunne

Northeastern University

Contributions



Contributions

- **IDMVis** – a temporal event sequence visualization tool to support diabetes treatment decision
- **Hierarchical Task Abstraction**

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Hierarchical Task Analysis

Contributions

- **IDMVis** – a temporal event sequence visualization tool to support diabetes treatment decision
- **Hierarchical Task Abstraction**

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- **IDMVis** – a temporal event sequence visualization tool to support diabetes treatment decision
- **Hierarchical Task Abstraction**

Imagine a 10-year-old kid, who has been diagnosed with type 1 diabetes...

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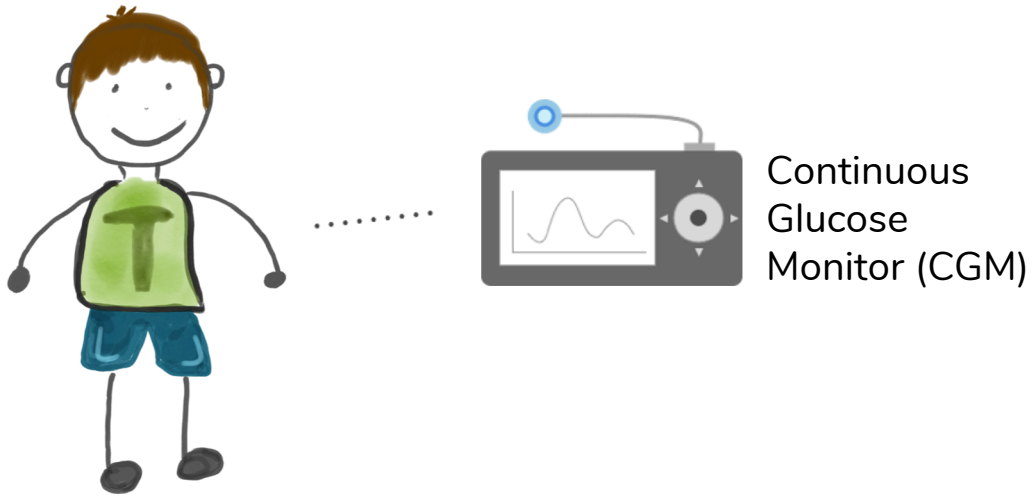

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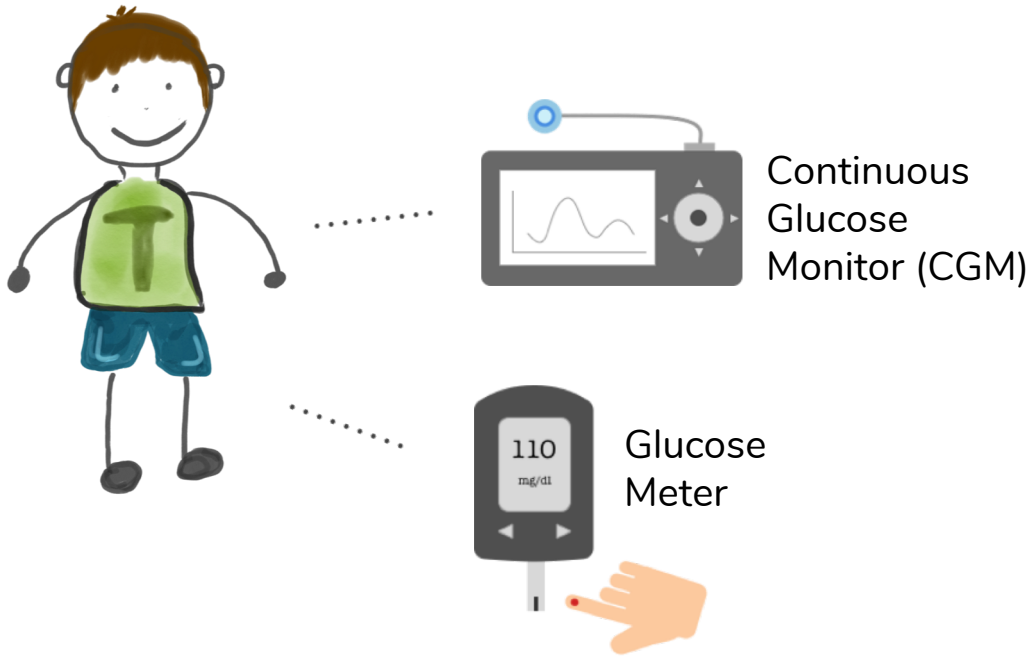

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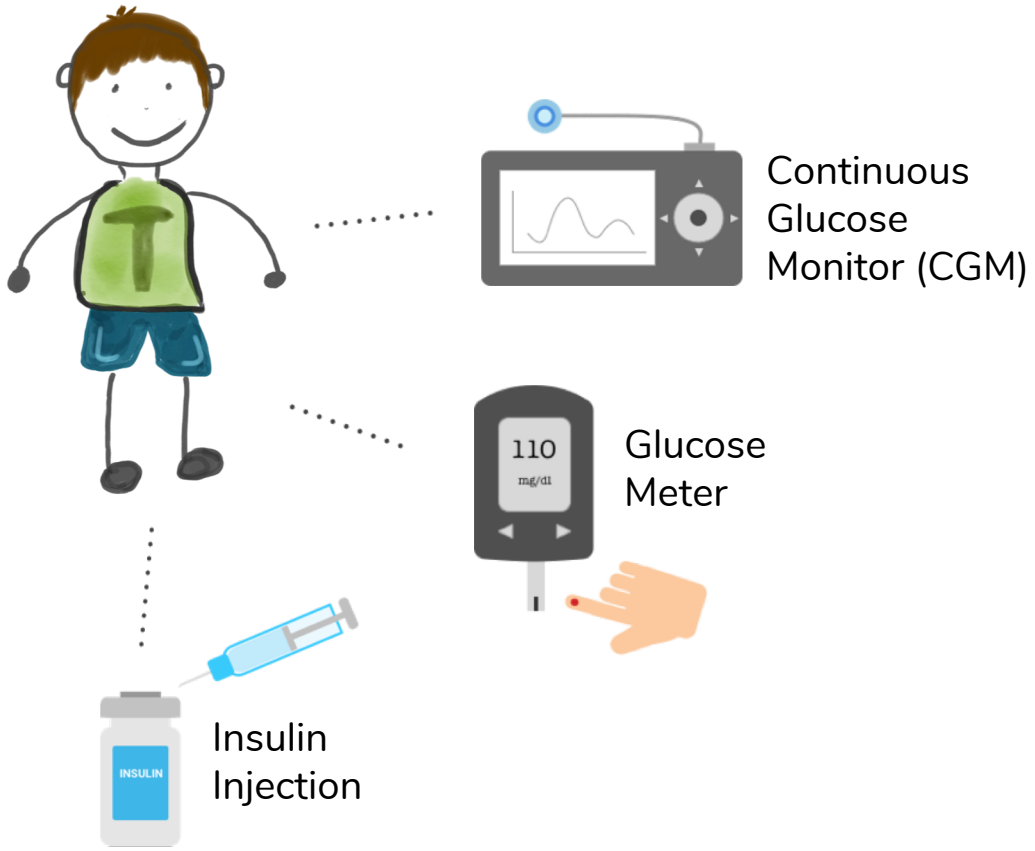

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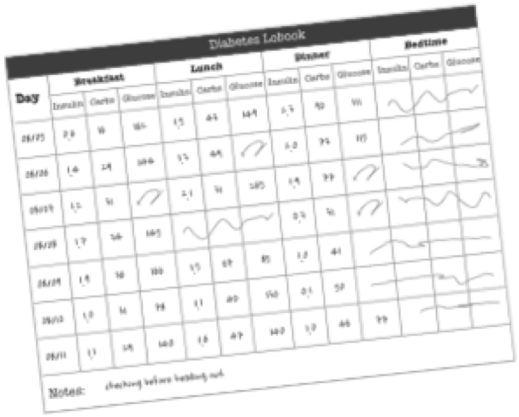
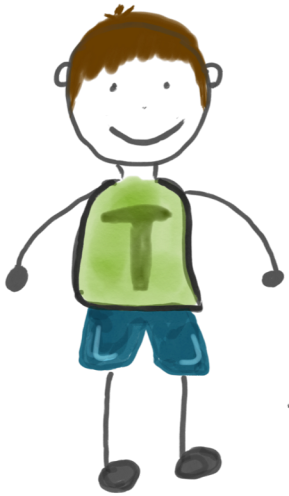
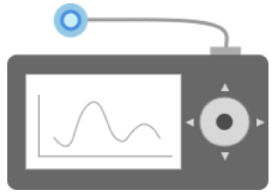


