TELEMEDICINE JOURNAL AND e-HEALTH
Volume 8, Number 1, 2002

Chapter 3

Public Health Applications

Contributors:

Stephen Kopp, Ph.D., Central Michigan University
Robert Shuchman, Ph.D., Altarum, Ann Arbor, Michigan
Victor Strecher, Ph.D., University of Michigan
and
Mamadou Gueye, M.D., University Cheikh Anta Diop, Dakar, Senegal
Jerry Ledlow, Ph.D., Central Michigan University
Tina Philip, MHSA, University of Michigan
Alison Grodzinski, MLIS, Central Michigan University

INTRODUCTION

THIS CHAPTER DESCRIBES telemedicine/telehealth applications in public health, including epidemiologic surveillance, remote sensing, geographic information systems, and health promotion/disease prevention. The work summarized here reflects recent developments in this field at the national and international levels. In addition, suggestions are presented for future research and planning and policy priorities related to dominant, emerging issues in public health.

Information technology has provided the means for integrating and analyzing diverse data sources in a spatial-temporal context. This approach supports the development of predictive models and timely intervention. Online media capabilities and the increasing number of application portals provide opportunities for governments, health care organizations, businesses, and individuals to devise creative solutions to persistent health problems of individuals, communities, nations, and the world.

The realities of differing socioeconomic, educational, cultural, health, and medical care systems, however, must provide the contextual basis for assessing the potential benefits that can be realistically achieved through the use of information technology and the problems of its use. These variations apply to geographic regions and population segments in the United States as they do to various countries. Indeed, the fundamental public health challenge ahead is to transform information, specifically unfiltered and widely available health information, into knowledge that can be used to promote the health and well-being of people globally.

EPIDEMIOLOGIC SURVEILLANCE

Epidemiologic surveillance is advancing rapidly, both in terms of international collaboration through integrated global health networks and through the development of sophisticated monitoring technologies. The growing use of geo-encoded information and geographic information systems (GIS) is transforming spatial analysis and mapping in epidemiology.[1,2] For example, GIS is being used in a variety of research efforts:

1. Geographical distribution and gradients in disease prevalence and incidence.
2. Geospatial and longitudinal disease trends.
3. Identification of differential populations at-risk based on risk factor profiles.

4. Differentiating and delineating risk factors within a population.
5. Population health assessment.
6. Intervention planning; assessment of various intervention strategies and their effectiveness.
7. Anticipating epidemics.
8. Real-time monitoring of diseases, locally and globally.

GIS can be used with new applications to augment planning, monitoring, analysis, and research capabilities in public health. GIS facilitates the standardization and integration of diverse data resources, and it permits the management and convergence of various disease surveillance activities.

Epidemiologic surveillance contains information on the incidence and prevalence of diseases, relevant demographic data, physical environment profiles, geo-referenced acute and chronic disease patterns within a defined population or defined geographic area that, together with a variety of ecological and socioeconomic factors, might account for these trends. These data sets can be amalgamated into a common data set for efficient multivariate analysis, trend analysis, and the search for causes.

A GIS-based method for acquiring, retrieving, analyzing, and managing data differs from traditional modes of disease surveillance and reporting. It facilitates the aggregation and integration of disparate data from diverse sources so it can guide the formulation of public health programs and policy decisions.

As shown in Figure 1, any disease entity can typically be depicted as having multiple etiologies and risk factors, and can point to a multicausal disorder with various health consequences and socioeconomic implications. Possible data sources for such model include existing literature, geo-encoded health status databases, environmental information obtained through GIS, health system utilization patterns, and clinical signs and symptoms, all within a defined population[1,2] or geographic area. In addition, geo-encoded information (not depicted in Fig. 1) from supermarkets, pharmacies, and other relevant retailers, as part of a comprehensive community network, would allow monitoring of purchase patterns for such items as prescription drugs, over-the-counter medications, dietary supplements, food, and other consumables. Aggregating these data with risk factor statistics and other health information could guide strategic community health interventions and planning initiatives. Figure 1 depicts how these complex data sources can be integrated via a multifaceted software "integrator."

