Fevers Are Rarer in the Morning—Could We Be Missing Infectious Disease Cases by Screening for Fever Then?

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Abstract (54/50 words)

We retrospectively studied US emergency department visits (n=295,406), including nationally representative results. Patients were less likely to have detectable fevers during mornings, with especially large morning-evening differences during influenza outbreaks (national RR=0.56, 95%CI=0.47-0.66). This suggests morning screenings could miss otherwise-detectable cases. Twice-daily screenings could be a simple solution. However, similar COVID-19 research is needed.

Keywords: Body Temperature; Communicable Diseases; COVID-19; Fever; Influenza, Human; Mass Screening; Preventive Measures; Thermometers; Vital Signs

Article Summary Line: Fevers were about half as common in the morning as in the evening during influenza outbreaks, suggesting that mornings may be a bad time to perform once-daily fever screenings for infectious diseases, and that twice-daily screenings could be preferable.
Main Text (787/800 words)

**Introduction:** Body temperatures are less likely to reach the fever range during mornings (I,2), but it is unknown how this affects practice during disease outbreaks. Using emergency department data, we retrospectively investigated fevers during seasonal influenza outbreaks and the 2009 H1N1 (swine flu) pandemic, which have been used as preparatory models for COVID-19.

**Methods:** Temperatures \(n=115,149\) were recorded during triages to monitor outbreaks at a Boston adult emergency department (September 2009–March 2012) (2). We also investigated adult triage temperatures \(n=218,574\) from a nationally representative study of US emergency department visits (December 2002–December 2010) (3). The thermometer types used were temporal artery (Boston) and a nationally representative sample (national). We analyzed exact measurement times (Boston) or arrival times as a substitute (national). We excluded records missing temperature or time (Boston=1.0%, national=7.5%), or indicating repeated or accidental measurement (repeated ≤ 15 seconds or temperature <95°F: Boston=18.0%), leaving 93,225 Boston and 202,181 national temperatures for analysis (2). High-influenza activity periods were defined as months fully exceeding CDC ILINet baseline thresholds in region 1 (Boston analysis; outbreak-period \(n=6627\)) or nationally (national analysis; outbreak-period \(n=29,908\)) (4). Using multivariate logistic regression, time-of-day case mix differences in 11 characteristics were excluded from responsibility for the time-of-day fever rate differences in national data (Appendix Methods). Our letter extends research that did not examine outbreaks, but analyzed fever in the same datasets, including additional methodological detail and analyses demonstrating robustness to exclusion criteria choices (2).

**Results:** Fever-range temperatures \((≥100.4°F, ≥38.0°C)\) were less common during mornings in all investigated periods (Figure 1; Appendix Table 1). Morning-evening differences were especially large during influenza outbreaks, including after adjusting for time-of-day differences in patient case mix (ratio of 6 AM–noon vs. 6 PM–midnight: Boston=0.43, 95%CI=0.29-0.61; national=0.56, 95%CI=0.47-0.66; case-mix-adjusted national=0.59, 95%CI=0.50-0.70). Findings were similar when studying other fever definitions used for COVID-19 (Appendix Figure 1), analyzing time as a continuous variable (Appendix Figure 2), and evaluating years separately (Appendix Figure 3). Investigations for Berkson’s bias (collider selection bias) continued to support the main findings, including in general population (non-medical) analyses \((n=6535; \text{Appendix, Berkson’s bias})\).
Figure 1. Time-of-day changes in the percentage of body temperatures that reach the fever range: Boston and US national studies. In both the Boston and US national studies, temperatures measured during mornings were less likely to reach the fever range (≥100.4°F, ≥38.0°C), especially during periods of high influenza activity (seasonal flu and the 2009 H1N1 pandemic). Overall, fever-range temperatures were roughly half as common in the morning as in the evening (Appendix Table 1). The results suggest that morning temperature measurements could miss many febrile disease cases, which raises concerns because workplace and school fever screens often occur during mornings, and because patients seen for potential COVID-19 may only have temperatures checked during mornings. A simple solution is twice-daily temperature measurement. National study results are nationally representative of adult visits to US emergency departments. Confidence intervals are 95%.

Discussion: Our results raise concerns that morning measurements could miss many (perhaps even half) of the individuals with fevers detectable during evenings, potentially allowing them to go to work, attend school, and travel. Physiologically, circadian rhythms usually reach temperature low points during mornings, and patients can lack fever signs or can present some signs without reaching cutoffs like ≥100.4°F (1,2,5). Although circadian rhythms are well known, their relevance to fever has rarely been studied because it was less important before COVID-19.
Temperature screenings are used for COVID-19 because measurements are simple, fever is common and presents early (6,7), and many symptomatic people do not self-isolate (8) (Appendix, COVID-19 Fevers). Temperature screenings cannot detect nonfebrile cases. However, partially effective measures can confer benefits by reducing COVID-19 transmission rates, a justification that also underpins public use of face masks (Appendix, Screening and Transmission).

Temperature screening is usually recommended once daily at morning arrival to workplaces and schools, yet our results suggest the morning could be the worst time. A rapidly applicable solution may be twice-daily screening, for example before and after shifts. The first measurement is retained to reduce possible during-shift transmission, and the second is for cases previously missed. With two widely spaced measurements, at least one avoids the temperature low point, regardless of differences in shift or individuals’ circadian timing. An alternative could be once-daily screening with morning-lowered fever definitions. One morning-lowered definition is available (1) but appears to overcorrect (2). Irrespective of screening frequencies, self-measurements at home may help meet privacy regulations and reduce burdens at large workplaces and schools.

Given the possibility of missing fevers during mornings, evening temperature remeasurements might be requested at morning COVID-19 examinations, an approach that could be useful where SARS-CoV-2 testing is limited to febrile patients because of shortages. Similarly, departure and arrival screens might both be worthwhile for long flights.

We end with some cautions: First, our results are from clinicians using hospital-grade thermometers, and may not generalize to other settings, layperson measurements, or low-accuracy thermometer guns and thermal imagers. Second, screenings should balance false-negative risks with false-positive burdens, which could increase during evenings when healthy temperatures rise (1,2). Third, our analyses may not fully address confounding and Berkson’s biases, which could contribute artifactually to morning-evening fever differences. Fourth, thermometer site, age, and other factors also affect temperature (5). Screenings may benefit from adjustment for some of these factors, especially thermometer site. Lastly and most importantly, although most diseases include morning temperature lows, this has not been shown for COVID-19. We hope our research encourages study of this topic and optimal screening strategies, especially to assist workplace and school reopenings where COVID-19 has been regionally controlled, but control is fragile.
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