Diabetes Logbook

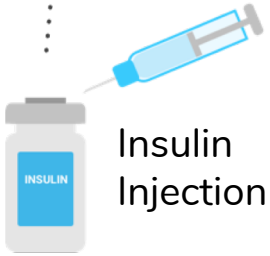




Continuous Glucose Monitor (CGM)

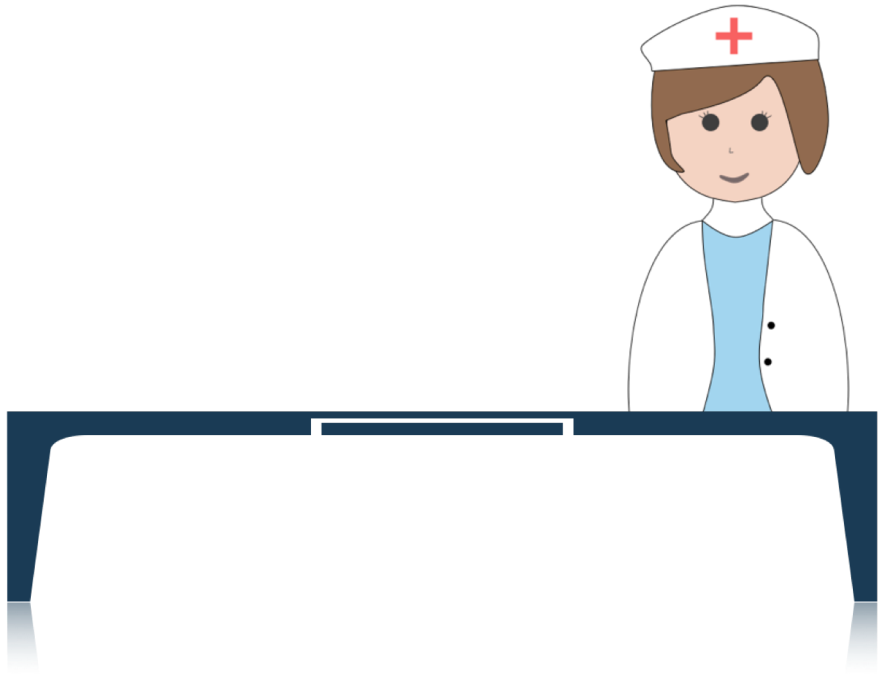
Glucose Meter

Sickness Food Exercise



Insulin Injection

During a clinical visit …



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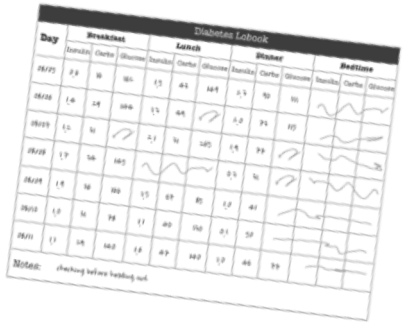

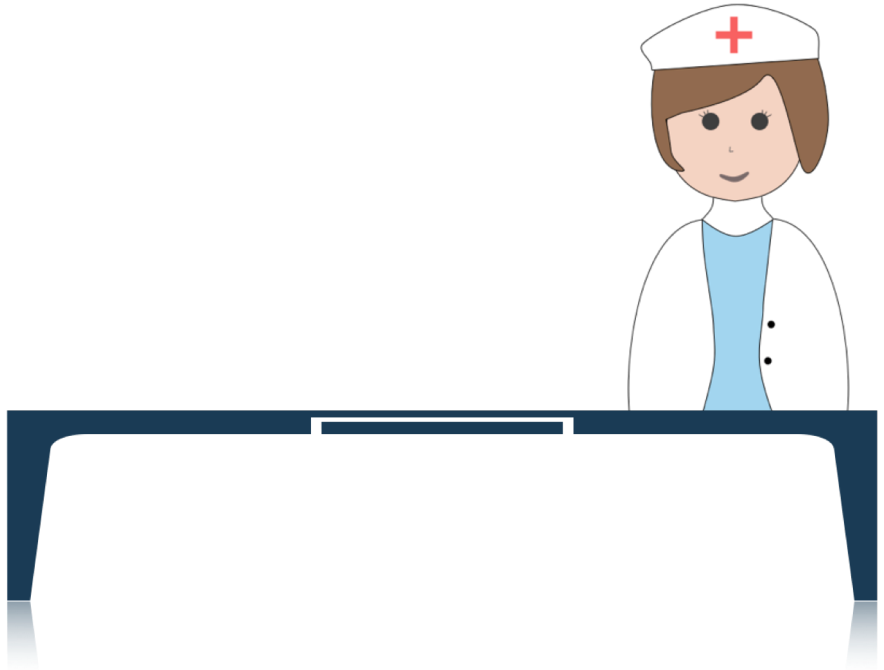

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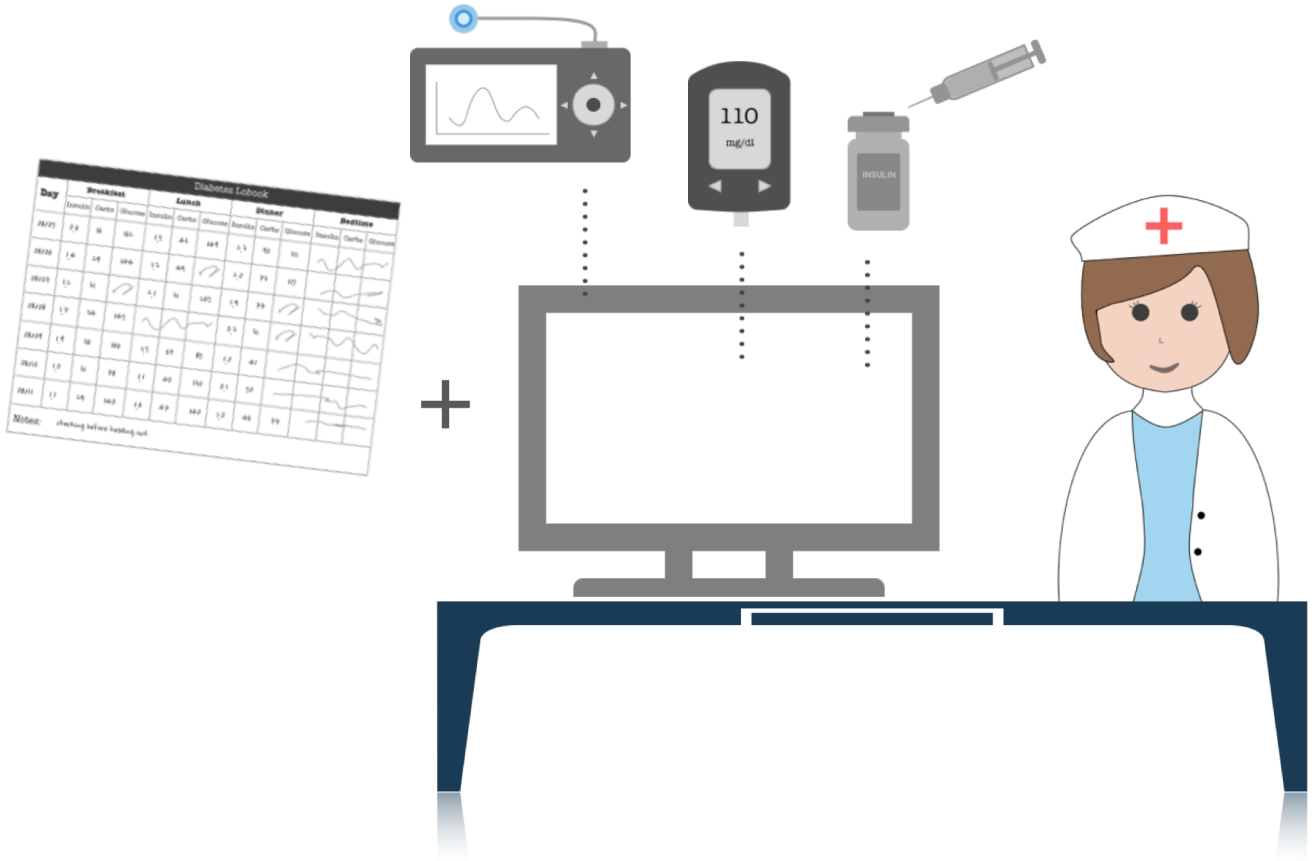


During a clinical visit ...

