# Detecting A H1N1 in Tocumen International Airport in Panama

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## ABSTRACT

During the SARS (Severe Acute Respiratory Syndrome) epidemic, IR cameras first began to be used in several international airports. The mistakes made during this first phase of implementation have yielded many valuable lessons. Although detecting fever with an IR camera is a viable technique, certain procedures must be consistently followed to obtain a reliable temperature measurement.

In this article, we will examine the implementation process along with applicable ISO standards, and evaluate the results of passenger screening in the Tocumen International Airport in Panama. Passengers were screened with IR cameras in order to detect elevated body temperature, which can serve as an indicator of potential H1N1 influenza.

## INTRODUCTION

By June 24 of 2009, at least 238 fatalities had occurred worldwide as a result of a new pandemic strain of H1N1 with 55,867 confirmed cases. The daily data published by WHO indicated that the number of patients was doubling each day in some countries.

*Figure 1: Influence Case Map A (H1N1) -Shows the distribution of cases across the world. (Source: WHO)*

## WHAT IS H1N1?

H1N1 (also known as swine flu) is a respiratory disease of pigs caused by influenza virus type A. The swine influenza virus has a high infection rate in pigs, but mortality rates are low. Although the virus can spread among pigs throughout the year, most outbreaks occur in the final months of autumn and winter—as is true for outbreaks in the human population.

Like all influenza viruses, swine influenza viruses are constantly mutating. In addition to swine influenza virus, pigs can also contract avian and human influenza viruses. When present in a single host, these viruses can exchange genes and create a new virus, with comingled characteristics. Currently, there are four main subtypes of influenza virus type A isolated in pigs: H1N1, H1N2, H3N2, and H3N1 with the H1N1 the most common in recent years.

There are sporadic swine flu outbreaks in the human population. In general, these cases occur in people who have direct exposure to pigs (children who show or interact with pigs at fairs or workers in the swine industry). In addition, it has been documented that people can pass the virus on to other humans through contact—exposure to infected droplets expelled by coughing or sneezing or through contact with contaminated hands o surfaces. The signs of influenza A (H1N1) are typical of influenza, i.e., fever, cough, headache, muscle and joint aches, sore throat, runny nose, and sometimes vomiting and diarrhea.

## WHY EARLY DETECTION IS CRITICAL

In these new influenzas with genetic mutations, epidemiological history is scarce, and unfortunately, the aggressiveness and virulence with which they can spread are not yet known

However, according to the 2005 International Health Regulations for health events of international concern, each country has an obligation to ensure the prevention and manage the control of epidemic cases to prevent the spread of the disease over international borders.

Obviously, a great need exists to establish mechanisms, processes, procedures, and diagnostic support tools that are effective, efficient, and yet do not seriously impede the flow of traffic in highly congested public areas. Classic screening questionnaires in public health rely on a series of questions aimed at detecting signs and symptoms, which are, of course, only as accurate as the validity and honesty of the answers given. The value of an impartial evaluation tool that can detect possible symptoms is obvious.

One such tool is infrared thermography, extremely useful because it allows us to monitor a large number of people, excluding, or verifying the existence of fever (T> 37.8 º C) in a short time while not hindering the smooth flow of passengers in public settings. Thermal imaging can measure temperature without contact and is non-invasive.

Infrared cameras detect infrared radiation (above the spectral red) and convert it to temperature using compensation parameters. The most commonly used IR cameras in the field today rely on microbolometer detectors that allow small size and efficient energy consumption. The ideal spectral range for an IR camera for such medical applications is the longwave infrared waveband of 7.5 to 13 microns.

The image produced by a thermal imaging camera is two-dimensional with each point of the image containing temperature data. Generally speaking, in order to determine whether the target area under study has a high or low temperature, cold temperatures are shown in dark colors and high temperatures in brighter colors. According to ISO 13154, diagnosis using infrared cameras can be affected by "... lack of sensitivity (asymptomatic infected individuals may not be identified) or specificity (for example, many individuals suffering from something like influenza could not be infected with a pandemic strain). The typical incubation period for influenza is two days, and infected persons are contagious 24 hours before the onset of symptoms. Other potential pandemic diseases have incubation periods more extensive. In addition, an asymptomatic traveler may become symptomatic during the course of his journey. The effectiveness of exploration could be improved by adopting measures of observation during the pre-boarding, travel, and landing processes. A policy of screening measures by levels should apply to all incoming travelers coming from affected areas. Note, however, that the characteristics of the outbreaks, including its dizzying spread, would necessitate the implementation of this detection or scanning in all international airports, where departing passengers could just then be exhibiting symptoms.