A comprehensive surveillance system of this type facilitates the monitoring and tracking of various health risk factors in the population, and it can suggest ways of reducing such risk. The resulting information provides multifactorial evidence to guide decision-making and effective public health strategies.

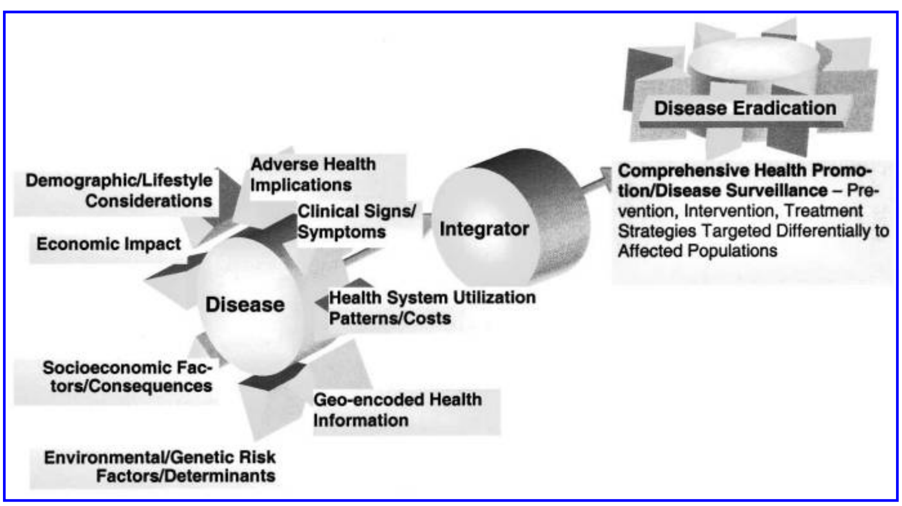

FIG. 1. A hypothetical model for disease surveillance and policy action.

VECTOR-BORNE DISEASE DECISION SUPPORT, GIS, AND REMOTE SENSING

The relationship among environmental factors, such as climatic change and vector-borne disease (VBD) outbreaks, is an area of increasing importance at regional, national, and international levels. Both traditional and emerging infectious diseases continue to pose threats worldwide, at least in part, because of frequent and rapid international travel. Observed and predicted climatic changes, too, have increased the need to understand the relationships between infectious disease and climatic and geographic regimes as changes in vegetation, industrial pollution, and other ecological factors have created or altered habitats for vector borne diseases.

Vector-Borne Disease Decision Support Systems

The basic components of a vector-borne disease decision support systems (VBDDSS) consist of geophysical information derived from remote sensing data and *in situ* sensors, as shown in Figure 2. This system can fulfill several functions:

- Accept remotely sensed data and apply the algorithms for estimating habitat conditions from satellite data.
- Provide the ability to incorporate online sources of information, such as socioeconomic data, other archived data, or data collected in near real-time *in situ*.
- Contain regional baseline environmental GIS databases, as appropriate.

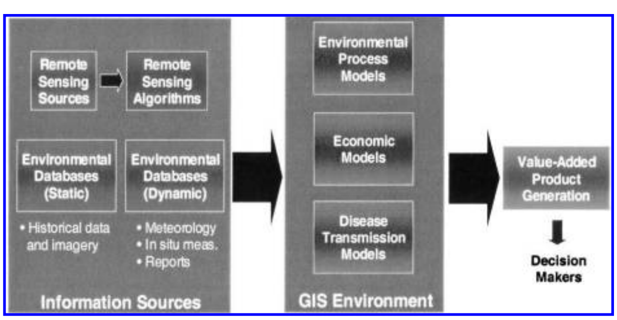

FIG. 2. A vector-borne disease decision support system.