> **How** to help diabetes clinicians make treatment decisions?
>
> What are the **tasks**?

Hierarchical Task Analysis

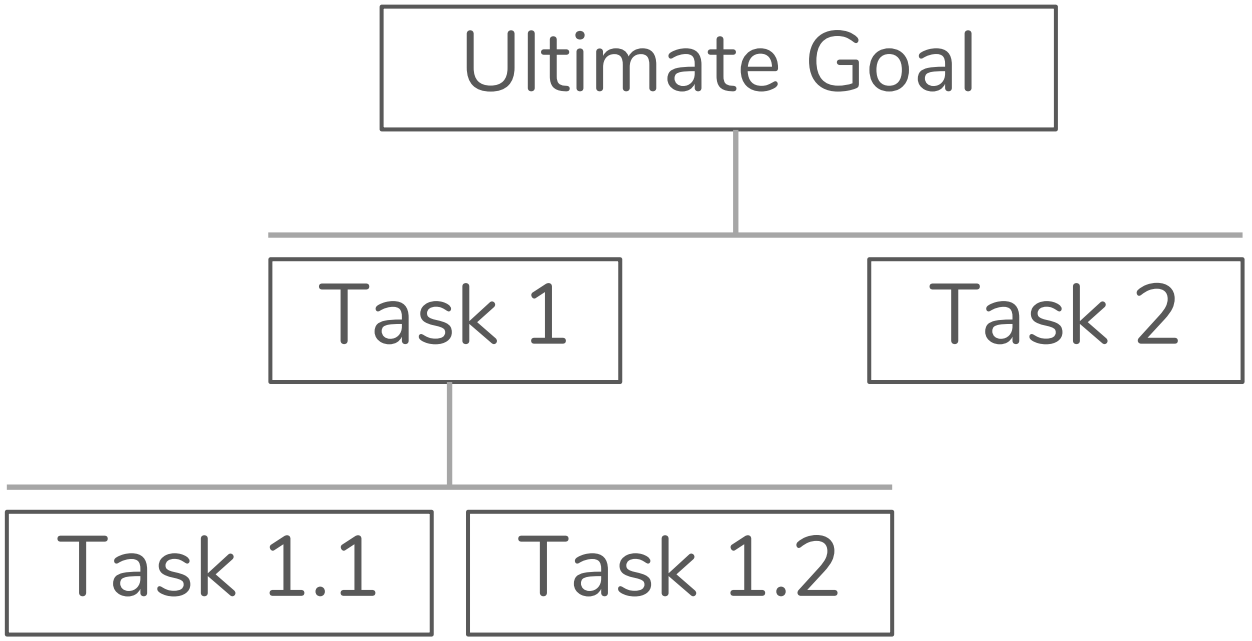
Task analysis:

Task 1 | Task 2 | Task 3 | Task 4

Task analysis:

^

Hierarchical



Develop a treatment plan and educate patients

0.
Develop a treatment plan and educate patients

Increasing Task Specificity

0.
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1.
Collect and display the patient's data

Increasing Task Specificity

0.
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1.
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2.
Overview the patient's data

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3.
Reason about patient blood glucose levels

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Educate patients and caregivers

Increasing Task Specificity

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Make a treatment plan

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3.1
Examine post-event glucose level

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3.2
Examine the interplay between events

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Examine post-event glucose level

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Examine the interplay between events

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Examine post-event glucose level

Examine related data to understand observation

Design Requirements

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- DR1. Composite Visualization of **Integrated** Data

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- DR1. Composite Visualization of **Integrated** Data
- DR2. Visualization of **Folded Temporal** Data

Design Requirements

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- DR3. **Align and Scale** Temporal Data

Design Requirements

- DR1. Composite Visualization of **Integrated** Data
- DR2. Visualization of **Folded Temporal** Data
- DR3. **Align and Scale** Temporal Data
- DR4. **Summary** Statistics

