

# **Thermal Screening White Paper: Athena Security Compared to Medical-Grade Thermometers**

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## Table of Contents

i.	Abstract.....	3
ii.	Literature Review.....	4
iii.	Solution.....	6
iv.	Accuracy Tests.....	7
v.	Results.....	8
vi.	Discussion.....	9
vii.	Future Directions.....	10
viii.	Conclusion.....	11
ix.	References.....	12
x.	Appendices.....	15-17



[Click Here To A Watch Video of How Temperature Detection Works](#)

## Abstract

As businesses in the United States reopen following the initial outbreak of COVID-19, there is a need to implement new systems that will reduce the spread of the virus. Public health solutions such as isolation, quarantine, social distancing and community containment are the preliminary methods of limiting COVID-19 transmission. However, as businesses and transportation return to normal functioning, additional protocols at the institutional level are essential to ensure continued safety. Athena's Elevated Temperature Detection System is a data-driven solution that facilitates greater protection against COVID-19 transmission in indoor spaces by using advanced thermal imaging at a building's entryways or chokepoints to identify potentially febrile individuals for further screening. The literature points to major improvements to infrared technology for fever screening in recent years and suggests that IRT is an effective alternative to non-contact infrared thermometers (NCITs) for on-site screening. Furthermore, NCITs violate social distancing protocol as the temperature screener must stand less than six feet away from the subject. Additionally, two studies of the Athena device conducted among a pool of healthy individuals demonstrate readings comparable to those of a hospital grade model 5000 contact thermometer and a normal temperature distribution, as well as low levels of variation based on changes in surface temperature.



## Literature Review

### *History of Thermal Temperature Detection*

The use of infrared technology (IRT) for mass fever detection was popularized in China and East Asia during the SARS outbreak of the early 2000s (Wang, Chua & Tan, 2004; Ng & Chong, 2006; Pascoe et al., 2010). It has since been used to screen for seasonal influenza, Ebola and H1N1 (Sun et al., 2014, Silvino et al., 2020). The technology has been tested extensively as an on-site screening system for high volume locations such as airports and hospitals (Liu, Chang & Chang, 2004; Ng, Kawb & Chang, 2004; Ng & Chong, 2006; Hausfauter et. al, 2008; Chiang et al., 2008; Sun et al., 2014). With the onset of the COVID-19 pandemic in the winter of 2019 and the subsequent pandemic resulting in over 140,000 deaths in the United States, public health professionals perceive a need for widespread use of virus-containing technology. As a result, the Centers for Disease Control and Prevention is recommending temperature detection as a best practice for employers implementing on-site screening protocols (CDC, 2020).

IRT is one of two methods of mass fever screening, the other being non-contact infrared thermometers (NCITs) (Ghassemi et al., 2018; FDA, 2019). While NCIT has been used more widely, IRT has in recent years seen significant improvement from earlier models through rigorous testing and the introduction of updated operational and procedural guidelines. Previously, researchers noted limitations, including the fact that individual-level factors such as medication use, physical exertion, perspiration, makeup, and consumption of alcoholic, caffeinated or hot beverages can all have a temporary effect on an individual's surface temperature (Liu, Chang & Chang, 2004; Ng et al., 2004; Pascoe et al., 2010; Sathyamoory & Yunus, 2011). IRT can now target the inner canthus and calibrate to environmental temperature to minimize the effect of these factors (Pascoe et al., 2010; FDA, 2019). Studies have noted that ambient temperature and ventilation can have a strong influence on the accuracy of the screening tool (Liu et al., 2004; Ng et al., 2004; Wong, 2006; Pascoe et al. 2010; Sathyamoory & Yunus, 2011). However, early studies finding lower rates of accuracy may be attributed to poor adherence to operational procedure (Ng et al., 2004; Pascoe et al., 2010; Sathyamoory & Yunus, 2011; FDA, 2019). Following its use during the SARS pandemic, new regulations were introduced specifying the use of IRT for fever detection (Ring et al., 2013; Ghassemi et al., 2018). A recent study found that the sensitivity, which corresponds to the rate of febrile individuals detected by the system, is now as high as 98% when regulations are followed correctly (FDA, 2019). The introduction of international standards allows for infrared devices to be used outside of the medical setting with an unprecedented level of accuracy.

