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DECISION SUPPORT SYSTEMS: AN EXPLORATORY RESEARCH EXAMINING PUBLIC HEALTH EDUCATORS' PERCEPTION OF GLOBAL SENSOR SYSTEMS

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ABSTRACT

Decision Support Systems are increasingly having implications and significance for public health, environmental monitoring, socioeconomic and national security. Increasing occurrence of man-made and natural disasters underlie a need for technologies and practices that can assist key decision makers in determining the most probable cause of a problem and facilitate methods to solve such problem most accurately. Public Health practitioners are interested in potential impact of new technologies especially innovations that have significance in informing public health policies. Therefore, it is important to understand issues and concerns that may associate with information- or decision support systems that potentially could impact socioeconomic systems. This study investigates Public Health educators' perception of global sensor networking, an innovation that has been touted as revolutionary to health and hence socioeconomic security. This is a qualitative research. Results provided in-depth information including issues that are important in Public Health and policy – privacy of information, ethics, information security and sovereignty among others.

Keywords: Information Security, Public Health, Ethics, Information system.

INTRODUCTION

Information technologies and specifically decision support systems (IT/DSSs) are critical aid to civil defense organizations and health professionals. In response to emerging threats to global socioeconomic systems, new technologies have been proposed – which oftentimes integrate principles from diverse fields. However, with the dual nature of technologies, combining benefits and risks, the objective of innovators in creating new technologies or innovations that address modern socio-economic problems is not to create more problems than they solve. A worldwide deployment of sensor systems is a new innovation and an unprecedented phenomenon that may impact human lives, health and socioeconomic systems in ways that are not yet understood. Specifically, global sensor networking involves a cooperative web of sensor systems working together to provide actionable data from different sources and location. An ambitious project unveiled by Hewlett Packard called Central Nervous System for the Earth involves distributing sensors throughout the world and using them to gather data that could be used to detect everything from infrastructure collapse to climate change, environmental pollutant and impending earthquakes [6]. The public deserves to be educated on this. Public Health professionals including university educators and also Information system/communication educated professionals have a huge role to play in educating, informing, and communicating with the public about potentially intrusive technologies. Closing knowledge gaps and influencing positive attitudes could enhance the prospect of early acceptance [16, 12, 10]. Are the promises of new innovations undeliverable except new technologies are first acceptable? No one can say with certainty; however, acceptance can enhance users' ability to derive utmost benefits from novel systems. One of the ways to avert failure or minimize complications that may lead to failure is to understand users' attitude, perception or perceived usefulness of technology [13, 7, 24]. Public Health practitioners are interested in entities that could impact our lives. There is a need for public and decision makers' awareness on sensing devices/systems. New technologies require preparation and awareness of those who will benefit from using such technologies in their public health and organizational decision-making processes.

Public Health roles extend into diverse areas of the global social economic systems especially in providing response to threats that may compound the universal consensus at building interconnected global health systems. Global sensor networking – an interconnected and cooperative web of sensor systems interacting to provide actionable data from different sources and location – has been proposed as decision support system for global public health management with potential application in the environment, bio/terrorism, and human health safety among others.

Public Health and Bioterrorism

The threat of bioterrorism has long been contemplated but was not published by researchers for fear that this could give ideas to unscrupulous entities that may lead to catastrophic experiments [11]. While citing events in Iraq, Japan and Russia, Henderson wrote that the threat of bioterrorism, although long ignored and denied, has heightened over the past few years [11]. The author suggested that longer-term solutions will require the medical community to educate both the public and policy makers about bioterrorism and build a global consensus condemning its use. The United States' national security faces threats whose source were described as diverse, non-traditional, unpredictable and covert [19]. The sources of concern include national entities and special interest groups representing a spectrum of causes from religious fundamentalism to extreme environmentalism that threaten military and civilian targets. These interests are likely to employ tools and technologies that are powerful as well as difficult to detect or deter and unlike explosions or chemical releases, a biological attack could be time-consuming to detect, hence difficult to curtail [19].

