Retrospective Analysis Using a Thermal Scanner  H1N1

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Presentation Outline

- Background
- Types of Screening
- Screening Thermography
- Issues Considered Screening
- Advantages /Disadvantages Thermal Scanners & Questionnaires
- Literature Review
- SA Experience : Methodology
- Challenges and Limitations
- Conclusion
Methods of Screening

- Questionnaires
- Visual Inspections
- Thermal Scanners
- Physical Examinations
- Interviews
OR Tambo Int, major travel hub, serving an estimated 17 million passengers annually.
State of Public Health System—Overwhelmed
HIV PREVALENCE IN SA ESTIMATED AT 11.4%-5.8 m in 2007

WHO/UNAIDS
December 2009

Total: 33.4 million (31.1 – 35.8 million)
Increased Number of Refugees
2010 SOCCER WORLD CUP
Increased Number of Passengers 2010
2003: SARS
The association between disease and temperature recognized.

The usefulness of scanners at airports has been a matter of debate for years - SARS-Canada-questionable

Thermal imaging has been promoted as a way to protect the public

Hopefully, delay the introduction of the virus into a country during a pandemic

The International Electrotechnical Commission (IEC) standardization scanners.
Screening Thermograph

- Short-wavelength infrared radiation band.

- Based on the Stefan-Boltzmann Law

- Provide a relation between the emissive power and temperature.

- An IR camera focuses the infrared energy emitted by an object on a detector

- The emitting property of the object is described by its ‘emissivity’.
Issues to be considered

- Sensor Distance

- Ambient temperature: a temp range of 18 °C to 24 °C

- Humidity: if exceeds 50%, accuracy may be degraded as passengers will be sweating

- Environmental infrared sources such as sunlight, nearby electrical sources, and lighting should be minimized.

- Object temperature

- Emissivity of the object & Transmittance of the air
PLEASE STAND WHERE INDICATED ON THE FLOOR. PLEASE REMOVE YOUR GLASSES!! LOOK UP AND DIRECTLY INTO THE CAMERA. POSITION YOUR FACE INSIDE THE GREEN BOX. THANK YOU. PLEASE PROCEED
The targeted area scanned by the detector plays a role due to:

- Physiological difference in vasculization.
- Consequently in heat distribution.
- The inner eye corner or the auricular area are less subject to variation, more reliable.
Screening Thermograph

- Skin Temp - Skin blood perfusion & environmental conditions

- The relationship - elevated skin temperature & febrile body core temperature is not well established

- Difficulty in determine core temp accurately by infrared measurement of skin temperature.

- The relationship can be further complicated by perspiration, facial skin flushed from exertion, etc.

- Suspected febrile cases with Thermal Scanner-Screening

- Confirmed with a 2nd screening with a clinical thermometer
Issues for Consideration

- Silently incubation of the virus, passengers not symptomatic-inflight-Short vs Long Incubation Period
- Taking antipyretics to ease the symptoms or evade the detection-Vietnam Publication-2009
- Passengers may have other symptoms (e.g. cough, etc), but not fever
- Asymptomatic carriers of the virus
- Flight Time (e.g. Incubation for H1N1 2 days, if flight time is shorter, passenger may still not be symptomatic at the time of destination.
- Most Influenza viruses have an incubation period of 1-4 Days
- Most flights in Mexico in 2009, took 12 hours

- Exit vs. Entrance Screening (Benefit to the international community vs individual affected country)
- Consumption of hot beverages.
- Menstrual Period – Temp rises sharply after ovulation due to hormonal changes
- Hormonal Treatment-Raises temperature by 0.6°C
- Age
- Pregnancy

Example (Reuters Report)-Vietnam Discover Passengers Beating Thermal Scanners-Took Aspirin, Tylenol, etc several hours before arrival.
Issues for Consideration

- Sweat-Humidity is known to be a factor affecting emissivity.
- Cosmetic makeup – may probably reduce the emissivity
- Contour-An area with a concave geometry - greater emissivity.
- Skin complexion - a darker skin MAY have a greater emissivity
- Jet Lag/Shift Work-Affects Temperature
- Outdoor Temperature
- Humidity
- Surrounding Temperature System (e.g Equipment Surrounding the Thermal Scanner)
Advantages/Disadvantages Thermal Scanners