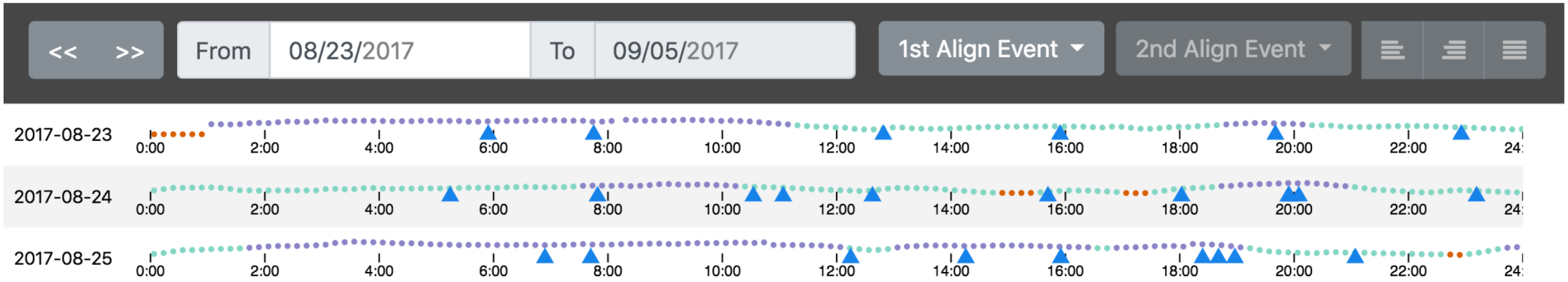
Design of IDMVis

14-Day Overview

Detail View

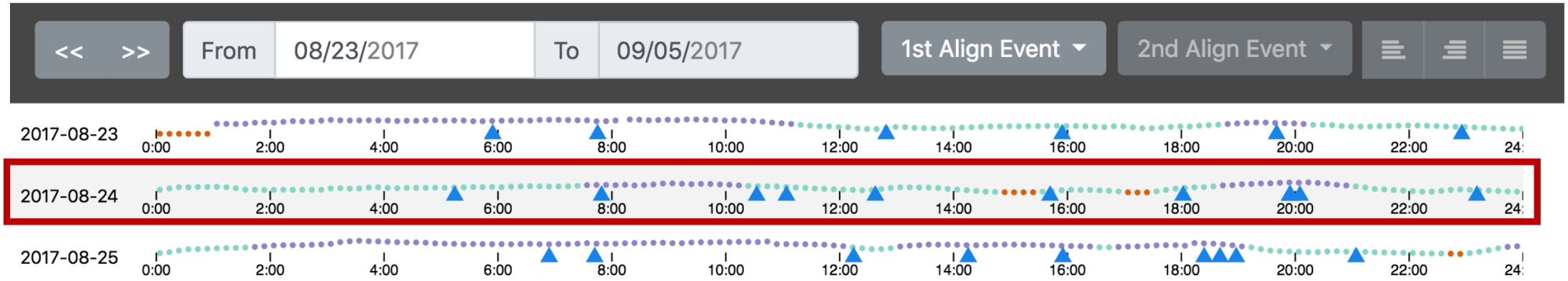
Summary Statistics Panel

14-Day Overview



Use small multiples to partition data folded by days

14-Day Overview



Glucose Meter

Events from **logbooks** with blood glucose readings

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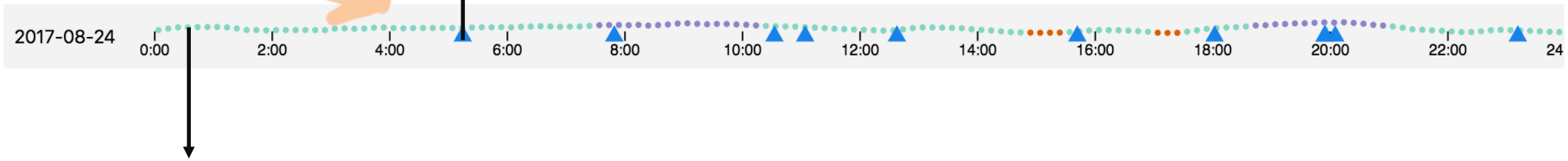
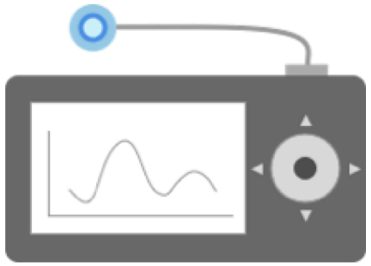


Continuous Glucose Monitor (**CGM**)



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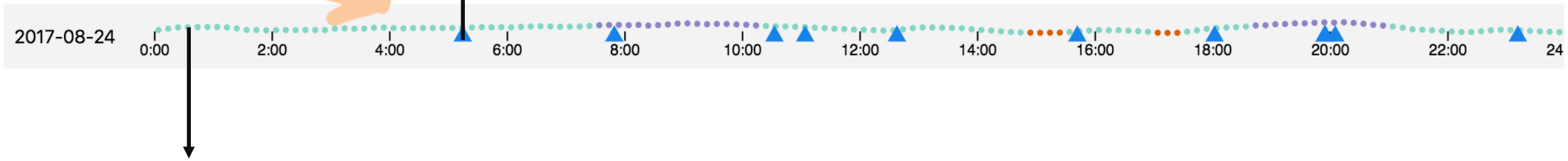

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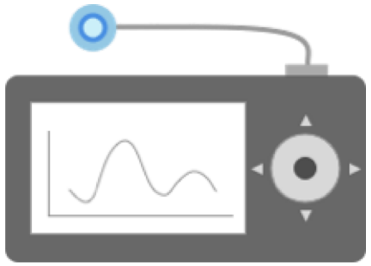
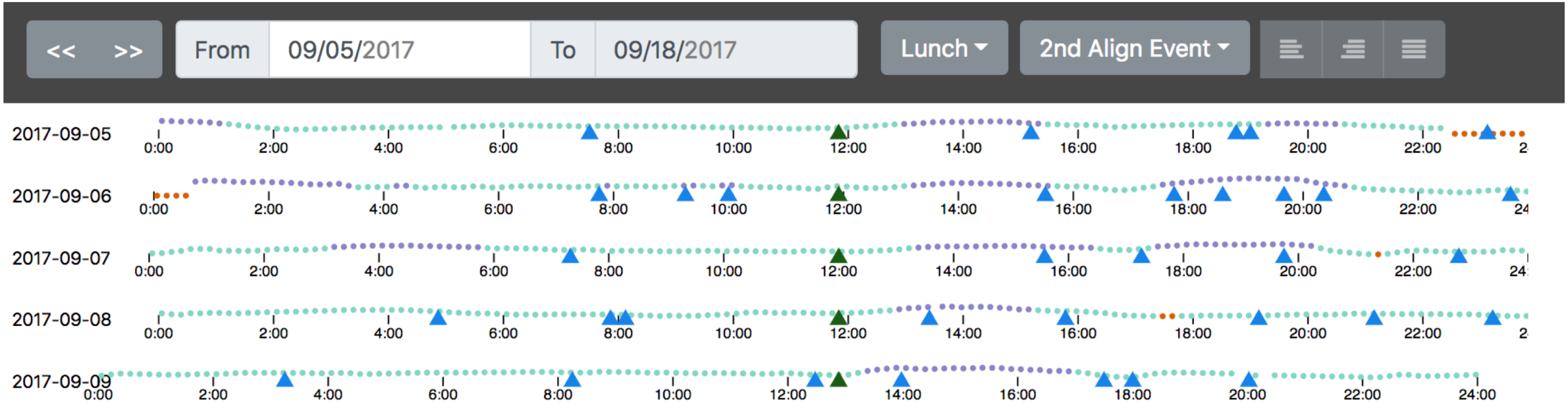


below range (<70 mg/dL)

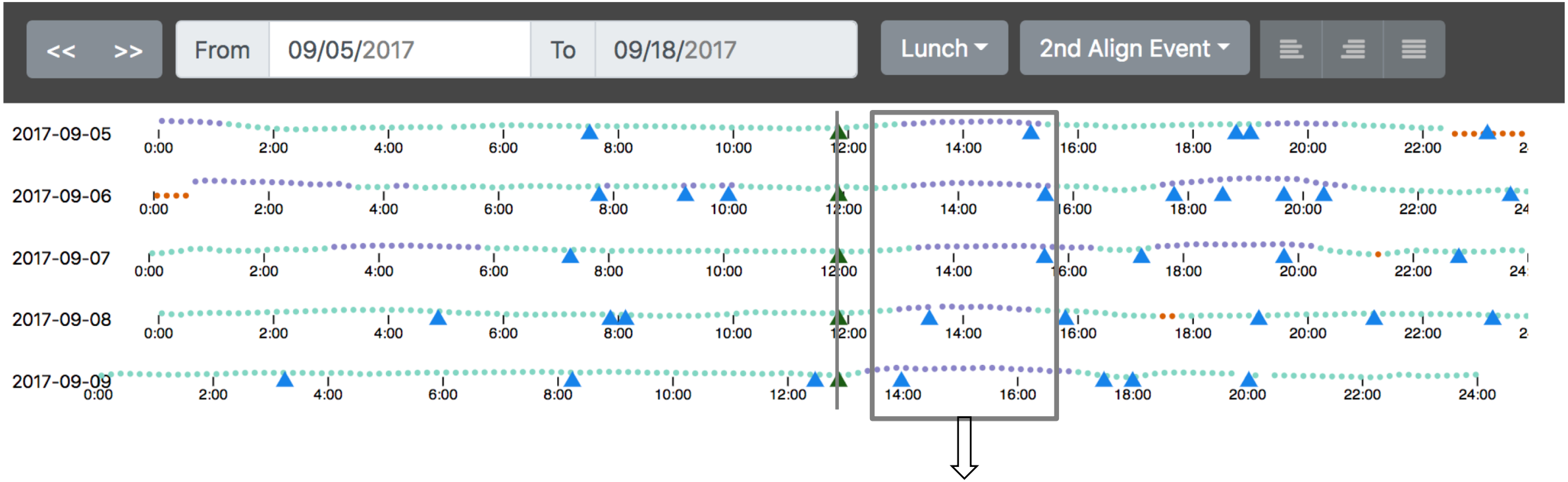
normal range (70-180 mg/dL)

above range (>180 mg/dL)