Before the United States Postal Service (USPS) anthrax event, President Clinton became personally engaged in what his administration National Security Strategy (NSS) identified as an emerging threat of bio-warfare and bioterrorism [19]. In recognition of the emerging threats of bioterrorism, his successor, President Bush named the Federal Emergency Management Agency (FEMA) to coordinate response efforts in the event of chemical, biological or nuclear terrorism. In the event of an attack, HHS mandates included disease detection, investigating outbreak, providing stockpiled drugs and emergency supplies as needed and providing secure communication systems for responding to bioterrorism. These mandates and the difficulty in providing means of detection and deterrence have led to more investment in anti-bioterrorism initiatives. Lovelace wrote that after the U.S. forces had overrun much of the territory of Afghanistan in December 2002, and discovered that the Al-Qaeda organization had spent several years trying to acquire the means to produce biological agents, the context in which biological warfare (BW) was considered relative to bioterrorism shifted [17]. The author also observed that within four (4) years, the US government had appropriated approximately $30 billion in federal expenditure to counter the anticipated threat of bioterrorism - a response that took place without any threat analysis [17]**.**

Public Safety and the Role of Information and Communication Technology

The convergence of genomics, robotics, information technologies and nanotechnology in newly emerging technologies has potentials in the fight against terrorism. Technologies often have dual natures – benefits and risks and an integrated system might cause unintended difficulties especially in the hands of unscrupulous entities with mischievous tendencies. Bravata, McDonald, and Owens prepared a report that details the methodology, results and conclusions of a systematic and extensive search for published materials on the use of Information Technologies/Decision Support Systems (IT/DSSs) to serve the information needs of health practitioners in the event of a bio-terror attack [4]. The researchers also developed a conceptual model to specify the decisions and tasks involved in the diagnosis, management, prevention, surveillance and communication by health workers and concluded that survey of Public Health officials could be used to better describe the information needs in preparing for bio-terror attack [4].

The early detection of disease outbreaks by a medical bio-surveillance system depends on two major components: 1) the contribution of early and reliable data sources and 2) the specificity, sensitivity, and timeliness of bio-surveillance detection algorithms [22]. In a study designed to determine whether automated detection algorithms can reliably and quickly identify the onset of natural disease outbreaks that are surrogates for possible terrorist pathogen releases, historic data were collected from five metropolitan areas over 23 months [22]. Collected data included International Classification of Diseases, Ninth Revision (ICD-9) codes related to respiratory and gastrointestinal illness syndromes. Considering the minimal availability of data for an actual biologic attack, the authors concluded that it might be difficult to determine how quickly an algorithm might detect an attack and suggested that research is needed to assess the value of electronic data sources for predictive detection. Chandler observed that research and development of bio-detection system is focused on detection technologies and has led to many advanced detection concepts in environmental samples analysis [5]. According to Chandler, the basic principles, technology and conceptual planes that constitute an integrated bio-detection system include:
1. Hardware: The machined parts, sensors, electronics, power supply, micro-processors, communications network and control software…2. Bio/chemistry: The biological sample, reagents, solutions, chemicals, biochemical process

and sequencing of events, etc. required to achieve the molecular detection objective; 3. Data: The information collected from each module, sensor or device, and 4. Output: Representing the synthesis of numerous data streams into a reliable, quality, quantitative report that is unambiguously and effectively communicated to the user. (pg. 20)

Advances in diverse academic fields have enhanced the prospect of the development of better detection systems. Kornguth suggested multiplexed, multi-array sensor systems as a component of a network needed for rapid detection and identification of biological threats [14]. According to the author, sensors system will be capable of recognizing all bacterial or viral genomic materials that determine bio-agents' virulent nature, pathogenicity and antigenic characteristics [14]. One of the most difficult aspects of a detection system is the development of multiplexed sensors capable of detecting several toxic agents. The new paradigm involves the development of nanotechnology based sensors capable of detecting all threat agents simultaneously. This can be coupled seamlessly with an integrated communication software capability able to convert large scale data to actionable information [14]. Other researchers explained that the development of a formidable bioterrorism surveillance system requires effective solutions to many critical challenges [3]. According to the researchers, such a system must be able to support multi-dimensional historical data provide a real time surveillance of sensor data and must possess the capability for recognition of patterns that enables it for quick identification of aberrant situations [3].