- Use these data and derived parameters as inputs to process models that predict future conditions.
- Integrate the results to generate map-like, value-added products tailored to user requests.

Benefits of this system include facilitating development of cause-and-effect relationships between parameters as well as simulating contingencies.

GIS

GIS provides the basic architecture and analytic tools to perform spatial–temporal modeling of climate, environment, disease transmission, and other factors helpful in understanding the spread of vector borne diseases. Remote sensing provides the environmental input into these models. With a remote sensing component, GIS could significantly improve the management of vector borne disease events by providing:

- Predictive capabilities based on climate and environmental models;
- Remediation measures through rapid and efficient allocation of resources; and
- Preventive methods by providing the ability to evaluate scenarios.

The discussion here focuses on the development of a GIS-based decision support system. Information management has four distinct phases: (1) data collection; (2) information extraction; (3) information synthesis (modeling); and (4) decision support. Data collection involves data acquisition and processing. Data sources can be imagery, *in situ* measurements, and reports or communications from the field regarding prevailing conditions. In the information extraction phase, the data are examined to obtain the desired information, such as geophysical parameters or environmental conditions. This information, in turn, supports and sustains the synthesis or modeling phase. In this phase, decision makers can modify the model parameters and develop alternative scenarios to test and, when necessary, alter or develop better informed action plans.

GIS provides the ability to analyze information in a geographic context by spatially registering data within a single processing environment. Historically, GIS has been used as a "map-maker." However, in recent years, the power of GIS as an analytical tool has grown substantially. Capabilities include interactive visualization, analysis of spatial data, and custom modeling for special applications. The value of GIS for VBD applications is its ability to integrate disparate sets of data. It supports multidisciplinary analysis and enables the prediction of disease outbreaks.

A number of issues must be considered when developing GIS, including data quality, confidentiality, and methodological pitfalls.[3] The currency and completeness of data incorporated into the system must be maintained. The scales of data used must be appropriate for the model or application they support. For example, 1-km imagery will not be appropriate for mapping wetlands and likewise, a 1:5000 land cover GIS is not necessary for climate modeling. Investigators must acquire correct data at appropriate and corresponding scales. Methods must be developed to ensure that no individual will be identified through hospital records or through isolated cases, which allow personal identification.

Remote sensing

Space-based imaging systems are commercially available. Some imagery, such as the Advanced Very High-Resolution Radiometer (AVHRR) sensor carried on the National Oceanic and Atmospheric Administration's orbiting satellites, can be downloaded from the Internet. Others, such as Canada's RADARSAT, must be purchased at a per-scene basis.

The sensors work in different regions of the electromagnetic spectrum—radar, near infrared, through the optical bands. Similarly, the spatial resolutions vary widely—from kilometers (AVHRR) to 4 m and less (1-m images can be obtained from Space Imaging's IKONOS satellite). Unlike satellite-based sensing systems, aerial systems usually offer the benefit of higher spatial resolution (each image pixel represents a smaller piece of the ground). They do this, however, at the expense of less ground coverage and the often-challenging logistics associated with aerial collection.

Development of algorithms for converting remote sensing signatures to physical measurements has been going on since the first satellite sensors were launched in the early 1970s. The algorithms fit into four general categories: (1) direct extraction; (2) time-series analysis; (3) spectral feature analysis; and (4) data assimilation techniques.

Direct extraction involves manual or automated approaches to converting imagery signatures to a geophysical value. For example, multispectral imagery can produce accurate land cover/land use maps using a combination of supervised classification algorithms and manual refinement. Time series analysis involves identifying the change between two images collected over the same area at different times. It can identify changes in land use patterns in an automated manner by looking for cues regarding the cause(s) of the change. Spectral feature analysis is the generation of linear combinations of spectral bands to form intuitive metrics, such as "wetness" and "greenness," rather than simply a radiometric value for a specific optical band. Examples of these techniques include Tasseled Cap[4] and the Normalized Difference Vegetation Index.[5] More recently, the concept of data assimilation has emerged to produce the next generation of algorithms. This iterative process combines imagery with proven process models to estimate geophysical properties.