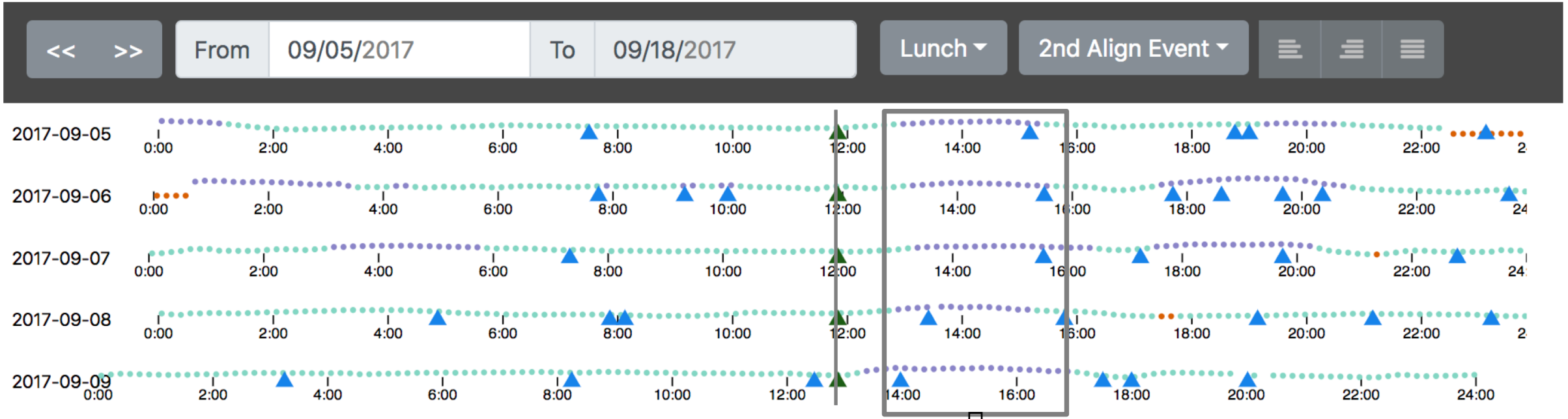


Events from logbooks with blood glucose readings

CGM normal range (70-180 mg/dL) CGM above range (>180 mg/dL) CGM below range (<70 mg/dL)



Single-event alignment ⟹ A pattern of high blood glucose after lunch shown by purple circles ●●●



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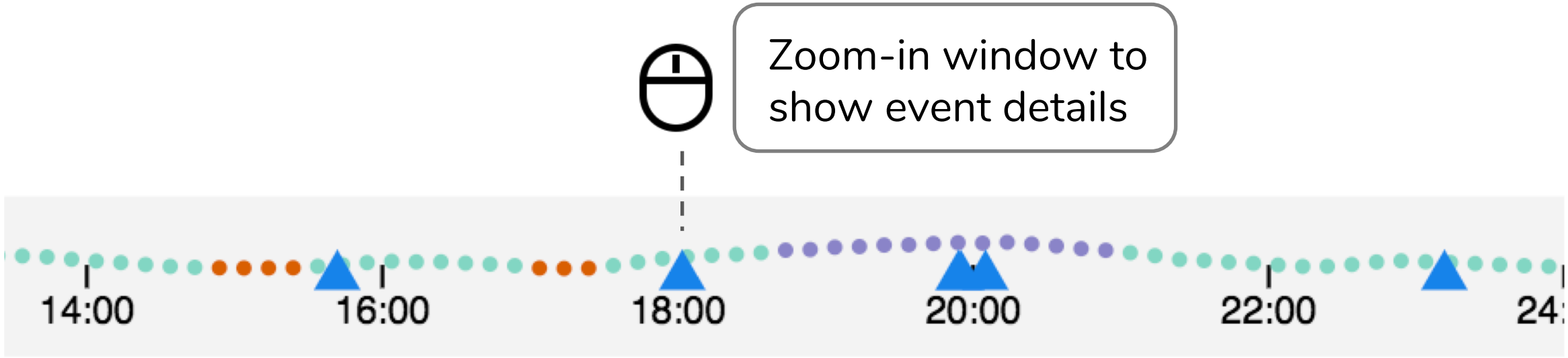

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Reason about patient blood glucose levels

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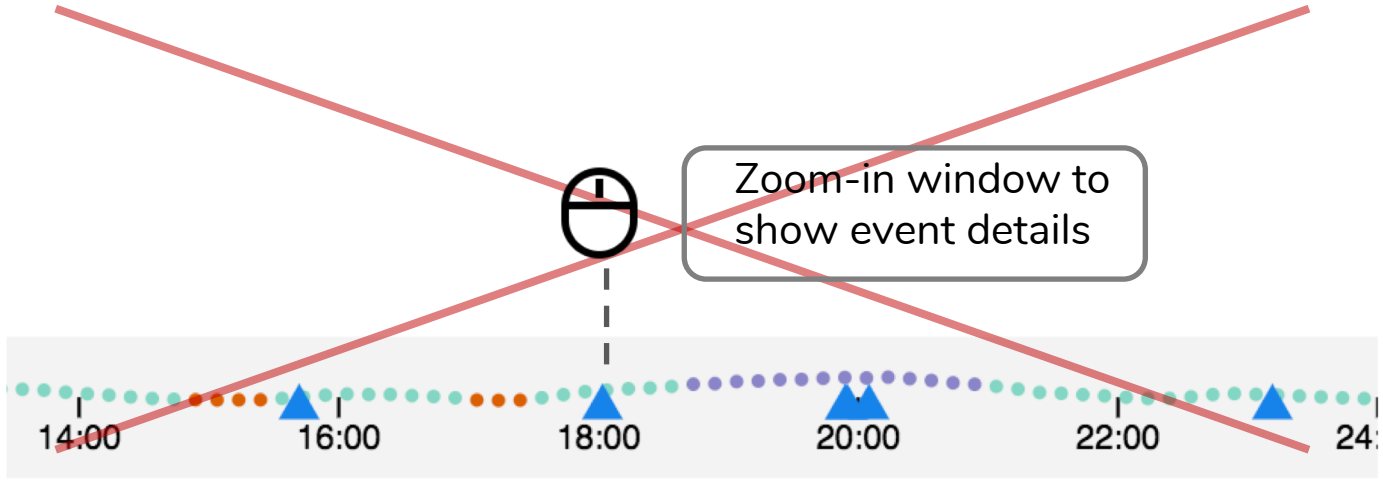
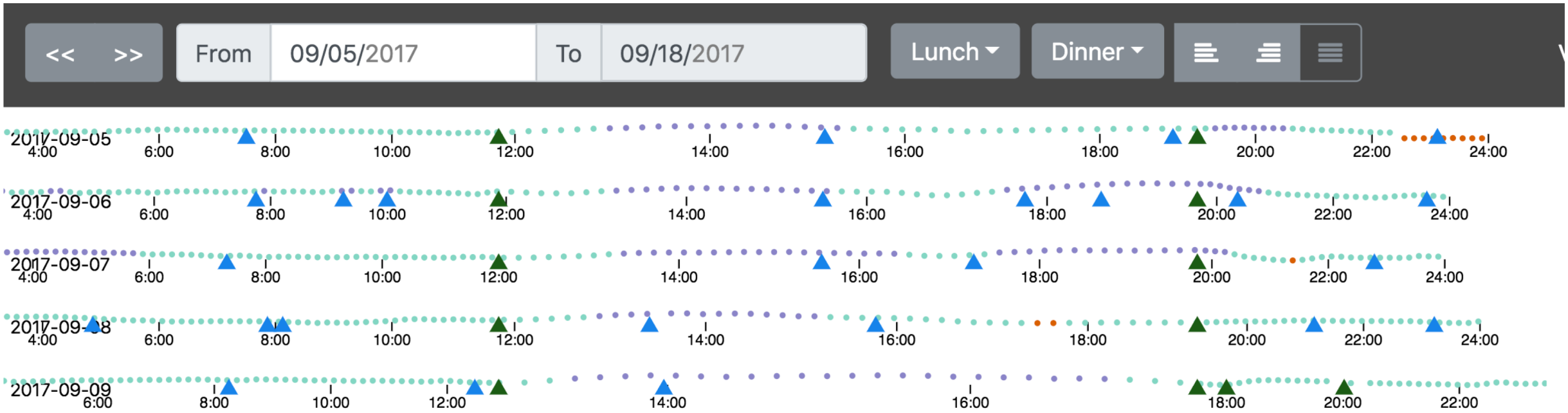