ISO recognizes that IR cameras can be extremely useful in helping to prevent pandemics by isolating potential infected individuals not only in airports, but also in:

- Entries of hospitals and clinics, including the emergency room
- Entrances to workplaces, public buildings, and schools
- Entrances to transportation

The use of an IR camera to detect people with an epidemic disease is just the first layer in the multiple levels of detection that should be used in isolating an individual with potential fever. Later in this article, we will examine the detection levels used at Tocumen Airport.

## FACTORS AFFECTING MEASUREMENT

Infrared cameras can receive radiation from a wide array of sources other than human face, the desired object in a health screening test, including other faces, bright lamps, nearby furnaces or boilers, and highly reflective surfaces. All of these sources of infrared radiation can affect the accuracy of the assessment. Ideally, the IR camera operator should have a basic understanding of thermography principles.

In order to get accurate measure of facial temperature, several camera parameters must be set. The emissivity range should be set between the value for the human body in dry conditions, 0.98, and the value for reflected radiation in the background (based on reading of aluminum foil-coated target) at 1.0. Note that the parameter set for the body temperature of the screened individuals may need to be adjusted for environmental factors including air conditioning or high ambient temperatures. The ISO study recommends an ambient temperature level in the location of the IR camera test of 20-24 C and a RH of 10 to 50%.

This variability in human body temperature is perfectly illustrated by our sampling of individuals at Tocumen Airport. Fifty-eight people were scanned: twenty crew members and thirty-eight passengers. The crew members had an average temperature of 35°C while the passengers had an average temperature of 35.85°C. We selected the passenger temperature average to be our base-line temperature parameter input value.

This difference between crew and passenger temperatures can be explained by the fact that the crew exits the plane last and remains in the air conditioned cabin environment longer. They also arrive at immigration more quickly than the passengers who tend to make a stop or two along the way. It therefore seems reasonable that the average crew arrives at the screening area with a lower body temperature than the passengers. It is important to make a correction to the alarm or threshold value for the crew cases if they are evaluated with the same IR camera.

Our recommendation is to have a person certified in infrared thermography to ensure the process of thermal evaluation is implemented correctly, accounting for as many variables as possible.

## DETERMINING THE TARGET

IR thermography is a surface measurement technique. Therefore, to measure body temperature accurately we have to determine which areas or points on the body will be most effective to measure. Doctors usually take temperature measurements in these areas:

a. Under the forearm: For practical and modesty reasons, we cannot ask people to leave the area exposed and it would slow the inspection process to ask them to reveal that area in private.

b. Within the ear canal (tympanic membrane): As shown in this figure, this area is almost within the body, and near several arteries that flow to the hypothalamus, which regulates body temperature, making it one of the best places to measure temperature. But with an IR camera, we only see the outside of the ear canal.

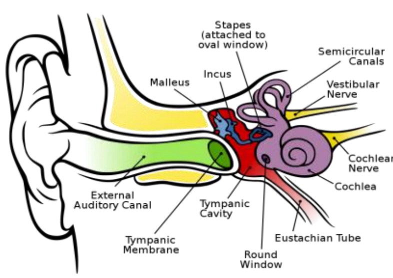


*Figure 2: Human ear.*

c. Corner of eye: This area is close to both the brain and hypothalamus, with a number of arteries and blood vessels. It is under constant irrigation, moist, and an ideal area to measure body temperature although the target size is only 5-6 mm.

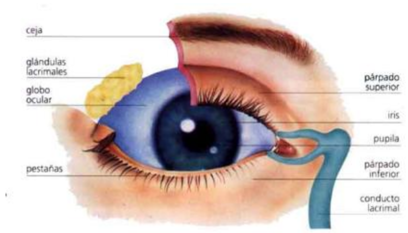


*Figure 3: Corner of the eye.*

To inspect passengers quickly in a stable area of temperature, it was decided to measure at the corner of eye.

## SELECTION OF INFRARED CAMERAS

Not all cameras have the technical features to give good results for detection of H1N1. The following points describe the technical parameters required.