Many disease vectors cannot be observed directly. However, the presence of the vector, or the conditions under which the vector thrives, can be inferred through such indicators as habitat or habitat change. For example, flooded pastures observed in multispectral or Synthetic Aperture Radar (SAR) imagery may indicate increased potential for mosquito breeding as demonstrated in Kenya.[6]

Remote sensing alone will not provide all the necessary information for detecting or predicting the effects of VBDs, but a number of studies (Table 1) have demonstrated the potential for correlating remotely derived information to VBD outbreaks. For example, Colwell[7] showed significant correlation between sea surface temperature and a cholera outbreak in Bangladesh.

TABLE 1. RESEARCH USING REMOTE SENSING DATA TO MAP DISEASE VECTORS

Disease	*Vector*	*Location*	*Sensor*
Cholera	Water/food supply	USA, Latin America	Ocean Color Scanner (now SeaWiFS)
Cholera	Water/food supply	Bay of Bengal	AVHRR
Dracunculiasis	*Cyclops* spp.	Benin, Nigeria	TM
Eastern equine encephalomhelitis	*Culiseta melanura*	Florida, USA	TM
Filariasis	*Culex pipiens*	Egypt	TM, AVHRR
Leishmaniasis	*Phlebotomus papatasi*	SW Asia	AVHRR
Lyme disease	*Ixodes scapularis*	New York, USA	TM
Lyme disease	*I. scapularis*	Wisconsin, USA	TM
Malaria	*Anopheles albimanus*	Mexico	TM
Malaria	*An. albimanus*	Belize	SPOT
Malaria	*An.* spp.	Gambia	AVHRR, Meteosat
Rift Valley fever	*Aedes* & *Cx.* spp.	Kenya	AVHRR
Rift Valley fever	*Cx.* spp.	Kenya	TM, SAR
Rift Valley fever	*Cx.* spp.	Senegal	SPOT, AVHRR
Schistosomiasis	*Biomphalaria* spp.	Egypt	AVHRR
Trypanosomiasis	*Glossina* spp.	Africa	AVHRR
Trypanosomiasis	*Glossina* spp.	Kenya	TM

AVHRR, Advanced very high resolution radiometer; SAR, Synthetic aperture radar; SPOT, Satellite pour l'observation de la terre (French); TM, Thematic mapper.

AVHRR imagery was used to produce 1-km spatial resolution temperature maps of the Bay of Bengal, and these temperatures were compared with reported cholera cases. Another study[8] demonstrated how landscape elements could be used to predict mosquito abundance and subsequent malaria outbreaks in Mexico. In this study, Landsat imagery was used to produce land cover maps that were correlated with mosquito populations to identify the statistical landscape conditions most likely to have the highest mosquito abundance.

The characteristics of the data source (resolution, revisit time, availability) as well as the maturity of the algorithms (amount of validation), both play a key role in the value of an algorithm for vector borne disease application.

A summary of existing commercial satellite systems is provided in Table 2. This is not a comprehensive list of commercial satellite systems, but rather a list of those that could support the algorithms useful in VBD research.

The rapid development and proliferation of commercial satellite imaging systems is providing new sensors that deliver better resolution and more spectral bands of information. For example, RADARSAT 2 will provide SAR imagery at a nominal resolution of 3 m, versus

TABLE 2. SELECTED EXTANT COMMERCIAL SATELLITE SYSTEMS

Sensor	*First launch*	*Bands*	*Number of spectral bands*	*Nominal spatial resolution*	*Swath size (km)*
Landsat MSS/TM	1972/1987	MS	7	80 m/30 m	185
Landsat ETM+	1999	Pan/MS	7*	13 m Pan/25 M MS	185
SPOT	1986	MS	4*	10 m Pan/20 M MS	60
IRS	1988	MS	4–6*	6 m Pan/23 m MS	148
IKONOS	1999	MS	4*	1 m Pan/4 m MS	11
RADARSAT	1995	C-band SAR	1	10–100 m	45–500
ERS1/2	1991	C-band SAR	1	12/5–100 m	100
SeaWiFS	1997	MS	8	1000 m	2800
AVHRR		MS	4	1100 m	2399
Terra	2000	MS	14	15/30/90 m VNIR/SWIR/TIR	60
MODIS	2000	MS	36	250–1000 m	2330

AVHRR, Advanced very high resolution radiometer.

