Development of a Temperature Sensitive Face Mask for Identification and Triage of Febrile Patients

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Annemarie Daecher,[1] Flemming Forsberg,[1] John R. Eisenbrey[1]
[1]Department of Radiology, Thomas Jefferson University, Philadelphia, PA 19107, USA

Abstract

Many infectious diseases are most transmittable when the carrier is presenting with fever. We propose a disposable face mask that changes color as an indicator of fever to provide hospitals with a quick and inexpensive method for triaging infected patients while limiting exposure to others. Two blue thermochromatic dyes which transition to white at 89°F and 92°F were mixed with white paint and applied to 5 types of disposable face masks. During trials, a wearer either sat at rest or ran on a treadmill for 20 minutes and images were obtained every 5 minutes with a thermal camera to record surface body temperature. At rest there was no change in body temperature or in mask color. After 20 minutes of running, a 5°F increase in surface body temperature was measured. Only the mask created with the 89°F dye showed a color transition with large white areas apparent post-run. This indicates the ability of thermochromatic masks to measure body temperature and potentially identify febrile patients.

Background

Acute respiratory infections kill about 3.9 million people per year, making them one of the top five leading causes of death worldwide.[1] One of the main symptoms of infection by any viral or bacterial pathogen is fever and it is during this time that the infected patient is most likely to pass on their illness to others. Therefore, it is critical that hospitals have a way to quickly identify infectious patients while still limiting exposure to non-infected patron and staff. Additionally, with the discovery of over 40 infectious diseases since the 1970s and an increase in international travel, the exchange and spread of infectious diseases are at an all time high.[2] Therefore, screening contagious individuals in airport and immigration settings to limit influx is essential. Determining fever using conventional methods (thermometer, vital signs, etc.) does not limit exposure to healthcare workers and other patients to the potential infectious agent. Direct, or even close, contact with a patient while in a communal waiting area or while attempting to perform a temperature reading risks infection to healthcare patron and other patients.

Sterile face masks are an inexpensive and effective commercially available mechanism for reducing viral transmission by limiting transmission of airborne particles and water droplets from coughing and sneezing. It is currently common practice to issue PPE (personal protective equipment) to patients with a confirmed fever and with suspected transmittable illness. Therefore, a face mask that can diagnose fever through a visible color change eliminates the risk associated with contact while providing information necessary for proper diagnosis and treatment.

Materials and Methods

Multiple prototypes were designed using 5 styles of disposable face masks and two temperature sensitive paints. Two blue thermochromatic dyes were purchased, with designated color transition points (blue to white) of 89°F and 92°F. Thermochromic pigments are colorants that change or lose color due to changes in external heat stimuli.[3] Therefore, incorporating these pigments into face mask fabric would give rise to an important diagnostic tool.

All experiments were conducted in rooms at 68°F. Five grams of dye was added to 100ml of white paint before being applied to each mask. After application and drying, the ability of all colored masks to turn from blue to white was confirmed by heating with a hair dryer; *Figure 1*.

Dual-tie masks were then selected for use in proof of concept studies. Skin temperature was monitored using a thermal camera. The first set of experiments consisted of the wearer sitting in a resting position for 20 minutes with images and temperatures obtained every 5 minutes. The second set of experiments involved the wearer running on a treadmill for 20 minutes with images and temperatures obtained every 5 minutes.

Materials and Methods (continued)

These experiments were repeated for both the mask created with the dye that transitions at 89°F and the mask created with the dye that transitions at 92°F. Changes in body temperature and changes in mask color were then compared.

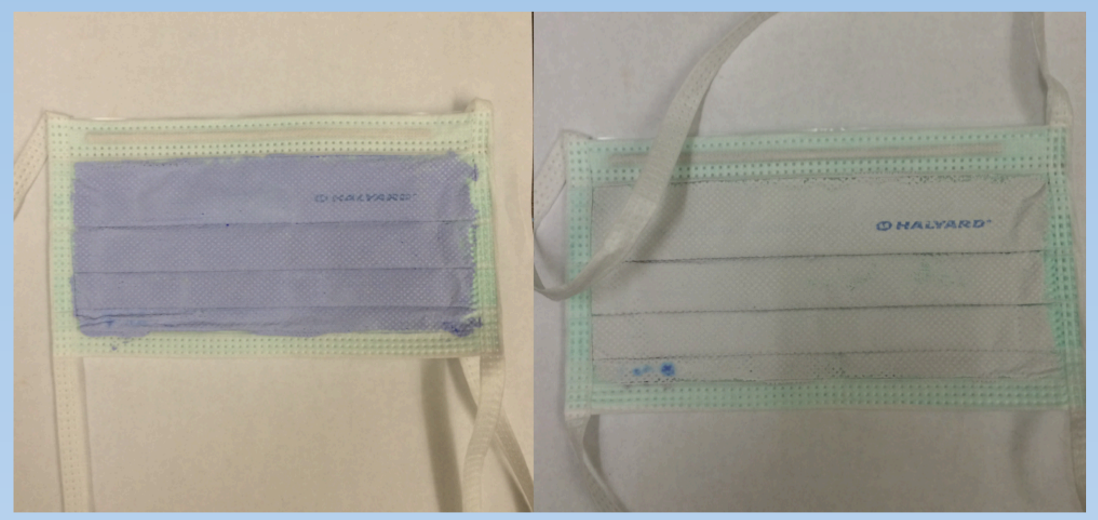

Figure 1: Temperature sensitive mask created with thermochromatic dye with a transition point at 89°F shows clear color transition from blue (left) at room temperature (68°F) to white (right) after heat from hair dryer was applied.