**NETD (Noise Equivalent Temperature Difference)**

The NETD, also known as thermal resolution, defines the smallest temperature change in the object that the camera can measure. It is closely related to the thermal sensitivity of the camera, for example an NETD of 100 mK (0.1°C) means that the camera can depict temperature differences of 0.1 C; if less than this, the camera does not see it, and it results in thermal noise.

NETD is related to the cost: the smaller the value of thermal sensitivity, the better the instrument, and the higher the cost. As a recommendation, it is not necessary to have IR systems with extremely high sensitivity for this application. A camera with a NETD of 100 mK (0.1 º C) is sufficient for the application under discussion.

**Spot Size Ratio**

Currently, the vast majority of cameras on the market use Focal Plane Array (FPA) technology formed by an array of detectors. Available resolutions generally range between 120 x 120 and 640 x 480 pixels. Each pixel of the camera receives infrared photons that are converted to temperature values.

The combination of the number of pixels and the lens used (field of view) form the Instantaneous Field of View (IFOV). The IFOV corresponds to the smallest object that the camera can see or observe, not necessarily measure. An analogy would be a page of song lyrics: the IFOV is the distance from which the human eye can discern that what is on the page is writing, but cannot read the words of the lyrics. We need to know the minimum size of the object that the camera can see in order to accurately measure temperature. This parameter is called the Measurement Field of View (MFOV).

The actual size of measurement is larger than the IFOV, for bolometer cameras typically 3 to 5 times larger. There are two main techniques to obtain this information: the SRF (Slit Response Function) and HRF (Hole Response Function), with the latter used in FPA cameras.

For the detection of swine fever, knowing the camera SSR is a critical. It must be close enough to measure the target. Too great a distance will result in an inaccurate measurement.

In our study at Tocumen, we used T-Series cameras made by FLIR Systems that met the minimum required resolution with an SSR of about 120 / 180 to 1 and a thermal sensitivity of 0.1°C to 0.08°C.

*Figure 4.T-series camera in action.*

## CAMERA POSITIONING

Tocumen Airport in Panama is a hub for Copa and Continental Airlines, with a monthly traffic rate of about 900,000 passengers at its peak season. At the time of the test, it had two immigration areas, North and South.

According to Airport Authority:

1. The cameras had to be positioned to give free incoming passenger flow.
2. There had to be an exclusive camera for diplomats and crew.

It was therefore decided to place two cameras in every area of immigration. A total of four cameras were needed.

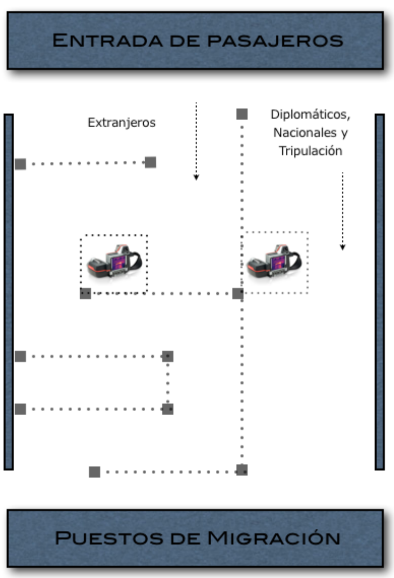


*Figure 5: Flow of passenger entry and positioning of cameras.*

Initially, tests were conducted in the north area to work out logistics such as availability of continuous power to the cameras, positioning with respect to the entry of passengers, to evaluate the passenger's flow, to verify results, and to train staff.

All cameras were mounted on professional tripods to adjust to the height of the passenger. An area was marked on the floor in front of the camera where the passengers were to stand. This area met the requirements of ideal SSR for the camera and the size of the target (inside corner of the eye.) Passengers were asked to look straight into the camera, pausing for 10-15 seconds, in order to allow the inspector to determine if the passenger needed to be examined by a nurse or doctor in another location. It is vital that the passenger does not wear glasses (they are opaque to infrared), hats, or scarves that interfere with the direct view of the eyes.

Airport staff created a banner (in accordance with our suggestions) to guide the passengers, explaining the test procedure before entering they entered the immigration line.


*Figure 6: Passenger flow and camera positioning*

## VERIFICATION AND TESTING

Similar to previous studies (Cronholm, 2004), we compared the results obtained with the infrared camera (in the corner of the eye) with those derived from an ear thermometer. Our test at Tocumen showed virtually the same results as the Cronholm study, with the ear thermometer temperature reading 0.9° C to 1.0°C higher than the IR camera temperature

As discussed previously, our base-line temperature of 35.85°C was taken from the 38 passengers (not crew).Therefore, our alarm threshold was placed one degree higher due to the difference with the ear thermometer at 36.85 C. (This difference is approved by WHO.)