Dual-event alignment

Stretch time scaling



Events from logbooks with blood glucose readings

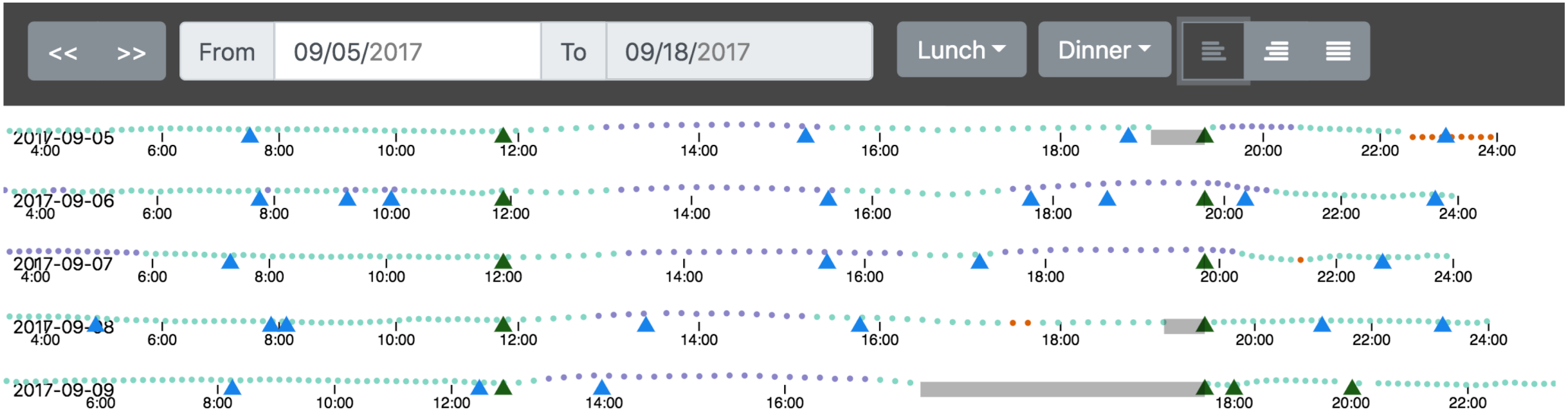
CGM normal range (70-180 mg/dL)

CGM above range (>180 mg/dL)

CGM below range (<70 mg/dL)

Dual-event alignment

Left-justified time scaling



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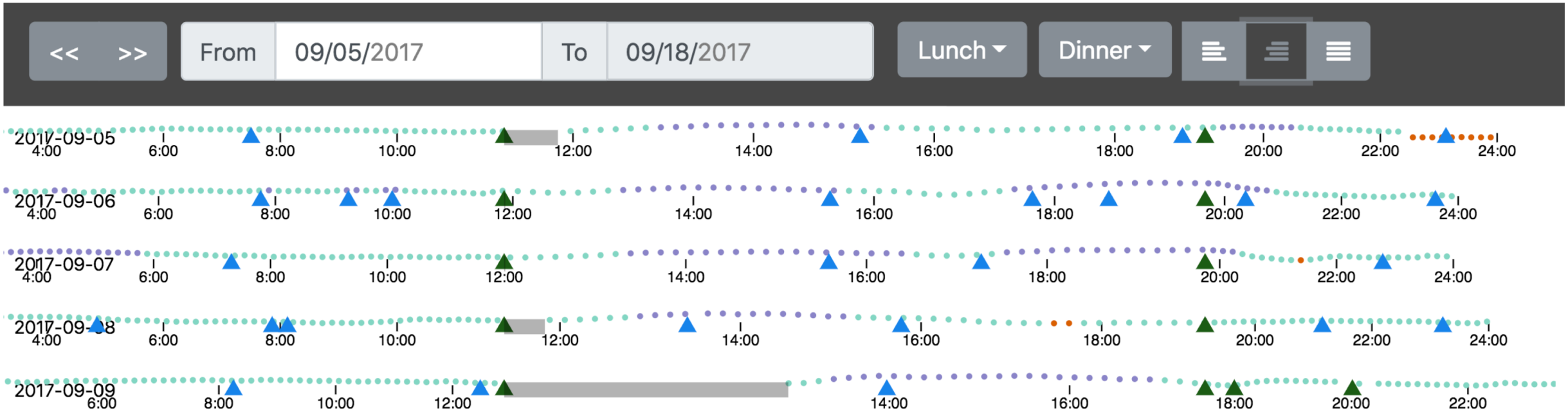

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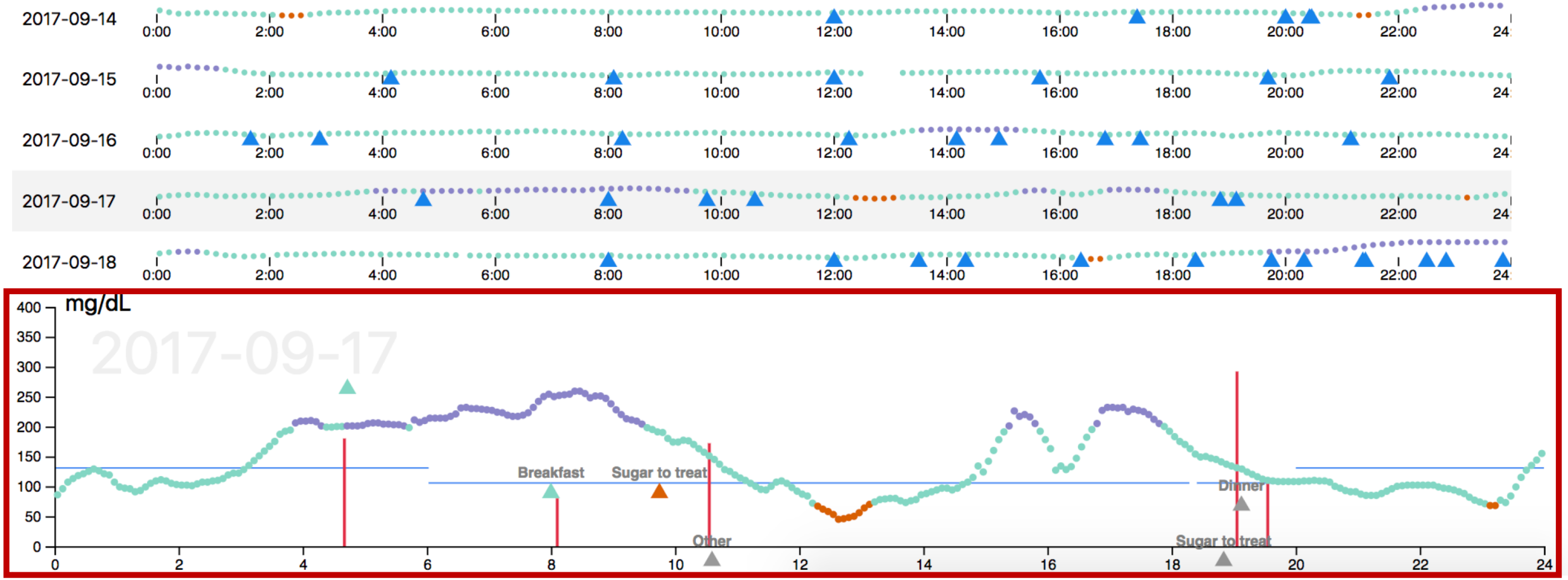
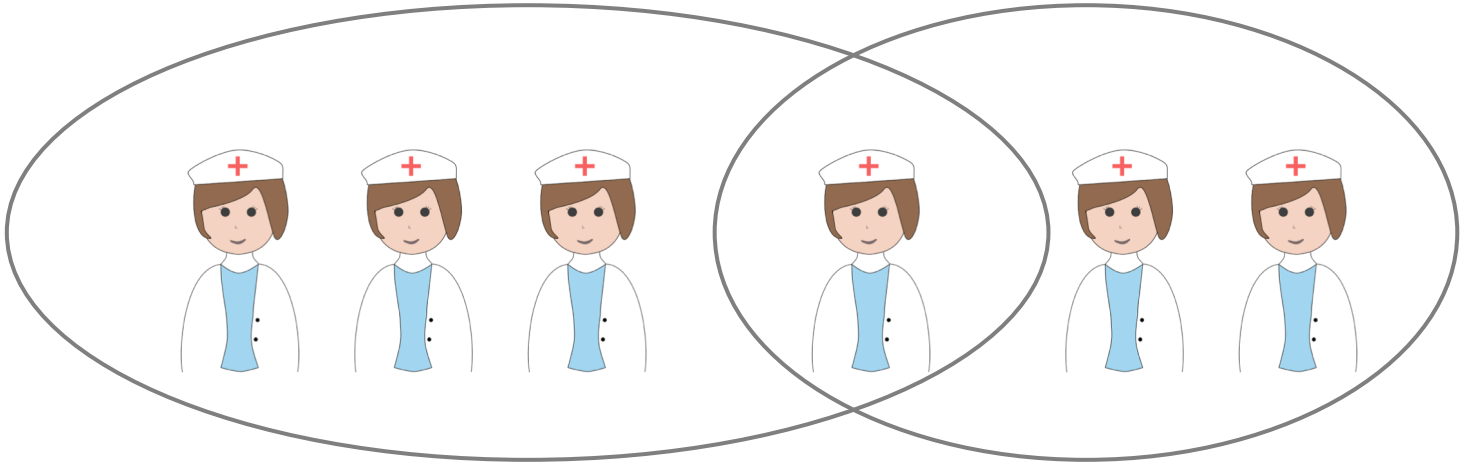

