User Engagement With the CamAPS FX Hybrid Closed-Loop App According to Age and User Characteristics

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CamAPS FX (CamDiab, Cambridge, U.K.) is a hybrid closed-loop app hosting the Cambridge closed-loop algorithm on an Android smartphone, and it is approved in the European Union for use in children ≥1 year and adults (including during pregnancy) with type 1 diabetes (T1D). The interoperable CamAPS FX app receives glucose data from a compatible continuous glucose monitoring system (Dexcom G6; Dexcom, San Diego, CA), connects to a compatible insulin pump (Dana Diabecare RS and DANA-i; Sooil, Seoul, South Korea) to direct glucose-responsive insulin delivery every 8–12 min, includes a bolus calculator allowing discrete bolusing via the app, and streams data in real time to cloud-based

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diabetes data repositories (Diasend/Glooko, Gothenburg, Sweden).

It is currently unknown how much time different user cohorts spend interacting with hybrid closed-loop systems. We aimed to investigate usage patterns of the CamAPS FX app across different populations by considering the amount of time a person spends using the app over a 24-h period.

We noted time spent within the CamAPS FX app over an 11-week period from February to May 2020 in 134 individuals from six ongoing clinical studies. Each study involved a different demographic cohort: very young children (1–7 years) in which caregivers use the app (NCT03784027, ClinicalTrials.gov), children and adolescents (6–19 years) (NCT02925299), adolescents (10–17 years) using the closed-loop system from diagnosis of T1D (NCT02871089), adults (≥18 years) (NCT04055480), pregnant women (≥18 years) (ISRCTN56898625, www.isrctn.org), and older adults (≥60 years) (NCT04025762). All studies received regulatory and ethical approval; participants/guardians signed informed consent.

User engagement is the duration of time that users have the application active and in the foreground, as calculated by an analytics cloud platform (Firebase; Google). Time spent using the application was divided into nighttime (0000–0559 h) and daytime (0600–2359 h). For each day of the 11-week observation period, average app usage was recorded per study cohort. Data are presented as median with interquartile range of these daily recordings.

The mean time spent in the CamAPS FX app across all user cohorts was 36 min/day. This includes all aspects of app engagement (initiating prandial insulin boluses, responding to sensor glucose and other alerts, reviewing data, altering app settings for exercise, troubleshooting connectivity issues, and starting/stopping the glucose sensor). Nocturnal engagement was low, with just 3 min of app usage, on average, during nighttime.

Participants from distinct demographic cohorts differed in the amount of time spent within the app, ranging from 10 to 81 min/day (Fig. 1). Caregivers of very young children and older adults had greatest app engagement (median [interquartile range] 81 [63–96] and 63 [39–83] min/day, respectively). Caregivers of very young children had the greatest nighttime engagement, reflecting the sleep disruption and anxiety around monitoring children's nocturnal glucose reported in this population (1).

Children and adolescents with established T1D spent time engaging with the app similar to that of adult users (16 [13–21] vs. 16 [14–18] min/day, respectively), while adolescents using the closed-loop system from diagnosis spent the least amount of time in the app, at 10 [9–11] min/day. Pregnant women, who target tighter glycemic control, spent double the amount of time in app spent by nonpregnant adults (32 [25–40] vs. 16 [14–18] min/day).

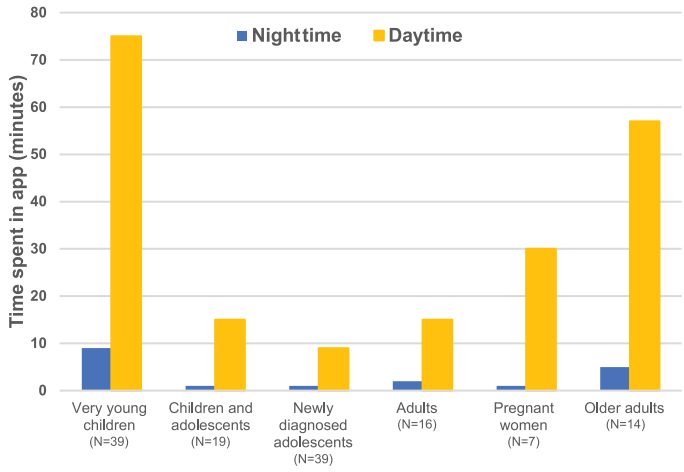

Figure 1—Duration of user engagement during nighttime (0000–0559 h) and daytime (0600–2359 h) with the CamAPS FX app across six closed-loop studies.