Public Health Impact of Sensor Technology

The science and research that are very important to the development of sensor innovations are based on materials created from organic and inorganic substances. Smith stated that "Both inorganic and organic materials are used in the fabrication of sensors [23]. Inorganic materials include single crystals like quartz, silicon, and compound semiconductors; polycrystalline and amorphous materials like ceramics, glasses, and their composites; and metals. Organic materials are mainly polymers; however, recently, lipids, enzymes, and biochemical compounds (e.g., antibodies and DNA molecules) are used in biosensors (p. 16)." According to Dreher, the micro technology developed in the latter half of the 20th century produced a revolution that led to the development of computers and the *Internet* and drove us into the emerging era of nanoscale technology [8]. In theory, nanoparticles can be created from almost every chemical. But most nanoparticles that are in use are made from transition metals, silicon, carbon (single-walled carbon nanotubes; fullerenes), and metal oxides such as zinc dioxide and titanium dioxide [8]. Muray et al. observed that some nanoparticles are made of a combination of metals and compounds forming nanocrystals or quantum dots [18]. Dreher observed that other authors discussed nanoparticles as materials which display peculiar physico-chemical characteristics that give unique mechanical, thermal, electrical and imaging properties associated with them [8]. The proposed plan for a global deployment of systems based on sensor technologies suggests a widespread installment and ubiquitous distribution of nanomaterials in the human environment. According to Dreher occupational and public exposure to these materials will increase dramatically soon because of their utility and sheer ability to improve quality and performance of many consumer products in the public, medical manufacturing and industrial sectors [8]. Yet information is scarce about the public health implications and especially environmental risk assessment of manufactured nanoparticles.

In an investigation conducted on laboratory rats, Lam, James, McCluskey, and Hunter used types of a specific form of nanoparticles called single-wall carbon nanotubes (SWCNT), each of these products induced dose-dependent lung lesions characterized by granulomas [15], a result that was corroborated [8]. According to Dreher, studies showed that SWCNT induced multifocal pulmonary granuloma without evidence of ongoing pulmonary inflammation or cellular proliferation; the lung's immune response to the removal of foreign particles that are not easily degradable has been associated with the observed pulmonary granulomatus lesions [8]. Other authors had previously observed the same clinical presentation in chronic beryllium disease, hypersensitive pneumonitis and sarcoidosis [9].

The purpose of this study is to: examine public health educators' perception of global sensor networking; determine the issues and/or benefits identified by respondents; and identify respondents' recommendations for improving the system. The researcher's proposition is that an understanding of public health respondents' attitudes toward this emerging technology, and their ideas for improving it, will enable system designers to comprehend behavioral patterns toward this technology that may ultimately lead to system improvements and effective integration strategies. Also it is the researcher's assumption that if people's attitudes toward a new technology are known, their overall reaction to the technology can be predicted.

RESEARCH METHODOLOGY

This study centered upon the following question: How do Public Health educators perceive Global sensor networking as a decision making tool for socio-economic security?

This research employed qualitative research approach by asking open-ended questions. The questionnaire included a description of *Global sensor networking*, i.e. "Projects are in the pipeline which involve the worldwide deployment of sensor systems that are designed to improve socioeconomic and global security. The global sensor networking involves a widespread distribution of sensors throughout the world for extracting data that are expected to be useful for the detection of everything from infrastructure collapse to environmental pollutants to climate change and impending earthquakes." Respondents were asked to provide responses to two questions including: "What do you consider likely ramifications of global sensor network systems?" and "What are your recommendations with respect to a widespread deployment of sensor networks?"

The open-ended questions and responses were analyzed for general themes including respondents' concerns, identified opportunities and recommendations. The target population was University educators in the field of Public Health (PH). The sampling frame includes the member schools of the Association of School of Public Health. Eligibility requirements for participating included a minimum of a Bachelor of Science degree. Participants were drawn from the Association of School of Public Health since this is one of the apex associations for Public Health schools and educators. Participants were given the opportunity to decline participation in the study. The researcher made efforts from contacting those who declined to participate especially when reminders were sent to those that failed to respond to previous survey requests. The Association of Schools of Public Health has a total of 52 members including accredited and associate members. Forty-eight of these schools were within the contiguous United States, the remaining being located in Canada, Mexico and Puerto Rico. A simple random sampling technique was used to select ten representative schools (from the 48 schools of Public Health in the United States) that participated in this study. A request to complete the web - based survey along with a description of the study was emailed to 1553 Public Health faculty university email addresses in December, 2010. The number of potential participants who actually received the request and survey could not be determined, but of the 205 returned, 70 were complete. In order to be considered complete, survey must have respondent's stated opinion on both questions or no opinion on both. Response rate was about 4.7%. By using this approach, the researcher's intent was to generalize from this sample to the United States PH educators' population [2].

RESULTS

Fifty-four (77%) of the 70 respondents that completed the open-ended questions indicated and provided opinions on the questions asked. Others had no opinion. Several respondents mentioned multiple facts that they considered likely ramifications of deployment as a result of which 122 statements were observed. There were 5 general themes. Respondents indicated that the environment-health-and-safety was a major source of concern (21%). Potential barrier issues were raised and recommendations made on the improvement of global sensor networking. Sociopolitical themes were observed in 14% of the respondents' statements. Furthermore, security (10%), international (7%) and economics (2%) themes were also prominent in the results. The most pertinent thematic statement in each identified category are presented and discussed below.