IRT has notable strengths that makes it a valuable tool for detecting febrile individuals during a pandemic. As compared to other screening devices, such as medical-grade thermometers and nasal swab tests, its main advantages are quick detection and minimal invasiveness (Wang, Chua, and Tan, 2004; Ng et al., 2004; Wong, 2006; Chiang et al., 2008; Sathyamoory & Yunus, 2011; Sun et al., 2014). Because the system does not require contact with potential cases, the risk of surface or person-to-person transmission is reduced (Silvino et al., 2020). Additionally, these devices are able to collect temperature readings from numerous points on the face.

Thermographic readings target a number of key facial points, including the inner canthus of the eye, which research suggests is the most reliable proxy of internal body temperature (Ng et al., 2004; Pascoe et al. 2010; Silvino et al., 2020; FDA, 2019). As a result, IRT can be used to quickly detect fever in a large number of individuals while maintaining accurate results.

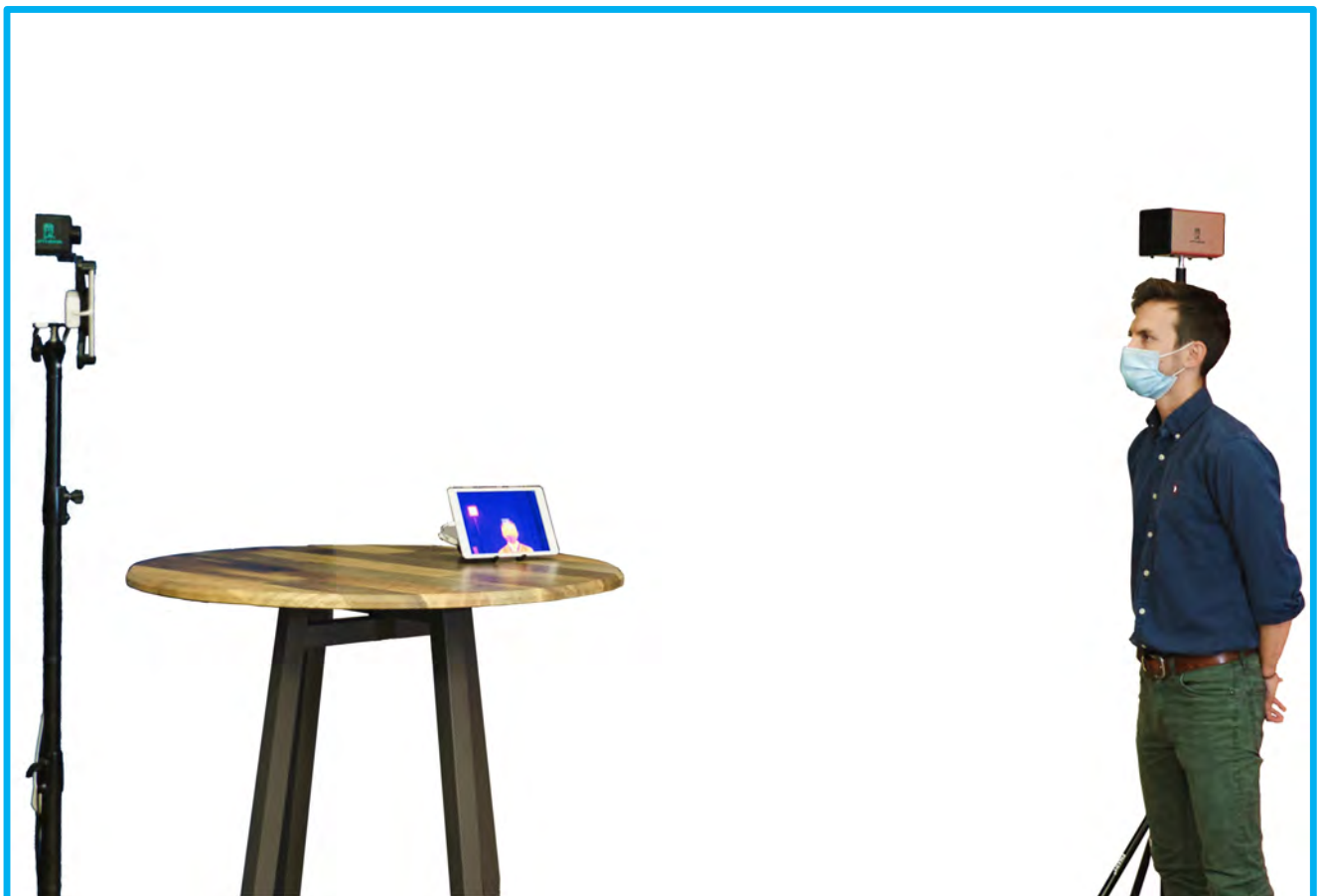
While the FDA has approved IRT for non-medical fever detection, users should be aware of some legal regulations that may be relevant to the use of these systems. The device's collection of personal identifying data may trigger state data breach laws, and businesses utilizing these devices will need to ensure that storage of data is HIPAA-compliant and does not violate the Americans with Disabilities Act (ADA) or other state-specific regulations (Benington et al., 2020). Businesses utilizing these devices should ensure that they are compliant with all relevant laws and regulations.