**Advantages**

- Temperature displayed within seconds
- Non-Invasive
- Groups
- Reduce close contact with infected person
- Psychological re-assurance of the public

**Disadvantages**

- Low sensitivity.
- Space Requirement/Human Resource
- Public may lose confidence-if it is unable to identify suspected case.
- Calibration & Trained Staff
- 2nd Assessment of Temperature
- Costly to maintain
- The outcome is influenced by many factors
Advantages

- Large amounts of information can be collected from a large number of people in a short period of time and
- Relatively cost effective way
- Can be carried out by the researcher or by any number of people with limited affect to its validity and reliability
- The results of the questionnaires can usually be quickly and easily quantified by either a researcher or through the use of a software package
- Can be analyzed more 'scientifically' and objectively.

Disadvantages

- There is no way to tell how truthful a respondent is being
- There is no way of telling how much thought a respondent has put in.
- Asks only a limited amount of information without explanation
- Is argued to be inadequate to understand some forms of information - i.e. changes of emotions, behavior, feelings etc.
- Lacks validity
Advantages/Disadvantages Interviews & Physical Exams

**Advantages**
- Most likely to obtain accurate information
- Answers can be explored in detail

**Disadvantages**
- Time consuming
- Costly
### Entry screening – search for febrile international passengers.

- **Sensitivity of fever for detecting H1N1–2009 case upon arrival was estimated to be 22.2%**
- Sensitivity and specificity of scanners in detecting hyperthermia ranged from 50.7–70.4% & 63.6–81.7% respectively.
- Sensitivity of fever (38.0°C) for detecting HINI was estimated
  - **Positive Predictive Value found to be low, at 37.3 – 68.0%**
- **Diagnostic performance of thermal scanners in detecting fever at cut–off level 37.5°C, 38.0 & 38.5 were estimated**

### Limitations
- **Identified**
## Singapore–Travel Associated H1N1–2009

<table>
<thead>
<tr>
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<th>Results</th>
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<tbody>
<tr>
<td>In 2009, Singapore PHO implemented a containment plan</td>
<td>Only 12% case patients were detected by the thermal scanner</td>
</tr>
<tr>
<td>Passengers arriving at Int. Airports, underwent thermal scanning.</td>
<td>Suggested that thermal scanner detected 40% of those symptomatic patients.</td>
</tr>
<tr>
<td>All passengers with influenza-like symptoms were referred</td>
<td></td>
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<tr>
<td>To a designated screening center for treatment and isolation.</td>
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<td>Investigators reported the 1st 116 patients hospitalized with travel associated H1N1 infection</td>
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<tr>
<td>Confirmed using PCR on respiratory samples</td>
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## New Zealand

### Results

| Screening was initially applied to all passengers using Visual Inspections, Questionnaires, Passenger Locator Cards, etc. | April–June–2009–International Airports (n=456518). |
| Initially focused on passengers from affected countries. | No identified as symptomatic and referred was 406 (0.09%). |
| All flights had to notify NZ before landing on passenger & crew health. | ILI case definition met, swab taken & traveler isolated, 109 (27%). |
| Aircraft was met by PHO who triaged the suspected cases. | Swab results obtained 89 (82%), and those lost were 20 (18%). |
| PHO were stationed at a checkpoint, visual inspection for all passengers took place. | No not identified as symptomatic was (297). |
| | Swab RT–PCR Positive: n=4 (4%) and Swab RT–PCR Negative H1N1 n=85 (96%). |

### Conclusion

- Screening programme had a low sensitivity.
Aim of the Survey

- Analysis of a % passengers who were detected by thermal scanner & followed-up and confirmed to have febrile core temperature.

- Determine a % of passengers detected by the scanner who tested positive for H1N1.

- Establish the average difference between core and scanner temperature.

