



THE FEVERPRINTS APP: CROWDSOURCING TECHNOLOGY TO STUDY TEMPERATURES IN HEALTH AND DISEASE

Jonathan. S. Hausmann^{1,2}, Nitin Gujral³, Soleh Al Ayubi³, Jared Hawkins³, John Brownstein³, Fatma Dedeoglu¹

¹Program in Rheumatology, Division of Immunology, Boston Children's Hospital, Boston, MA

²Division of Rheumatology, Beth Israel Deaconess Medical Center, Boston, MA

³Innovation & Digital Health Accelerator, Boston Children's Hospital, Boston, MA



Purpose

Fever is a cardinal feature of autoinflammatory diseases and complicates the course for other rheumatic illnesses. Despite the widespread use of temperature measurement in healthcare, our ability to use temperature for diagnosis is limited, and distinguishing fevers of rheumatic illnesses from those of infectious or malignant conditions remains challenging. We created Feverprints, a crowdsourcing research app to understand temperature variation between individuals, determine unique fever patterns (“feverprints”) for a variety of illnesses, and examine how antipyretics affect disease course. We report preliminary data from temperatures and symptoms collected during the first 9 months of the study.

Methods

We developed the Feverprints app using Apple’s HealthKit and ResearchKit. Participants downloaded the app from Apple’s App Store and provided consent. Children and adults living in the US were eligible to enroll; ownership of a thermometer was required. Surveys assessed demographics, medical and family history, ancestry, and medications. Participants completed a “Daily Check-in” in which they registered their temperature, associated symptoms, and use of antipyretics. We analyzed temperature data from March 2016-January 2017.

Results

1,118 participants signed consent and 685 completed the demographics surveys; their characteristics are shown in Table 1. Participants recorded 11,458 temperatures; average daily temperature was 97.8°F/36.5°C and showed significant gender and diurnal variation, with average temperatures being lower in males (97.5°F/36.4°C) than in females (97.9°F/36.6°C), as shown in Figure 1. Frequency of symptoms reported during the “Daily Check-in” are shown in Figure 2.

Table 1. Participant characteristics.

* Participants could choose more than 1 response

| | Number (%) | | Number (%) |
|------------------------------------|------------|--|------------|
| Gender (n=681) | | Ancestry (n=850)* | |
| Female | 369 (54.2) | Irish | 245 (28.8) |
| Male | 312 (45.8) | Ashkenazi Jewish | 51 (6.0) |
| Age in years (n=675) | | Dutch | 56 (6.6) |
| 0-9 | 49 (7.3) | Italian | 94 (11.1) |
| 10-19 | 48 (7.1) | Spanish | 33 (3.9) |
| 20-29 | 118 (17.5) | Greek | 18 (2.1) |
| 30-39 | 188 (27.9) | Arab | 7 (0.8) |
| 40-49 | 96 (14.2) | Armenian | 7 (0.8) |
| 50-59 | 85 (12.6) | Turkish | 7 (0.8) |
| 60-69 | 57 (8.4) | Sephardic Jewish | 16 (1.9) |
| 70-79 | 31 (4.6) | None of these | 236 (27.8) |
| 80-89 | 3 (0.4) | Don't know | 80 (9.4) |
| Race/Ethnicity (n=724)* | | History of recurrent fevers (n=634) | |
| White | 602 (83.1) | Yes | 130 (20.5) |
| Asian | 48 (6.6) | No | 467 (73.7) |
| Hispanic / Latino | 32 (4.4) | Don't know | 37 (5.8) |
| Black / African American | 13 (1.8) | Autoinflammatory disease diagnosis (n=113)* | |
| American Indian / Alaska Native | 8 (1.1) | FMF | 12 (10.6) |
| Native Hawaiian / Pacific Islander | 2 (0.3) | PFAPA | 10 (8.8) |
| Other | 13 (1.8) | CAPS | 4 (3.5) |
| Country of birth (n=683) | | SoJIA | 5 (4.4) |
| USA | 587 (85.9) | TRAPS | 2 (1.8) |
| India | 9 (1.3) | MKD/HIDS | 4 (3.5) |
| UK | 6 (0.9) | Behcet's | 1 (0.9) |
| Romania | 5 (0.7) | NAID | 1 (0.9) |
| Canada | 6 (0.9) | AOSD | 2 (1.8) |
| Germany | 5 (0.7) | PAPA | 1 (0.9) |
| China | 8 (1.2) | SAVI | 1 (0.9) |
| Other | 46 (6.7) | Don't know | 43 (38.1) |
| | | Other | 27 (23.9) |

Figure 1. Daily temperature variation in females and males from 11,458 recordings.