Whereas there is some evidence that IRT may be less effective at detecting individuals positive for COVID-19 than those infected with other viruses due to a higher rate of asymptomatic cases (Quilty et al., 2020), fever has been found to be a statistically significant predictor of the virus, suggesting that screening for this symptom is worthwhile (Yombi et al., 2020). One small-scale study found that 84% of individuals hospitalized for COVID-19 had a fever, while a slightly higher percentage of febrile individuals were found among hospitalized patients in China (Burke et al., 2020; Silvino et al., 2020). While both studies were conducted from a pool of symptomatic cases, they provide evidence that fever detection may be valuable in identifying infectious individuals. Simultaneously screening for other additional symptoms, such as cough and loss of smell or taste, can result in a high-sensitivity test (Clemency et al., 2020).

Furthermore, while at-home temperature tests and wearables may be mandated by employers, there are currently no viable alternatives to infrared technology for quick, on-site screening. Guidelines from the World Health Organization and public health professionals therefore emphasize the value of using thermal screening devices alongside other methods of screening and preventative measures (Jefferson et al., 2011; Frank, 2020). In particular, when combined with physical interventions such as hand-washing, wearing masks, disinfecting surfaces, and remaining physically distanced from others, screening for probable infections is highly recommended (Jefferson et al., 2011). Public health professionals highlight the importance of preventative measures that curb the spread of COVID-19, which will allow hospitals to adjust and lower the rates of disease-related mortality (Wilder-Smith, Chiew & Lee, 2020). By implementing technology that prevents the spread, businesses can play a vital role in minimizing COVID-19 transmission, keep employees safe, and prevent the need for further economic closures. Ultimately, research suggests that IRT will serve as a powerful tool and valuable component of public health infrastructure as the world adjusts to a new normal.

## Solution

Athena's Elevated Temperature Detection system uses advanced thermal imaging to collect 110,000 possible points of temperature from an individual's facial region, including the inner canthus of the eye. The device can be positioned 6-15 feet away from the screening site, which may be located at a doorway, entryway or chokepoint. The device can detect temperature to  $\pm 0.2^{\circ}\text{C}$ , has drift of 0.1, and users have the capability to set the temperature threshold to their desired point. There is no operator necessary to run the device, and therefore the system does not violate social-distancing guidelines in order to operate. When the system detects a temperature above the threshold, it immediately alerts the designated officials via mobile, browser, email, and SMS, who may then send the individual for further screening.



## Accuracy Tests

In April 2020, a medical study on the effectiveness of Athena's Non-Contact Infrared Thermal was conducted at a hospital in Houston, Texas and published at Cambridge UN. The Athena device was tested against two models of hospital grade contact thermometer, the 2000 and the 5000. A sample of healthy healthcare workers (n=104) was utilized to test the contact thermometers, a smaller sample from the same pool (n=13) was utilized to test the Athena device. Data was collected on two dates, April 8th and April 27th, and an ANOVA and two-sample t-tests were used for the analysis.

In October 2020, Cambridge University Press in Infection Control & Hospital Epidemiology published results from the medical study conducted, titled "Evaluation of a Telethermographic System for Temperature Screening at a large Tertiary Referral Hospital During COVID-19 Pandemic." Please see the research brief [here](#).

In September 2020, a second study was conducted at the same site. Two devices, a handheld tympanic thermometer and a handheld non-contact forehead thermometer (NCIT), were used as a comparison point for the Athena system. Ambient temperature was recorded at 71°F, which falls in the recommended range for optimal performance (Pascoe et al., 2010). A sample of individuals entering the hospital (n=100) were administered the three temperature screenings consecutively by a certified nurse. Additional covariates collected include sex, anti-pyretic use in the last 6 hours, moderate to intense physical activity in the last 30 minutes, and nicotine or caffeine use in the last hour. Paired t-tests and multivariable linear regression were used in the analysis. All analysis was conducted using SAS Studio.