Results

At rest, there was no change in the wearer's body temperature and neither the mask made with 89°F dye nor the mask made with the 92°F dye changed color; *Figure 2*. After the wearer ran on a treadmill for 20 minutes, a 5°F increase in surface body temperature was measured but only the mask created with the 89°F dye transitioned from blue to white, with large white areas around the nose and chin apparent post-run; *Figure 3 and Figure 4*. This change in color was not observed when the wearer ran for 20 minutes with the 92°F mask.

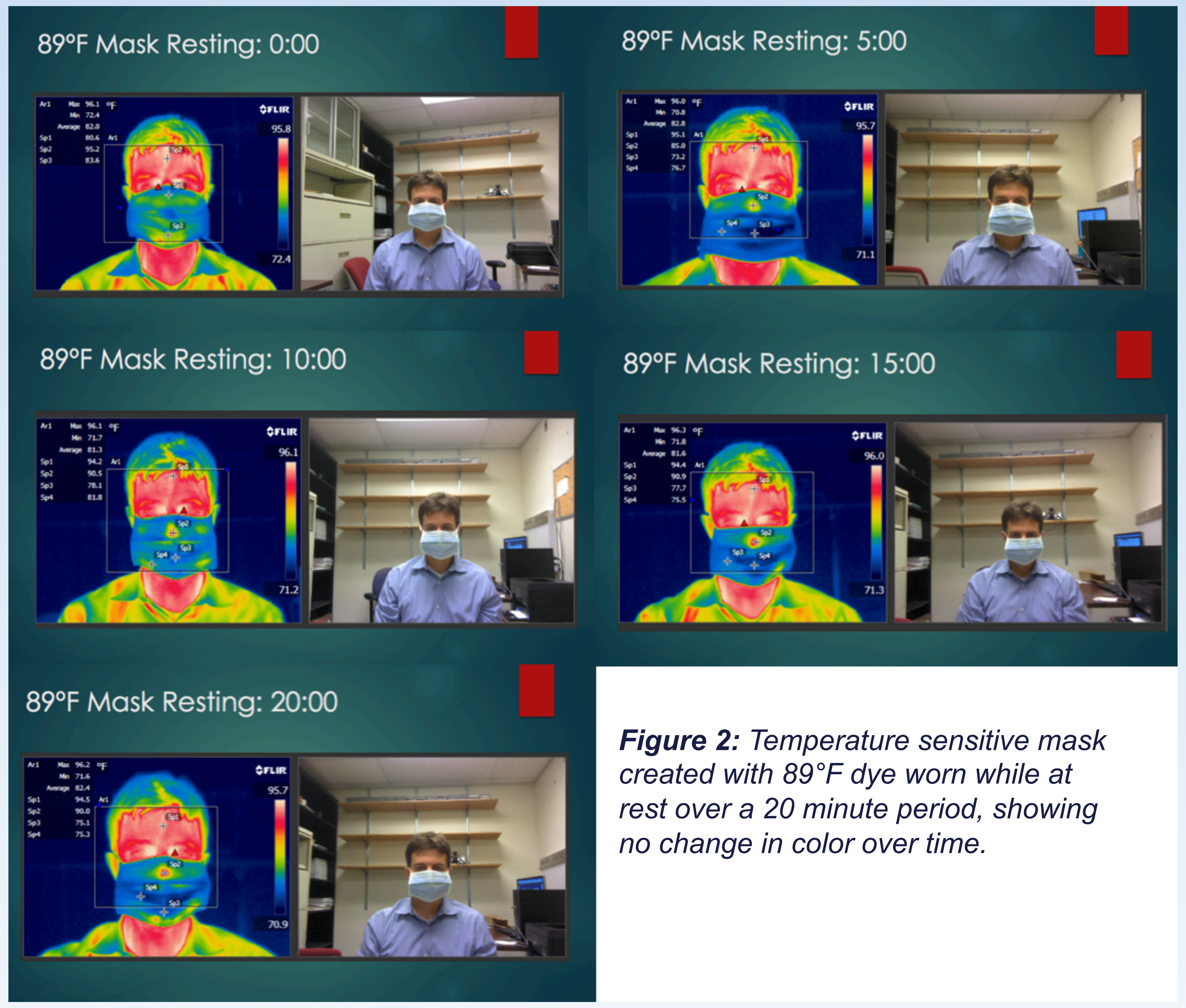

***Figure 2:** Temperature sensitive mask created with 89°F dye worn while at rest over a 20 minute period, showing no change in color over time.*

***Figure 3 A)** The 89°F mask before the wearer runs is a dark blue color and **B)** post-run the 89°F mask fades in color overall with clear/white areas forming between the flaps and around the chin and nose.*

Results (continued)

***Figure 4:** Temperature sensitive mask created with 89°F dye worn while running, showing increasing color change from blue to white in response to increasing skin temperature. An increase in mask temperature using the thermal camera was also apparent.*

Conclusions

Our results demonstrate the feasibility of developing a face mask that remains one color when worn by a non-infected patient with a normal body temperature, and transitions in color when worn by a patient with an elevated body temperature. Such a device would enable faster triaging of infectious patients, reduce infection from patient to patient in a crowded setting, and reduce risks of infection to the clinical care provider. The inexpensive and disposable nature of the device would be especially beneficial to understaffed and impoverished areas where immediate isolation facilities are not available. Future work will focus on the use of red face masks with the same thermochromatic dye (that transitions from blue to white) to accentuate the color change from blue at normal temperatures to red at elevated temperatures. Additional trials will also be done to create masks that can be used in varying environments, since this technology proves beneficial for both hospital environments and warmer, impoverished areas affected by pandemics. Pilot studies will also be conducted to identify patients with fever.

References

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