- Sensitivity of fever(38.0C) for detecting H1N1 was estimated

- Diagnostic performance of thermal scanners in detecting fever at cut-off level 37.5C, 38.0
Analysis in SA Using Thermal Scanners

- Entrance Screening for all International Passengers-June-August 2009

- Absolute minimum and maximum limits that were entered by the Scanner manufacturers
  - Min = 36.0°C
  - Max = 38.0°C

- Software programmed to calculate the standard deviation of the last 50 consecutive passengers’ temperatures

- Other public health measure such as questionnaire and 2% physical examinations by nurses introduced
All passengers arriving from International Arrivals O.R. Tambo Airport July & August 2009 identified by the scanner =820

Inflight announcement, locator card completion, travel advisory information, self-presentation and/or aircraft met at gate

Confirmed by a clinical thermometer as Febrile after being picked up the scanner n = 70

Core Temperature not febrile. N = 750
All passengers identified by scanner, completed a questionnaire

ILI case definition met: taken and traveler isolated
N = 248
Further physical examination.

ILI case definition not met: Discharged
N+ 572

Swab results obtained
N = 35

Swab Positive for H1N1
N = 13

Swab Negative for H1N1
N = 13

Majority of the cases were referred to GP management of other conditions
N = 213

Other Diseases
N = 4:
Retrospective Analysis H1N1

- Large no of passengers detected by scanner as having abnormal temp.
- This is attributed temp setting on a scanner as minimum temperature.
- Estimated 36 passengers are detected daily by the scanner.
- Difference between Scanner & Core was 0.3
Analysis of Data SA–2009

Core Temperature & H1N1

Specificity = 55%

Sensitivity = 80%

Limitation

- Scanner Set-Up–Inter-scanner variability
- Unknown number of passengers on anti-pyretics.
- Cofounding factors were not taken into consideration
Analysis of Data SA–2009

SYMPTOMATOLOGY

<table>
<thead>
<tr>
<th>TOTALS</th>
<th>PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTHER</td>
<td>20</td>
</tr>
<tr>
<td>URTI</td>
<td>33</td>
</tr>
<tr>
<td>COUGH</td>
<td>102</td>
</tr>
<tr>
<td>FEVER</td>
<td>93</td>
</tr>
</tbody>
</table>
Analysis of Data SA–2009

REFERRALS

- 93% DISCHARGED
- 7% GP
- 0% HOSPITAL
Analysis of Data SA–2009

<table>
<thead>
<tr>
<th>Region</th>
<th>Totals</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASIA AND PACIFIC</td>
<td>177</td>
<td>21.59</td>
</tr>
<tr>
<td>WESTERN AND CENTRAL AFRICA</td>
<td>30</td>
<td>3.66</td>
</tr>
<tr>
<td>EASTERN AND SOUTHERN AFRICA</td>
<td>232</td>
<td>28.29</td>
</tr>
<tr>
<td>EUROPE AND NORTH ATLANTIC</td>
<td>303</td>
<td>36.95</td>
</tr>
<tr>
<td>NORTH AMERICA, CENTRAL AMERICA AND CARRIBBEAN</td>
<td>49</td>
<td>5.98</td>
</tr>
</tbody>
</table>
Conclusion

- No single screening measure that provides the requisite sensitivity and specificity
- A combination of measures may be required depending upon the prevailing situation
- Symptom-based border screening cannot detect infections among persons who are asymptomatic on arrival
- Airport thermal scanners/ may benefit short incubation disease
- Passengers travelling short haul flight, symptoms would become evident after entry, thermal scanner missing to detect.
- Thermal Scanner/Questionnaires has to be supplemented by core temperature measurement.
- Screening ThermographQuestionnaires remains the one of the best way to screen people in crowds for elevated temp values
- Cost Benefit Analysis
Conclusion

- Targeted vs. Indiscriminate entry screening—based on risk

- Indiscriminate entry screening of travelers on international flights would be highly disruptive, inefficient and impractical.

- Entry screening in cities not receiving direct flights from a source area are highly inefficient and can be disruptive.

- May draw valuable health and human resources away from areas of potentially greater need.

- Exit screening of airports with greater traffic is more efficient than entry screening.

- Significant political, legal and practical obstacles often hamper the timely and effective implementation of national strategies for exit screening.

- Currently, most national authorities are structured to prevent the import of pathogens but not their export.

- Thermal Scanners not developed for medical reasons.
"That's all folks!"