## Results

Figure 1a and 1b (see Appendix A) refer to the April 2020 study and show the temperature by model for each of the three devices as a boxplot and interval plot. The model 2000 and 5000 contact thermometers detected mean sample temperatures of 98.27°F (95% CI: 98.22, 98.33) and 97.81°F (95% CI: 97.76, 97.86) respectively, while the Athena system detected a mean sample temperature of 97.88°F (95% CI: 97.73, 98.03).

The tests found statistically significant differences ( $p < .001$ ) in mean temperature between the 2000 and 5000 models and between the 2000 and the Athena; only the Athena and the 5000 did not display a significant difference in means ( $p = 0.266$ ), suggesting that temperature readings for the two devices may be comparable. For a complete analysis of the results, please read the full study published in the Cambridge University Press.

A larger second study including multiple covariates allowed for more comprehensive analysis. As indicated by Figure 2 (Appendix B), the study sample included 100 individuals, 49% of whom were female and 51% of whom were male. Approximately one-tenth of the sample had engaged in moderate to intense physical activity in the last 30 minutes or taken an anti-pyretic drug in the last 6 hours. Of the participants, 18% had used a nicotine product and 69% had consumed a caffeinated beverage in the past hour (Figure 2, Appendix B).

The Athena device measured a mean temperature of 97.38 (95% CI: 97.03, 97.73). The difference in mean temperature between the Athena and forehead thermometer was 0.5°F, or 0.278°C (95% CI: 0.52, 0.68,  $p < .0001$ ) degrees (Figure 4, Appendix D). While there was no evidence of a significant correlation between the two devices' readings, this may be attributed to inconsistencies in readings from the other devices, the still relatively small sample size, or the absence of febrile individuals from the study. Furthermore, under the assumption that the forehead thermometer produced accurate readings, the mean temperature measurement difference between devices is well within the range of 0.9°F or 0.5°C accuracy that the FDA recommends for telethermographic systems (FDA, 2020).

Additionally, Figure 3 (Appendix C) demonstrates that the Athena device's temperature readings was closest to a normal distribution. While the forehead and tympanic thermometers showed statistically significant differences based on anti-pyretic use and physical activity, respectively (Figure 4, Appendix D), the Athena device did not demonstrate significantly different temperature ranges for any of the covariates. Figure 5 (Appendix E) shows boxplots of temperature range by covariate, with the diamond representing the mean temperature, illustrating the closeness of these measurements even in the presence of potential confounders. This suggests that not susceptible to variation based on individual-level variations as measured by the covariates and that, in correspondence with the literature on thermal temperature detection, it is able to successfully target core body temperature. Based on our data, the Athena device produces readings most consistent from what one would expect from a pool of healthy individuals.





## Discussion

In the first study, the data suggests that the Athena device and the hospital-grade model 2000 contact thermometer produce comparable results. Strengths of this study include the use of two models of thermometer in comparison to the Athena device, which minimizes the likelihood of instrumental error. However, the study involved notable limitations. First, the small sample size limits the power of the study. Second, the use of different test subjects for the three devices prevents us from making conclusive statements about the accuracy and precision of the Athena device. Lastly, the use of different devices of the same model, unless conducted systematically, may have resulted in diagnostic bias. This research brief however was not focused on accuracy as much as it was on efficiency. The hospital ran an investment recovery analysis to better understand how many temporal scanner operators they needed for every thermal camera operator. They concluded that for every six temporal scanner operators they only needed one thermal camera operator. By investing in telethermographic systems, the hospital was able to reduce screening staff from twenty-four to four individuals, resulting in significant cost savings in only months after purchasing the solution. To read a complete discussion on the medical study, [click here](#).

The second study included many strengths, including the use of three devices for measurement and the collection of covariates. The tympanic thermometer was selected based on claims from the literature that they are most accurate for temperature readings following the rectal thermometer. Based on Hausfauter et al.'s recommendations (2008), the study procedure involved taking tympanic measurements from each ear to increase precision of the control measure. Additionally, the forehead thermometer, also known as a NCIT, was selected because it is most often compared to a thermal system as a device for quick temperature screening and fever detection. It is also referenced in CDC recommendations for screening at high occupancy sites (CDC, 2020).