*Figure 10: Correlating data – article authors.*

If an elevated temperature was detected with the IR camera, it was verified with a tympanic thermometer. The IR camera was operated by trained staff and the high temperature verification was conducted by doctors and nurses well-versed in infrared tympanic thermometer technology.

## TRAINING

During the implementation process, a Level 3 thermal imaging specialist was present to advise us the following matters:

1. Determining the positioning of the cameras with airport staff and marking the optimal distance between the camera and the passenger.
2. Setting the alarm threshold by determining desired measurement area and adjusting isotherm parameters. They also set the appropriate level and span in order to see heat differences more clearly.
3. Training Ministry of Health of Panama on-site personnel to operate the cameras.
4. Defining a protocol to get people to remove at risk individuals from line.
5. Training local technical personnel to support as necessary.

## ACTIONS TAKEN FOLLOWING DETECTION OF FEVER

Once a fever was verified, epidemiological data was collected and the traveler sent to the primary care clinic at the airport to be assessed by medical health professionals of the Ministry of Health.

Samples were taken from nasopharyngeal swabs, which were sent Gorgas Memorial Center laboratory, where ELISA tests were performed to confirm the presence of the new viral strain H1N1. Contact details of the patient were recorded and attached to the lab samples so that passengers could be notified of the results.

If passenger/patient presented only with fever and no respiratory distress, they were sent to their final destination in either Panama City or in another country with general health recommendations, supplied with N95 masks for their travels, and recommended to auto quarantine once home. Travelers/patients who presented with both high fever (> 38.5ºC) and respiratory distress were sent under strict sanitary standards to a hospital designated for health emergencies. At the hospital, they were isolated in intensive care units and treated with oseltamivir.

## STATISTICS

As of June, 1st of 2009:

| ***Screened Passengers with IR camera*** | ***Positives with Fever*** | ***False positives verified with tympanic thermometer*** | ***Positives with A H1N1 (after performing the ELISA test)*** |
|---|---|---|---|
| **23675** | **124** | **18** | **86** |

* A couple of week's data

## CONCLUSIONS

1. The H1N1 influenza has become an emergent disease in epidemiological surveillance plans.
2. The H1N1 virus is a mutation of seasonal influenza A viruses, which includes genetic material from three serotypes of influenza: fever, avian and human.
3. To date, virulence has been high, but mortality has been low.
4. However, mortality rate is expected to get worse in the last quarter of 2009.
5. The speed of movement between countries today allows the spread of the virus to spread much faster than in past years of the great influenza pandemics o (1918, 1965, etc)
6. The use of infrared technology is of vital importance in the early detection of primary symptom of respiratory infections such as influenza, fever.
7. In the Tocumen study, the IR camera was able to quickly and reliably detect changes in body temperature of passengers. The success ratio was close to 70%.
8. The quick results provided by thermography are very useful for the early identification of persons with suspected cases of febrile influenza.
9. The percentage of false positives verified with tympanic thermometer was low.
10. The infrared camera was an efficient and effective tool in the detection of fever in passengers at the Tocumen International Airport, decreasing the probability of entry of people suspected of carrying H1N1 to the country. The use of thermal imagers avoided unnecessary interruptions in the free traffic

at the immigration area, deemed critical by International Health Regulations in order to avoid security surveillance issues.

## ABOUT THE AUTHOR

JC is a graduate of the University of Costa Rica with a BS in Electrical Engineering, and a Masters in Business Administration from the Costa Rica Institute of Technology. He has over 16 years of experience in infrared thermography applications and training. He became involved with infrared in 1994. He founded TERMOGRAM, a Central American Company, a leader in condition monitoring in 1995. He is an ITC-certified Level III thermographer and an ITC-certified Level I thermography instructor. He has taught many IR courses in Latin America and is very involved in developing new applications.

He is currently working with Ad Astra Rocket and the Ross Foundation in Costa Rica on a project to use IR thermography for breast cancer diagnostics and some other medical applications.

He has published technical papers on infrared thermography, vibration analysis, and electrical motor testing applications for ITC newsletters and IEEE.

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