10 m for RADARSAT, and will be useful for identifying areas of standing water. Forthcoming commercial hyperspectral sensors such as Orb View 4 may provide improved real-time performance of existing multispectral algorithms, and will support new approaches to solving key information requirements related to geology, hydrology, agriculture, and air quality.

The DSS event management system

The decision support system discussed here can be a component of a larger event management system as shown in Figure 3. It comprises four stages: (1) planning, (2) mitigation, (3) response, and (4) recovery/preparedness.

In the planning stage, the DSS provides the ability to monitor environmental conditions and habitats and perform environmental forecasts. If conditions were determined to be conducive to VBD development, the mitigation stage is entered where the DSS will perform a series of modeling activities based on the planning inputs. This will help decision makers develop mitigation plans for a pending outbreak. These plans include not only environmental and health forecasts but also economic and resource forecasts.

Based on the forecasts, decision makers can formulate a response that reduces the impacts of the VBD. In this stage, the infected are cared for, vector elimination programs begin, and the public is alerted to the presence of an outbreak. In the last stage of recovery/preparedness, the environment is restored, potentially harmful material is removed (such as tires in the case of Rift Valley fever), and hospital inventories are stocked with appropriate supplies. This four-stage process is essentially iterative. Through experience and identified shortcomings, the models can be improved, thereby ultimately improving the management of future VBD threats and events.

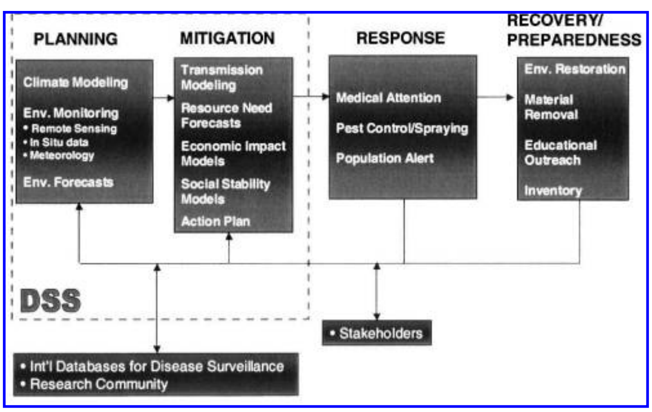

FIG. 3. Decision support systems (DSS) as part of comprehensive event management system.

In brief, effective VBD management requires simultaneous consideration of environmental, socioeconomic, and anthropogenic factors. GIS provides the infrastructure for an end-to-end VBD decision support system for monitoring and responding to the critical phases of VBD. Remote sensing can provide environmental information and support larger scale models. The VBDDSS could significantly enhance the ability of local, national, and international communities and governmental organizations to plan for future outbreaks. A VBDDSS would not only benefit the stakeholder community but would also provide valuable analytic capabilities in other related domains such as biosurveillance and health care forecasting.

INTERACTIVE HEALTH COMMUNICATION FOR HEALTH PROMOTION AND DISEASE PREVENTION

This final section is devoted to the use of information technology to inform, influence, and motivate individuals, populations, and organizations on health, health-related issues, and the adoption of healthy lifestyles. The various approaches and applications can advance and support primary, secondary, and tertiary health promotion and disease prevention agendas. The efficacy, as it relates to the actual value of these applications, however, is yet to be determined.