Some limitations in the study design and implementation must be noted. Due to health and safety concerns, febrile individuals were not recruited into the study, which prevented us from conducting analysis on the sensitivity and specificity of the Athena device. The hospital did not permit the collection of age or age ranges as a covariate, which may have allowed for further analysis of its effect on temperature readings. Additionally, the tympanic thermometer performed poorly, registering unusually low body temperatures. To adjust for this, temperatures below 90°F were excluded from the analysis, but this still resulted in low readings. The non-contact forehead thermometer, representing an alternative of quick temperature screening, was therefore used as primary reference. Finally, the sample size was still relatively small, limiting the power for subgroup analysis.

Overall, outcomes of the two studies are supportive of the evidence in the literature that find IRT to be an effective method of temperature screening. While neither the tympanic or NCIT was able to provide a true temperature value in the samples studied, the Athena Elevated Temperature System yielded temperature readings closest to a normal distribution. Additionally, the findings of limited variation based on covariates is promising and confirms the system's ability to detect core body temperature.



## Future Directions

The literature also suggests that an assessment of sensitivity and specificity of the device, including cut-off temperature, is necessary to determine its rate of false positive and false negative results. This would require recruitment of febrile patients, which was not possible for the current study. Wang et al. (2004) also assert that it is important to test a number of key parameters, which include the following:

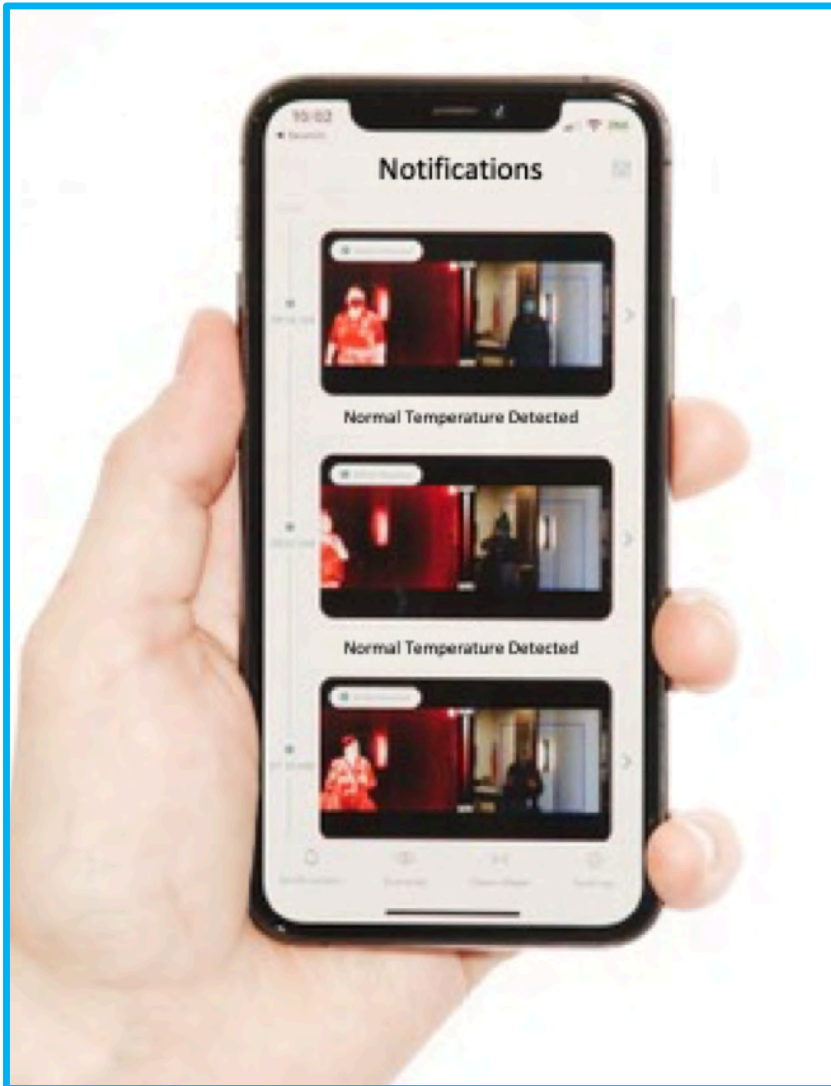
- Drift between self-correction
- Minimum detectable temperature difference (MDTD)
- Non-uniformity
- Distance effect
- Calibration of threshold temperature and its stability
- Spatial resolution

Other research confirms the importance of understanding the effect of ambient temperature and testing the efficacy of the device under various environmental conditions (Liu et al., 2004; Ng et al., 2004; Wong, 2006; Pascoe et al. 2010; Sathyamoory & Yunus, 2011). While the aforementioned studies were only able to test the device under one temperature condition, future studies might evaluate the system's effectiveness in a wider range of settings.