2017-09-14
2017-09-15
2017-09-16
2017-09-17
2017-09-18
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
mg/dL
2017-09-17
400
350
300
250
200
150
100
50
0
Breakfast
Sugar to treat
Other
Dinner
Sugar to treat
0
2
4
6
8
10
12
14
16
18
20
22
24

Detail View

Qualitative Study

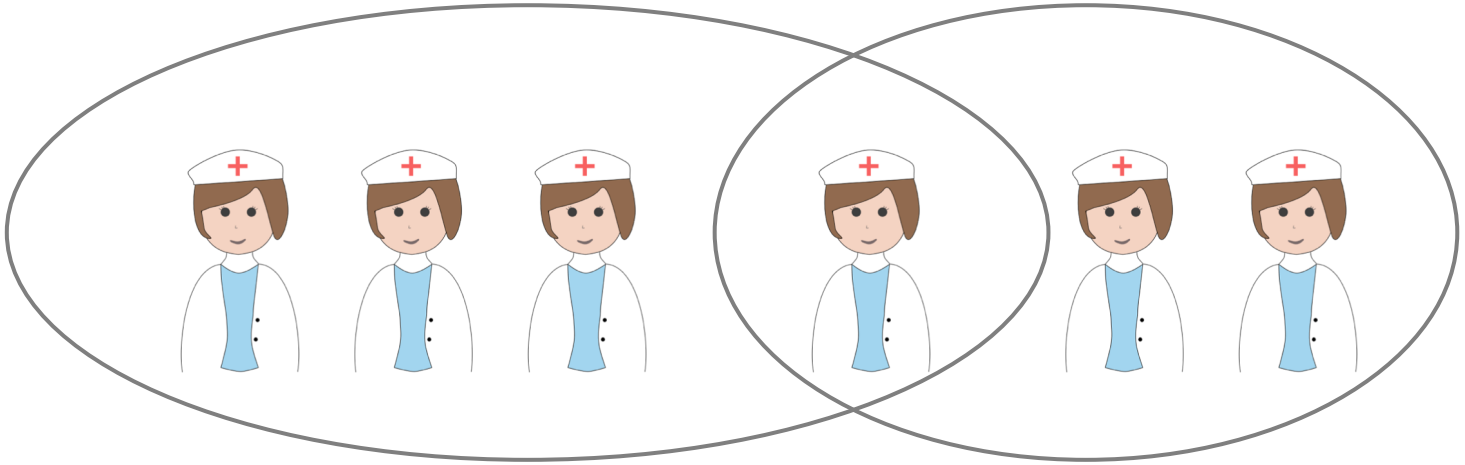
Participants



Certified diabetes educators (CDEs)

Dietitians

Participants



Certified diabetes educators (CDEs)

Dietitians

Average years of work experience:

17.2 years

Methodology

<< >> From 08/23/2017 To 09/05/2017

Date	Breakfast			Lunch			Dinner		
	Insulin	Carbs	Glucose	Insulin	Carbs	Glucose	Insulin	Carbs	Glucose
2017-08-23	0.6	16.0	162.0	1.5	43.0	149.0	2.3	90.0	111.0
2017-08-24	1.4	29.0	144.0	1.3	49.0	-	2.0	73.0	115.0
2017-08-25	1.2	31.0	-	2.1	31.0	265.0	1.9	77.0	-
2017-08-26	1.7	34.0	145.0	-	-	-	0.3	11.0	-
2017-08-27	1.9	36.0	166.0	1.5	67.0	85.0	1.0	41.0	-
2017-08-28	1.0	31.0	78.0	1.1	40.0	130.0	0.1	5.0	-
2017-08-29	1.1	29.0	140.0	1.6	47.0	140.0	1.0	46.0	77.0
2017-08-30	1.2	21.0	145.0	1.3	54.0	85.0	2.3	72.0	161.0
2017-08-31	0.6	19.0	88.0	1.7	46.0	162.0	-	69.0	184.0
2017-09-01	-	-	-	1.3	36.0	147.0	1.6	63.0	115.0
2017-09-02	1.8	38.0	138.0	1.3	52.0	85.0	1.9	75.0	-
2017-09-03	-	-	-	1.7	60.0	80.0	1.9	65.0	153.0
2017-09-04	1.1	19.0	151.0	2.4	28.0	325.0	-	56.0	-
2017-09-05	0.6	10.0	135.0	2.1	54.0	169.0	1.4	50.0	-

Day-by-meal table

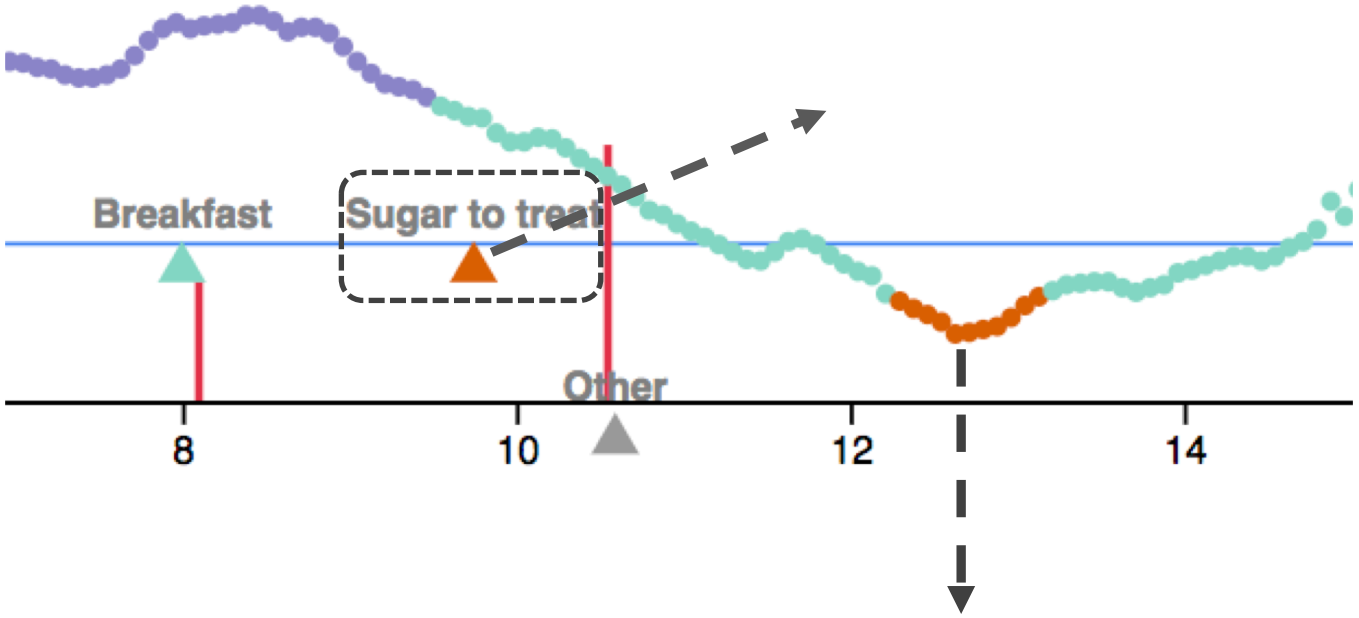
Exploration using IDMVis

Semi-structured interviews

Results

Results

Superimposed detail view helps identify issues of data quality (e.g., missing or conflicting data)