In general, the design of the various modalities, such as content organization, media support, and methods, is predicated on various cognitive and behavioral theories, models, and evidence. Collectively, these concepts parallel the considerations involved in the genesis of effective distance-education programs, which is a similarly emerging and dynamic field of endeavor.

Health literacy and knowledge are necessary for achieving personal responsibility for health and greater health self-management and empowerment. Whereas access to information is now within reach, people's ability to search, filter and manage health information effectively continues to be a major societal challenge. Figure 4 summarizes and illustrates some of the essential considerations and steps to achieve this objective.[9]

Elevating health knowledge and literacy of the public poses local, national, and international challenges of vast complexity and proportion.[10] An illustration depicting some of the patterns of interactivity and expectations that might be considered in developing interactive communication applications is shown in Figure 5. This diagram brings attention to various factors that are likely to have significant influence over the use and effective deployment of information health communication (IHC) applications, as will be explained.

The potential for IHC applications to influence personal and population health services is substantial. The key areas that should be monitored and studied include the effect on patient care, and patient relationships with clinicians and health care providers, health care systems, and public health systems. The potential for incorporating information-processing programs that can operate autonomously and adapt to the needs of users remains largely undetermined. Similarly, data-mining and expert software systems hold promise that has yet to be fully realized.

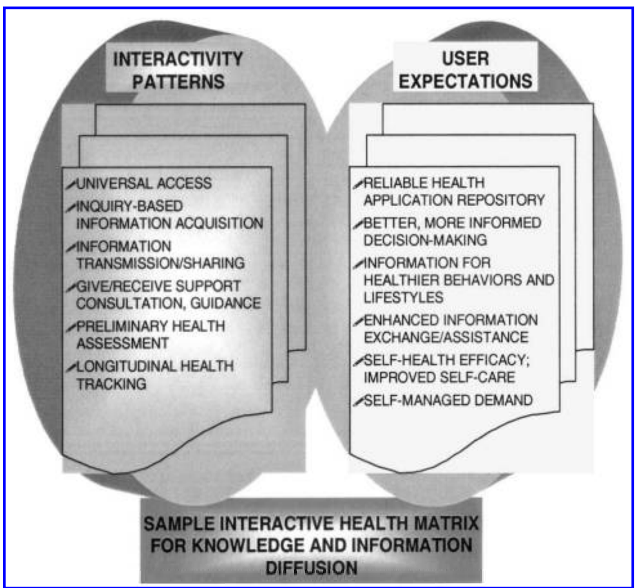

FIG. 4. Interactive Health Communications.

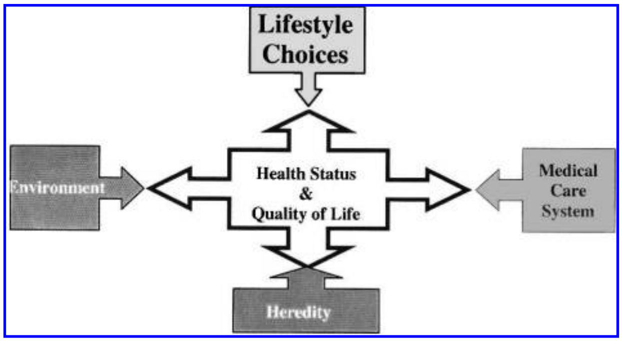

FIG. 5. Relationship between health status and risk factors.

IHC CHALLENGES

The U.S. Science Panel on Interactive Communication and Health[11] prepared a blueprint for addressing the extensive potential that IHC possesses for improving people's health. The scope and breadth of the challenges involved mirror those of distance education and e-learning. They include the design of courseware for Web-based education and the development of interactive health programs that meet the needs of the user. For instance, the demand for customization of learning modules tailored to the way an individual student learns best parallels the demands of the health consumer, who expects applications that address his or her individual needs. And, of course, the cultural and linguistic contexts, not only the type or content of information, represent challenges at the international level.