Time in app across pediatric cohorts overall was lower than that reported in a survey of diabetes educators, where the estimated time required for routine diabetes self-management for a child with T1D using multiple daily insulin injections and fingerstick glucose monitoring is 78 min/day (2).

A feasibility trial of long-term closed-loop use in adults reported that users spending "low" amounts of time engaging with the system reported fewer benefits than "high" users who used the system for longer periods (3). Increased time spent with closed-loop in operation is associated with improved glycemic outcomes (4). High users must also consider the burden of diabetes management for optimal long-term benefits and prevention of management-related fatigue and burnout. There is a need to balance optimal glucose control and time spent managing diabetes using hybrid closed-loop to truly reduce burden.

Strengths of the study include evaluating usage patterns across different user characteristics from multicenter, and, for some, multinational studies, thereby increasing generalizability. Whether these engagement patterns are similar to those observed with closed-loop systems, where the control algorithm resides on the insulin pump (5), remains to be determined. Limitations include an inability to link app engagement to glucose outcomes and an unbalanced number of subjects per cohort. The duration of time participants had been using the app prior to the observation period varied between studies and individuals within a study.

We conclude that considerable differences in closed-loop app engagement exist among different user cohorts. Further research is warranted to elucidate drivers for user engagement and identify means to reduce overall diabetes burden for people with T1D and caregivers using hybrid closed-loop systems.

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Duality of Interest. S.H. serves as a member of Sigma-Aldrich (Dexcom) and Medtronic advisory boards; is a consultant for CamDiab and a director of Ask Diabetes Ltd., providing training and research support in health care settings; and reports having received training honoraria from Medtronic and Sanofi. M.E.W. reports receiving license fees from B. Braun, patents related to closed-loop systems, and being a consultant at CamDiab. E.F.-R. reports having received speaker honoraria from Medtronic, Eli Lilly and Compant, Novo Nordisk, and Sanofi and serving on advisory boards for Eli Lilly and Company. B.R.-M. received speaker honoraria from Eli Lilly and Company, Medtronic, Novo Nordisk, Roche Diabetes Care, and Sanofi. R.E.J.B. reports having received speaking honoraria from Eli Lilly and Company. R.L. reports having received speaker and advisory board fees from Novo Nordisk, Servier, and Eli Lilly and Company. E.M.S. reports having received speaker honoraria from Abbott Diabetes Care and Eli Lilly and Company. H.T. reports having received research support and speaker honoraria from Dexcom. L.L. reports having received speaker honoraria from Animas, Abbott, Insulet, Medtronic, Novo Nordisk, Roche, and Sanofi; was on advisory panels for Animas, Abbott, Novo Nordisk, Dexcom, Medtronic, Sanofi, and Roche; and received research support from Novo Nordisk and Dexcom. M.L.E. reports having received speaker honoraria from Eli Lilly and Company, Novo Nordisk, Abbott Diabetes Care, Medtronic, AstraZeneca, and Ypsomed and acting on advisory boards for Medtronic, Zucara Therapeutics, Pila Pharma, and Abbott Diabetes Care. J.K.M. is a member of the advisory boards of Abbott Diabetes Care, BD, Boehringer Ingelheim, Eli Lilly and Company, Medtronic, Prediktor A/S, Roche Diabetes Care, and Sanofi; received speaker honoraria from Abbott Diabetes Care, AstraZeneca, Dexcom, Eli Lilly and Company, Novo Nordisk A/S, Roche Diabetes Care, Servier, and Takeda Pharmaceutical Company; and is a cofounder and shareholder of decide Clinical Software Ltd. R.H. reports having received speaker honoraria from Eli Lilly and Company, Dexcom, and Novo Nordisk; receiving license fees from Medtronic; receiving patents related to closed-loop systems; and being director at CamDiab. No other potential conflicts of interest relevant to this article were reported.

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