## Conclusion

Thermal imaging technology is a well-tested tool with known strengths and limitations. According to the literature and preliminary tests, Athena's Elevated Temperature System provides an accurate and reliable alternative to NCITs for quick on-site temperature screening to be utilized in office-buildings, hospitals, airports, schools, universities, and other high-traffic spaces. Given the danger of utilizing non-contact infrared thermometers because they do not abide by social distancing guidelines, implementing thermal imaging technology is a safer alternative. For this paper, two sets of studies have demonstrated Athena's effectiveness, by showing its comparability to a hospital-grade thermometer, highlighting its adherence to a normal temperature distribution, and assessing its sensitivity to confounding factors. The Athena Elevated Temperature System is valuable and useful technology in allowing institutions to return to normal while prioritizing safety and reducing COVID-19 transmission.



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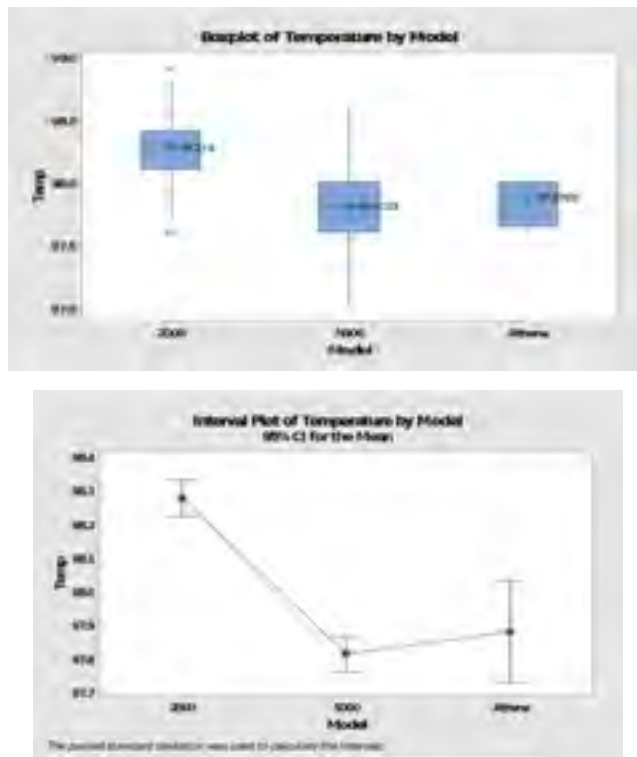
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## Appendix A