> *So sugar-to-treat [blood glucose] should have gone up from here, not down. It went down. Kept going down.* ***Sugar to treat should be here****, before this curve comes back up. That's my concern.* **It's missing something here.**

Results

Sentinel event alignment allows exploration of event sequence relationships

Sentinel event alignment allows exploration of event sequence relationships

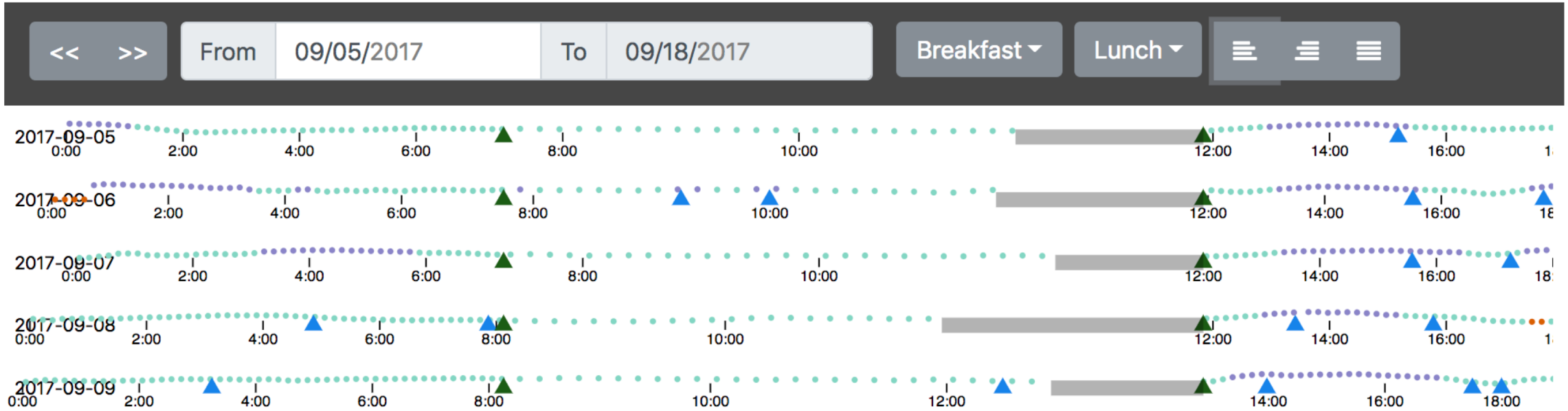
- Use **single-event** alignment to look for event consistency

Results

Sentinel event alignment allows exploration of event sequence relationships

- Use **single-event** alignment to look for event consistency
- Use **dual-event** alignment to examine variability of patterns

Results



> *I like being able to see how you could* ***separate and see between the length, the time between meals****... You can't tell them to eat three times a day at the same time. So it's just sort of helpful to see the* ***variability****... It would help you plan for it in the fact that you might* ***reduce his basal based on the fact that he's an erratic eater****.*

Conclusion

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- IDMVis – a temporal event sequence visualization
  - Novel techniques for temporal folding
  - Aligning by dual sentinel events & scaling the intermediate timeline

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  - Novel techniques for temporal folding
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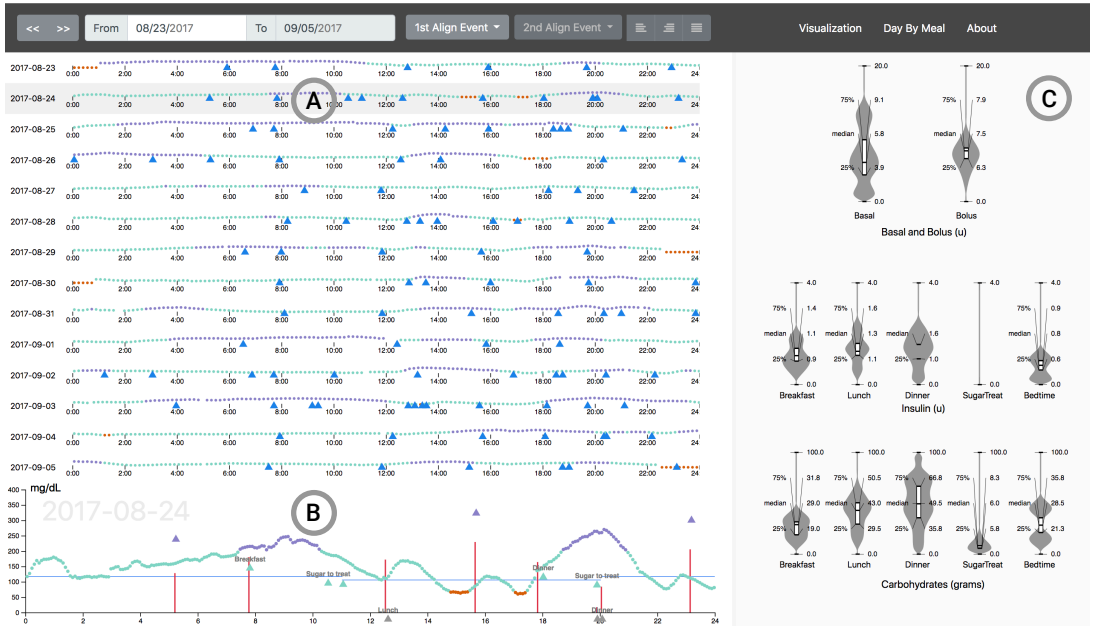
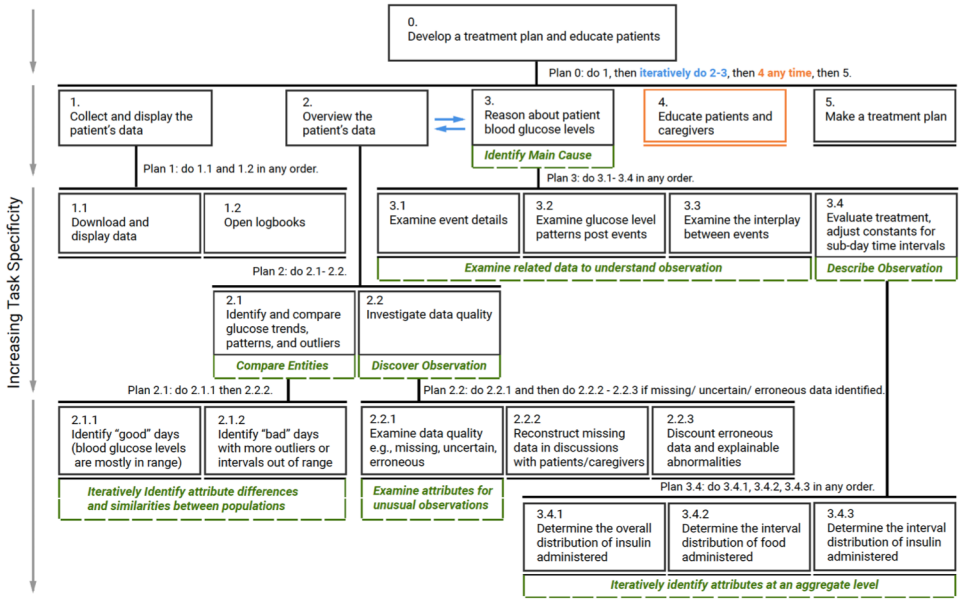
- Hierarchical task abstraction

For more information, please visit bit.ly/IDMVis



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