Environmental and Human health safety

One respondent stated that "In general, having more information about the state of the world is generally good. Depending on the data to be collected, this might make possible interesting correlations of e.g., climate and health, environmental changes, and effects of migration." Furthermore, the respondent indicated that the most interesting ramifications are most likely to be the unexpected or unintended. For example, the Human Genome Project was extremely (some would say, overly) ambitious, but also motivated technological advances in genomics and bio-infomatics generally. "One concern is (depending on nature and placement of the sensors) possible implications for personal privacy, and ethical implications (for example, are there requirements for action when anomalies or emergencies are discovered)." One respondent lauded the ability of the system for early epidemic and infectious

disease detection and the opportunity this presents for preventive treatment or quarantine until suspected victims show evidence that they are not infected. However, fears were raised about the potential misuse in the hands of the wealthy and the politically connected using it to dispossess people living in 'flood prone' areas of their estate and land properties without full compensation – the privileged then turns around to use their influence to "circumvent the designation of flood prone,"

Sociopolitical

Issues were raised that border on ethics and privacy violation. One respondent suggested that it (global sensor network system) could lend itself to abuse, misuse and political agenda in the hands of the government "just like the sensor systems currently used in the U.K." Quite a few of the participants insinuated that a "total police state" is not far behind that would result from increased consolidation of power in a minority hence loss of freedoms and civil liberties. According to one respondent, "Nazis would have loved it." Yet others do not trust in the capacity of sensor systems because "these types of sensors are limited in their functionality and perform basic testing for certain things." One respondent wanted to know "what does the ACLU has to say about all of these things?"

Security

Although **s**ensors with well-established triggers could be useful, the "deployment of unvalidated sensors could result in a sense of false security through false negatives or much time and effort spent on false positives." Others raised issues of sensitivity and specificity of the system. The possibility is always there that some sabotage could happen that "could rock the entire world rather than small parts of it." Overall, this may increase safety and awareness.

International

There is an opportunity to develop worldwide compatible data. However, complex phenomena could be reduced into simplistic models which could be a precursor to lax in security and removed attention to international threat. In general, projects that increase world cooperation and interaction are a good thing as this could lead to better "political relationships" and "global communications among countries that do not always have an interest in communicating with one another." However, concerns about sovereignty and privacy should not be discounted as "it will be difficult to get national agreement on this, much less global."

Economics

This will improve our ability to reduce energy consumption. However there will be cost implication for the society to deploy and manage. It is very important to weigh cost versus benefits and privacy of individuals, The cost may not be worth the deployment because of these shortcomings that were identified inter alia: "short-term and continuing expense," "limited and very specific usefulness," "Easily circumvented or otherwise taken advantage of for unintended purposes," "complexity and lack of standardization," and "suspect data"

Respondents' Recommendations

Some of the most pertinent recommendations suggested by respondents have been arranged in themes and discussed below:

Educating the general citizenry. It is notable that a majority of this population have at least a Master's degree, most have doctoral level degrees and many are a couple of years away from earning one. The dismal knowledge status with respect to sensor system may be a good indication that the general population with much lesser education is unaware of this technology, a situation that does not bode well for the acceptance of an innovation that is expected to have such a far reaching impact in use and interaction with the populace. As such, respondents' suggestion should not be taken lightly that we should "educate a diversity of professionals and general citizens about the potential and tradeoffs of deployment." Investigators in public health and different biomedical fields could benefit from information on usage and applications. The National Issues Forum is a network of civic, educational, and other organizations, and individuals, with a common interest and mandate to promote public

deliberation in America, their civic approach to issue deliberation was suggested for a proper public discourse on this subject.

Safety and security. There is a need to build systems that could prevent sensors from being hacked because of the sensitivity of the information they provide. Standards should be established that helps integrate and centralize overall data collection. A system that would foil a terrorist attack or other breaches of security must have a back-up system that is at least equally effective and as formidable as the original sensor network system.

Redundancy prevention. Redundancy and unnecessary spending should be prevented by deploying sensors only in high risk situations. This can be done by balancing cost, risk, reward and privacy requirements.

Social benefits. Potential benefits should first be examined, technical and social issues addressed, costs quantified and mechanism for funding established. Privatization may work in this regard but social benefits such as ecosystem improvements, and monitoring of climate change and emerging diseases should be included. Funding should include staffing for monitoring trends and Public Health responses.

