Time in Tight Range for Patients With Type 1 Diabetes: Examining the Potential for Increased Alarm Fatigue

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Patients with type 1 diabetes continue to adopt continuous glucose monitoring (CGM) and hybrid closed loop systems. Time spent with glucose in target range (TIR), fraction of time with CGM readings between 70 and 180 mg/dL, is widely used to guide glucose management, with a target of TIR >70%. The target of >50% of time spent with glucose in tight range (TITR) (70–140 mg/dL) is a proposed alternative. Adolescents with type 1 diabetes and their parents report worries that the use of TITR may increase stress about not meeting targets (1). Retrospective studies of TITR do not inform concerns that its use in clinical practice may contribute to alarm fatigue, diabetes distress, and heightening fears of hyperglycemia leading to more aggressive insulin dosing (dose stacking) with subsequent hypoglycemia (2). We examined the potential consequences of lowering the threshold for hyperglycemia alarms and a potential way to mitigate spurious alarms.

We used data from four published studies: two in which patients started CGM within 1 month of diagnosis—the Teamwork, Targets, Technology and Tight Control (4T) pilot study and 4T Study 1—and two of closed loop systems: DCLP3 and DCLP5 (3–5). All patients with reported CGM data were included. We defined a hypothetical "TIR alarm" as an instance of a CGM reading <180 mg/dL followed by a CGM reading >180 mg/dL, a hypothetical "TITR alarm" analogously using the threshold 140 mg/dL, and a hypothetical "robust TTIR alarm" as an instance of three consecutive glucose readings <140 mg/dL followed by three consecutive readings >140 mg/dL. We report TIR, TITR, mean glucose, and the number of alarms for each kind of alarm for each patient day.

Available data included CGM data for a total of 198,865 days from 493 patients in the 4T pilot study (130 patients, median 821 days of data per patient), 4T Study 1 (133 patients, median 591 days per patient), DCLP3 (137 patients, median 27 days per patient), and DCLP5 (93 patients, median 188 days per patient). The median daily mean glucose and TIR over the course of the studies were 163 mg/dL and 64% in the 4T pilot study, 156 mg/dL and 69% in 4T Study 1, 158 mg/dL and 64% in DCLP3, and 171 mg/dL and 61% in DCLP5.

The median number of TIR alarms per patient per day was 2.1 (interquartile range 1.8–2.5) in the 4T pilot study, 2.1 (1.5–2.4) in 4T Study 1, 2.6 (2.1–3.0) in DCLP3, and 2.1 (1.8–2.3) in DCLP5. For TITR alarms, the median was 2.8 (2.2–3.1) in the 4T pilot study, 2.9 (2.4–3.2) in 4T Study 1, 3.2 (2.7–3.8) in DCLP3, and 2.5 (2.1–2.9) in DCLP5. Across patients in each study, in comparisons with the median frequency of TIR alarms, the median frequency of TTIR alarms was higher by 29% in the 4T pilot study, 41% in 4T Study 1, 23% in DCLP3, and 22% in DCLP5. Across patients in each study, compared with the median frequency of TIR alarms, the median frequency of robust TTIR alarms differed by −4% in the 4T pilot study, 3% in 4T Study 1, 7% in DCLP3, and 12% in DCLP5 (Fig. 1).

In an analysis of CGM data from 198,865 days of CGM use by 493 patients across four recent clinical trials of diabetes technology in which participants achieved TIR >60%, we found that hypothetical TITR alarms would trigger between 22% and 41% more frequently than TIR alarms. Use of robust TITR alarms, set to trigger on the basis of three consecutive readings below the threshold followed by three consecutive readings above the threshold, mitigated the increase in alarm frequency.

An important limitation of our work is that the numerical analysis does not include patient-facing considerations. In this study we used data only from Dexcom sensors taking glucose readings every 5 min, for which robust alarms would be delayed by 10 min, in comparison with alarms based on a single reading. Further work should be conducted with consideration of the potential consequences of and patient attitudes toward such delays and with use of sensors that take more frequent glucose readings. In subsequent work, investigators should examine more sophisticated algorithms with consideration of additional factors such as hybrid closed loop systems that do not allow user intervention, to reduce or eliminate alarms that cause distress without informing management.

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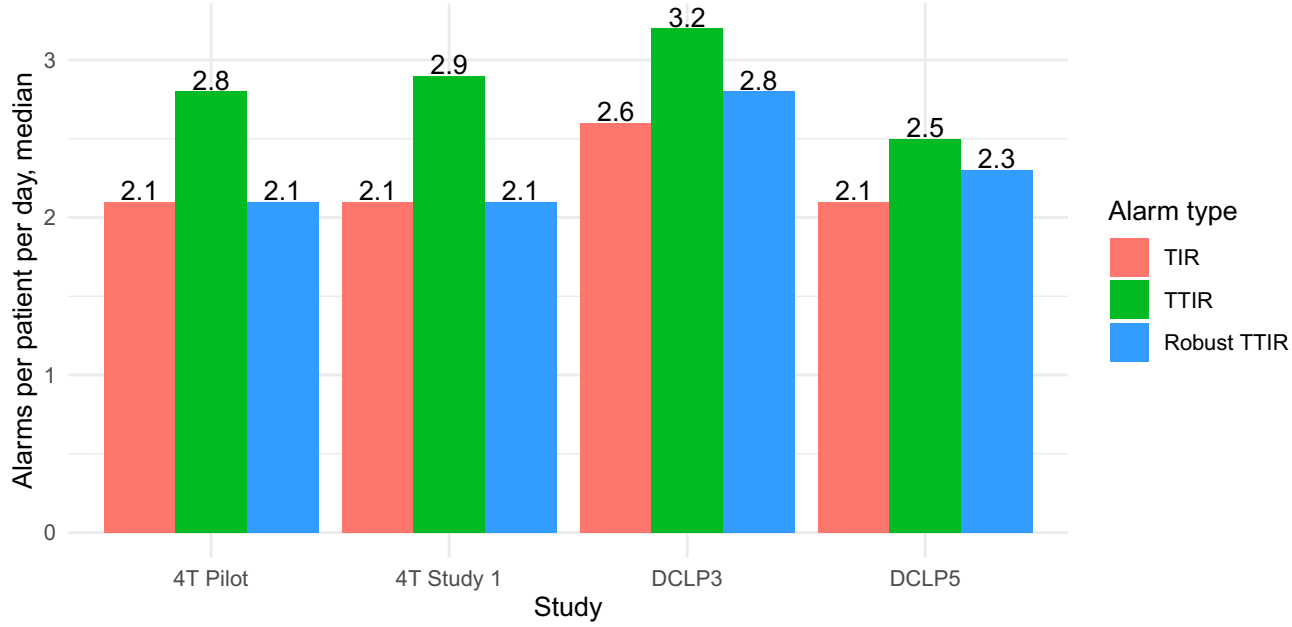

Figure 1—Daily alarm frequencies.

Prospective clinical research is required for determination of how targets set in terms of TITR versus TIR will affect glycemic and patient-reported outcomes and how these glycemic targets can be translated to clinical care (1,2). The data from clinical trials of diabetes technology are particularly relevant to discussions of the future of diabetes management. Compared with current TIR-based glucose management targets, equivalent TITR-based targets may result in more alarms, but the increase may be mitigated by use of robust alarm settings.

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