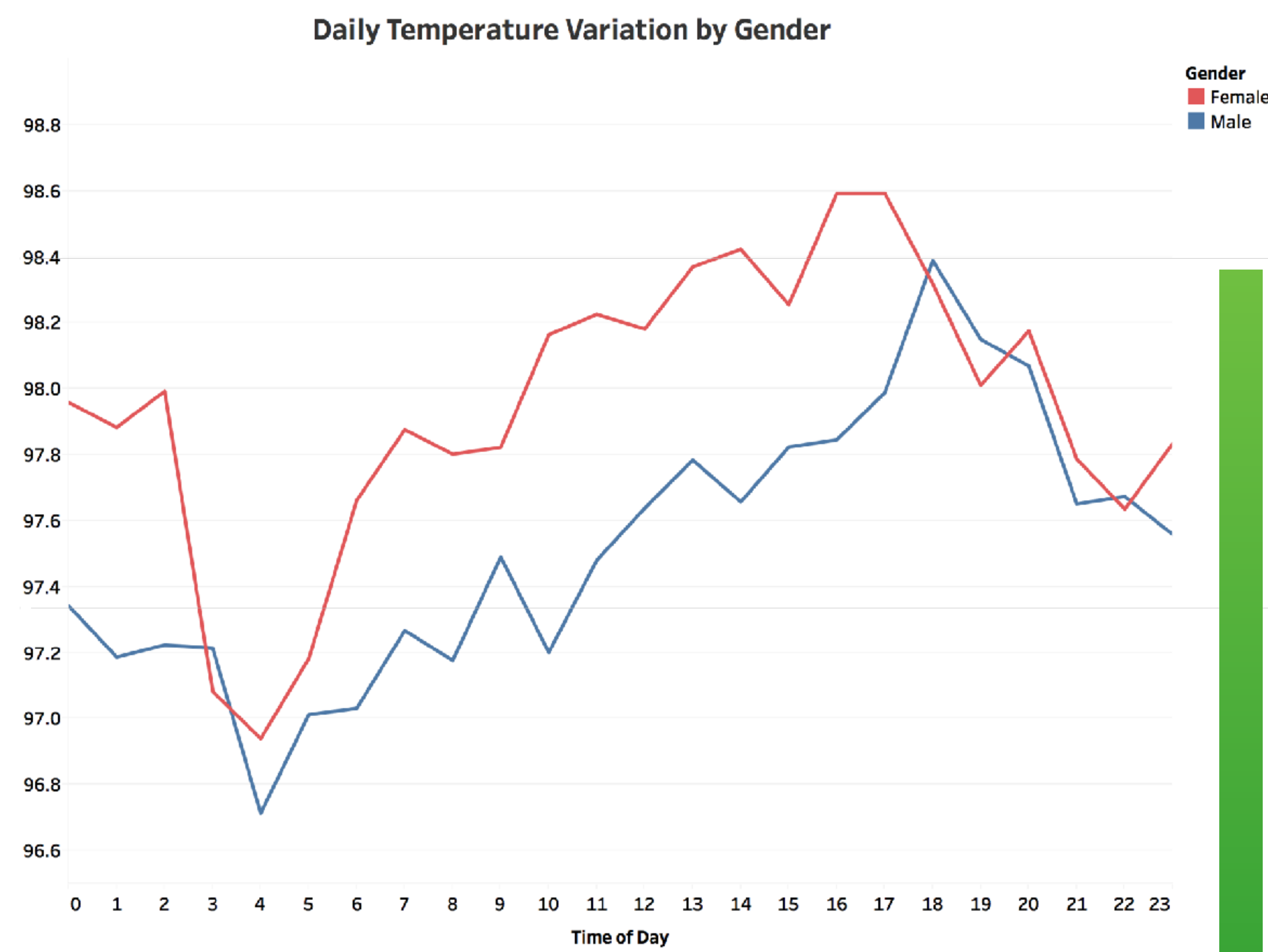
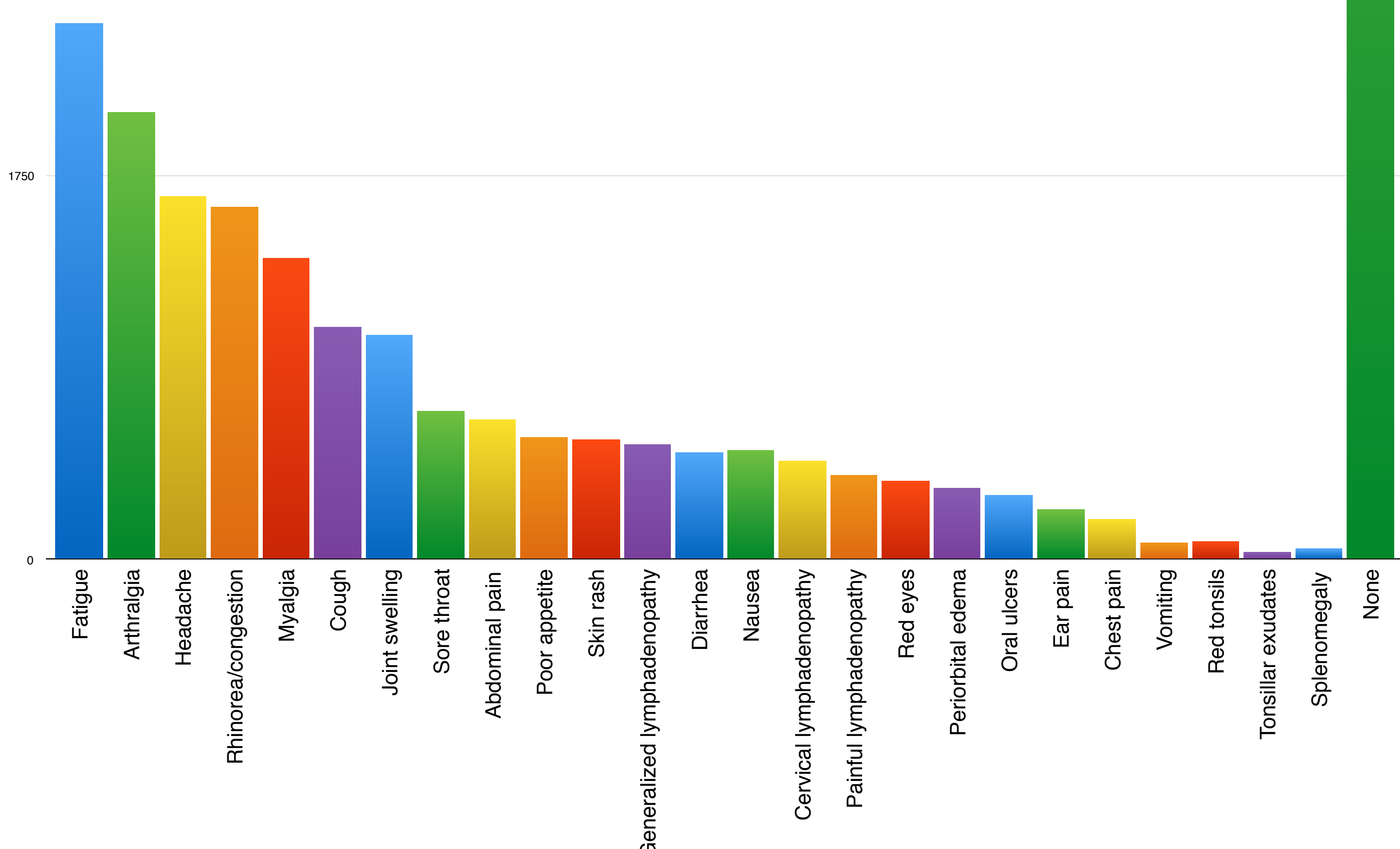


Figure 2. Symptoms reported during “daily check-in.”



Conclusions

We leveraged technology to rapidly recruit large numbers of patients, including those with rare autoinflammatory diseases, and crowdsource health data for research. Preliminary results reveal average temperatures from study participants that were significantly lower than 98.6°F/37°C, a value often defined as “normal.” In addition, temperatures varied significantly by gender and time of day, an important factor when interpreting temperatures in the healthcare setting. Future analyses will attempt to redefine average temperatures in participants of various demographics, identify “feverprints” to distinguish autoinflammatory diseases from other conditions, and examine the effect of antipyretics on temperature and disease course.