International and Social considerations. There should be internationally institutionalized ethical guidelines and principles. International panels should be formed to review issues of use and deployment. A consensus should be sought before creation and deployment should not take place until there "is a clear evidence of support among all stakeholders, especially including those persons whose information is likely to be catalogued." Determine what the objectives will be, clearly state them, and drive global participation

Sustainability. This is probably more important than the science of the system or its deployment. A system of sensor network must fit within cultural and socio-political context in order to be able to deliver its promises in a sustainable manner.

Legal oversight and governance. There is a need for meaningful governance of the process and its outputs. Proper "ethical controls and systems of oversight and accountability." One respondent suggested that issues of "human rights, and legal rights are anticipated and built in to the system prior to collecting and disseminating the information," accompanied by a system of intervention to remediate or respond to an alarmic situation.

Privacy standards. This must involve the provision of notice of all persons/human activity that could fall in jurisdiction being monitored. Public disclosure of data and open sharing [access] to assure discourse. No secrecy should be permitted.

Establishing appropriate perception. Efforts should be made to prevent overselling the potential value of the innovation. It is essential to develop motivation while allowing time and scope to discover and establish value. This may be difficult but allowing "time for establishing baseline and understanding signal characteristics, as distinguishing "signal" from noise is important and will likely evolve as the system and signals are better understood."

False alarms. Minimize conditions that create false alarms that could lead to inappropriate action. Over-reacting can undermine system credibility, hence the importance of developing proper baselines, analytic function and criteria for triggering action. Wide scale alpha pretest (pilot projects) must be conducted to determine pitfalls of false positives before any such system can be reliably deployed

Other recommendations. Other respondents recommended against this technology because of their distrust in its effectiveness, prospect for misuse and abuse, and the waste it represents in the face of a citizenry whose standard of living needs improvement rather than more security.

CONCLUSIONS

The research findings have great implications for research and practice as potential issues of barrier to acceptance were also highlighted in the themes that were unraveled through the open ended questions. While respondents noted the potential benefits for the environment, health and safety, concerns about the system's implications for personal

freedom, civil liberties, security and privacy of personal information were paramount. Furthermore, for a technology that is projected to have a global spread, respondents raised concerns about sovereignty and the cultural push-back that may be encountered from other sovereign nations when companies headquartered in a Western nation propose technologies of such global magnitude. Although the unit of analysis was at the individual level, with questions asked to draw responses on individual perceptions, however observed expressions of respondents' concerns and recommendations had in addition to individual inferences, considerable allusion to institutional and organizational factors regarding the concept- and perceived benefits of sensor systems. The institutional, organizational and individual contextual factors of technology have been used to construct theories that were used in several models including those developed to study users' acceptance, technology adoption and behavior prediction [21, 7].

Education and awareness programs as suggested by some respondents will be good tools for decision makers who may be burdened with the issue of perception about the system and its implementation. There is no better recipe for preventing resistance to new innovation than effective knowledge deployment. The Public Health sector is very essential to this purpose because if the possibility of resistance is reduced, it could be easier to persuade or convince the general population of the prospect of this system. Additionally, issues and questions raised by this well-educated section of the general population could spur decision makers, engineers and designers of this system to address such potential complications before being made public when it will be more financially difficult to address the consequences of failed system acceptance.

One of the outcomes of this study may be the potential education or knowledge it could provide to the participants through generated discussion. This fulfills the social awareness and knowledge components of Innovation of Diffusion theory [20]. Furthermore, it is also known that societal knowledge about an innovation is a great instrument for engineering positive opinion or attitude toward a novel technology. A theoretical framework developed to study the diffusion of complex technologies in organizations revealed that a lack of knowledge is an important barrier to diffusion [1]. As a result, organizations tend to delay the adoption of complex technologies until employees acquire sufficient technical know-how to implement and operate new innovations successfully [1]. The global society is analogous to an organizational system with a tremendous requirement for its own socio-economic health. Although value predispositions may play a role in behavioral intention toward technology acceptance, the acceptability and effectiveness of new global health innovations is not entirely the responsibility of the members or individuals in the society, rather, it is the preserve of that segment of the society that is first exposed to new technologies. Oftentimes it is the field experts and/or the media. These exclusive groups are often saddled with the task of providing enlightenment and news frames that may serve as heuristic cues for societal judgments on technology. In this case, the public health professionals' right or wrong perception on global sensors and their framing of the importance or lack thereof, of this system will mediate perception, perceived risks-vs-benefits, attitudes and or knowledge at the lower end of the societal spectrum.

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