Bioterrorism Protection of Particulate Matter in Ventilation Systems

New Mexico Supercomputing Challenge

Final Report

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Team #96

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EXECUTIVE SUMMARY

The purpose of this project is to examine particulate matter in the form of an aerosol as it progresses through a ventilation system using computation analysis in a complex variant model. The use of a programmable model is highly beneficial to those responsible for the protection and security of persons within an institutional facility. Allowing variants within the model allows the user an opportunity to explore functions that could potentially reduce threats. Specially, security employees would have a better understanding of the risks associated with a potential for a bioterrorist threat on humans. Vulnerable populations may be exposed to lethal agents that may likely result in serious illness or death.

Understanding that the United States government is concerned about the heightened threat to all citizens, specific measures should be taken to reduce the threat in communal environments. In order to examine the risk, a model is created to examine and measure initial exposure. The threat of bioterrorism is probable in an unsecured environment. Furthermore, studies have shown that bioterrorism is most likely in situations where damage, destruction, or highly negative impact will result. Identifying areas where large numbers of people are gathered in a compact area is most relevant and known as the target zone.

In Santa Fe New Mexico, Christus St. Vincent Regional Medical Center is the largest medical center and hospital in Northern New Mexico. Additionally, it is one of the most significant employers. Understanding that this facility is at a high level of risk due to the large population and lack of emancipation of the patients, the facility is a target and has been identified as a target zone.

In order to provide protection to all persons in a target zone, heightened security is required. While the facility has security personnel that rotate within the large facility, they do not monitor the air quality for biohazard materials. Continuous monitoring of air quality within the ventilation system, with previously established known parameters, would allow security personnel to be alerted if variances occurred. In the event that biological weapons were expelled into a ventilation system, the variances would be noted. A warning alarm installed into the system would immediate alert sercurity employees and measures could be taken to reduce exposure.

Using a variable model in the NetLogo program, the program analyses air samples of the environment for a period of 10 days. These recorded samples allow a baseline to be established for the model. Five specific agents with unique characteristics including density will be infiltrated into the system. These viral hemorrhagic fever (VHF) viruses are infectious via air contamination and could conceivable be used as an adversary bioterrorist agents. Exposure times vary, however, each agent

At the Federal level, there are many government agencies charged with developing a coordinated bioterrorism response plan. The Department of Health and Human Services (HHS) is the primary federal agency responsible for the nation’s health and medical response.

A NetLogo simulation has been constructed to demonstrate the path of the viral agent in the ventilation system in the hospital. As the agent is being released, a monitor will detect the threat and the control monitor will engage to alert personnel.

The programmed model will be used to test the efficiency of the installed safety monitor. This system will be vital to the protection of various entities in the setting where additional precautions should be implemented. The model will be used to demonstrate the efficiency and practical nature of the solution.

PURPOSE

Understanding that the purpose of the Supercomputing Challenge is to identify a real world problem and find potential solutions using computational science, the team focused on an issue of significant importance where feasibility could be employed. Rather than select an abstract issue, the team understood the importance of researching an area of science that could better society and potentially be a benefit to larger society.

BACKGROUND INFORMATION

Bioterrorism is an attack that is deliberate with the purpose to cause illness or death in people. The agents may be a virus that is spread into the air. Many agents may be difficult to detect and may cause harm in hours or days. In addition, once a person is exposed, the virus may be further advanced from person to person. In order to focus this examination, agents with the highest priority and risk to public health were chosen. Specifically these agents can all be spread or transmitted via air particles. They result in high death rates. The potential for major public health impact are the greatest. Due to the risk factor, it is highly likely that the public will panic and social disruption will take place. As a result, special action which is immediate for public health protection is suggested by the Centers for Disease Control and Prevention of the United States.

MATERIALS AND PROCEDURE

In order to design the computation program for aforementioned mission, the team first examined the hospital environment at Christus St. Vincent Regional Medical Center. With authorization from Alex Valdez, the CEO of organization, the team made numerous visits to examine the ventilation system. The system is a highly machine with various operational centers due to the size of the facility. In order to make a realistic analysis, one centrally located air unit was analyzed. It is a logical conclusion that the results would apply in other locations.

In order to provide a positive environment within the hospital, air is transmitted throughout the system that may be either heated or cooled. The goal of the system is to maintain a constant temperature within the facility that is 71 degrees Fahrenheit. The variance in temperature ranged in the facility from 64 degrees Fahrenheit to 77 degrees Fahrenheit. These variances took place due to proximity from vents, windows and elevation within the buildings.

RESULTS

While it would not be appropriate to release potentially harmful agents into the ventilation system, the team was able to make real world simulation using the NetLogo computational system. With over 3000 lines of codes, the team worked approximately 117 hours in the creation of a program that would simulate the exposure of persons in the hospital facility. The results indicate that all biological agents would easily transmit via the ventilation system and exposure to person would vary from 3 minutes to 1 hour and 17 minutes. While it would be impossible to determine the exact harm, it was concluded that exposure is eminent as the alarms sounded. The computational models indicate that biological exposure via air ventilation is a serious high threat risk.

REFERENCES

Bartlett, J. G. 131: 273-280, PMID: 10454959.

Khan, A. S. Ready or Not Preparedness for Bioterrorism. N. Engl J Med 2001 Jul 26: 345 (4) 287-289, PMID: 11474670.

Dennis, D. T. Tularemia as a Biological Weapon: Medical and Public Heath Management. JAMA 2001 Jun 6: 285, PMID: 11386933.

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