Figures 1a and b: Boxplot and Interval Plots by Temperature for April 2020 Study



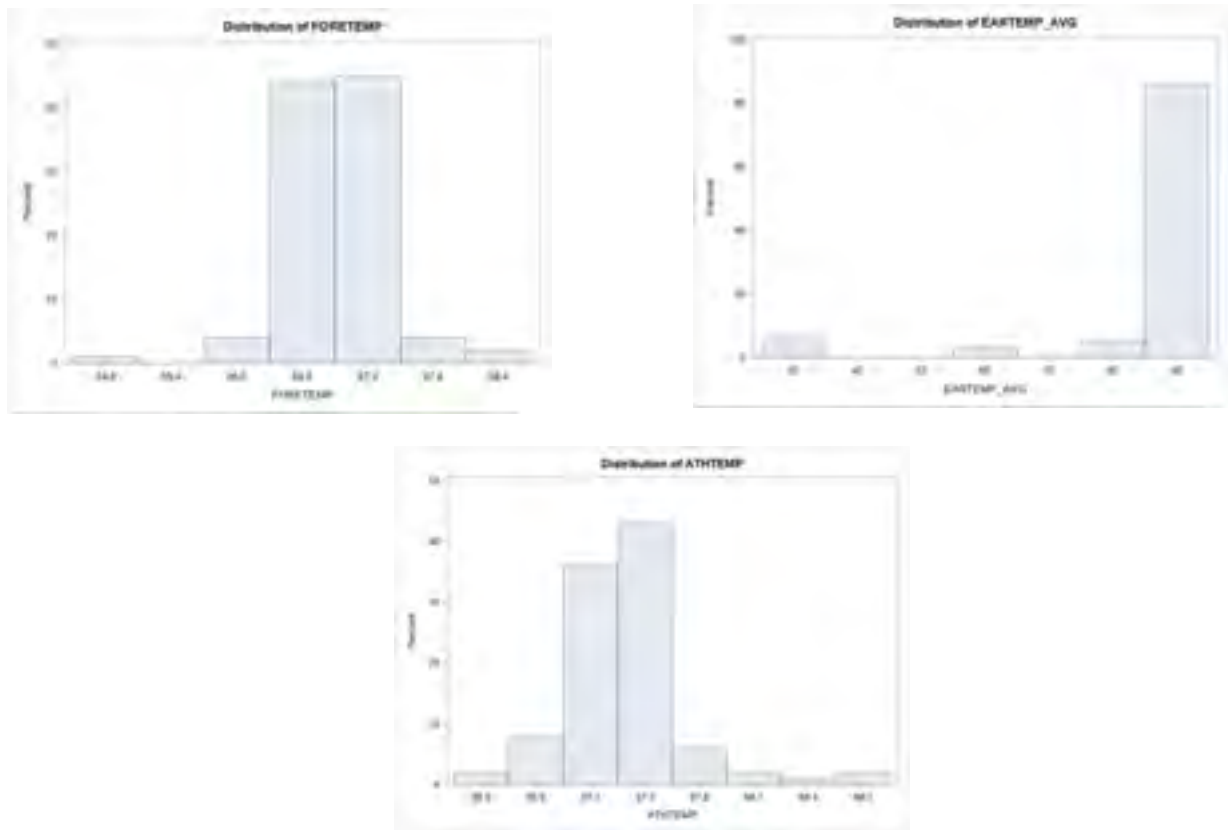
## Appendix B

Figure 2: Sample Characteristics for Sept 2020 Study

Sample Characteristics—No. (%)		
Sex	Female	49 (49%)
	Male	51 (51%)
Anti-pyretic use	Yes	9 (9%)
	No	91 (91%)
Physical Activity	Yes	10 (10%)
	No	90 (90%)
Nicotine Use	Yes	18 (18%)
	No	82 (82%)
Caffeine Use	Yes	69 (69%)
	No	31 (31%)

## Appendix C

Figure 3a-c: Temperature Distribution by Device for Sept 2020 Study



## Appendix D

Figure 4: Mean Temperature Readings by Device and Covariate for Sept 2020 Study

\*Indicates statistical significance at  $\alpha = 0.05$

†Recorded temperatures below 90°F were excluded from the analysis

		Athena (n=100)	Forehead (n=100)	Ear† (n=86)
		97.379 ± 0.351	96.877 ± 0.482	91.737 ± 1.450
Sex	Female	97.400 ± 0.365	96.957 ± 0.463	91.527 ± 1.073
	Male	97.359 ± 0.340	96.800 ± 0.492	91.947 ± 1.736
	p-value	0.560	0.103	0.182
Anti-pyretic use	Yes	97.411 ± 0.145	97.100 ± 0.212	92.414 ± 1.708
	No	97.376 ± 0.366	96.855 ± 0.496	91.677 ± 1.422
	p-value	0.574	0.012*	0.199
Physical Activity	Yes	97.350 ± 0.118	96.800 ± 0.414	93.140 ± 2.265
	No	97.382 ± 0.368	96.886 ± 0.490	91.552 ± 1.213
	p-value	0.553	0.597	0.055*
Nicotine Use	Yes	97.517 ± 0.409	96.917 ± 0.411	92.147 ± 1.364
	No	97.349 ± 0.332	96.868 ± 0.498	91.643 ± 1.462
	p-value	0.066	0.702	0.212
Caffeine Use	Yes	97.322 ± 0.368	96.929 ± 0.343	91.867 ± 1.294
	No	97.404 ± 0.342	96.854 ± 0.533	91.667 ± 1.534
	p-value	0.284	0.399	0.546



## Appendix E

Figure 5a-e: Boxplots of Athena System Temperature Reading by Covariate for Sept 2020 Study