There is limited research pertaining to the effectiveness of IHC and e-learning applications in the health sector. This precludes informed and definitive conclusions, particularly pertaining to lowering or containing health care costs, predictability, improved health outcomes, and awareness of alternative care decisions. In addition, evaluative norms, benchmarking and comparative approaches between telematics-based applications and approaches that are more traditional remain to be tested.

TABLE 3. INFORMATION HEALTH COMMUNICATIONS SYSTEMS CHARACTERISTICS

Intended major functions	*Factors influencing utilization*	*Major barriers to widespread use*	*Benefits to users*	*Risks to users*
Relay information—individualized health information on demand.	Increasing telecommunication and computing capacity—rapid advances in capacity, power, speed and transmission options present vast opportunity.	Health care provider resistance—perceived threat to professional autonomy and authority.	Improved access to individualized health information—interactive technologies offer potential for customization to support needs of specific groups.	Inappropriate treatment or delays in care—inaccurate/inappropriate information may confound or complicate treatment decisions and delay care.
Enable informed decision-making—applications dealing with health decisionmaking process and/or communication between health care providers and individuals (families, patients, caregivers, etc.) regarding prevention, diagnosis or management of a health condition.	Increasing computer literacy and access—exponential rise in users continues unabated; universal access still remains a destination and not a reality.	Lack of financial incentives to change behavior—without reimbursement providers have little incentive to encourage use of IHC.	Broader choice for users—media design flexibility enables mixing of text, audio, visual modalities tailored to learning style of users.	Damage to patient-provider relationship—inappropriate use of applications or information obtained may undermine trust and prompt conflicts and motivate consumers to seek care from questionable providers.
Promote healthy behaviors—applications promoting adoption and maintenance of positive health behaviors (individual/community).	Increasing consumer demand for health information and shared decision-making—demand fueled by array of factors including greater consumer involvement in medical/health decisions.	Lack of access to infrastructure and inability to utilize applications—barriers to access follow socioeconomic, geographic and other delimiters.	Potential improved anonymity of users—privacy of individuals accessing information can be protected, while improving quality of information.	Violations of privacy and confidentiality—unintended diffusion of sensitive information obtained through IHC interactions may lead to adverse consequences.
Promote peer information exchange and emotional support—examples include online Internet applications that enable individuals with specific health conditions, needs, or issues to communicate with each other, share information and provide/receive peer and emotional support.	Increasing emphasis on primary and secondary prevention—Major component of national health policy strategy; IHC may be effective tool for advancing this agenda.	Substantial implementation and maintenance costs—cost parallels degree of sophistication of the applications.	Greater access to health information and support on demand—applications accessible anywhere, anytime via the Internet.	Wasted resources and delayed innovation—absent cost-effectiveness data, applications may be implemented which drain resources, preventing development of improved systems.

(*cont'd*)

TABLE 3. INFORMATION HEALTH COMMUNICATIONS SYSTEMS CHARACTERISTICS (CONT'D)

Promote self-care—facilitate self-management of health problems or supplement existing health services by facilitating remote health monitoring and care.	Increasing trend to reduce cost of health care services—implementation of preventative health programming has potential for major cost savings (~90%).	Lack of convincing data on effectiveness—much more data are needed.	Ability to promote greater communication—potential to increase interaction and social support among users and between consumers and health professionals.	Unintended errors—assumptions in the development of more sophisticated applications may prove erroneous leading to unintended errors.
Manage demand for health services—specific information tool kits and other resources to support wellness, self-care and self-efficacy/advocacy to enhance effective utilization of health care services and reduce unnecessary services.	Increasing telecommunication and computing capacity—rapid advances in capacity, power, speed and transmission options present vast opportunity.		Expanded dissemination and currency of information—applications reach ever-increasing audience and updating of information is virtually immediate.	Widening of technology and health gap—failure to achieve universal information and technology literacy and access to Internet will lead to tiered system.

IHC, Information health communication.

Based on theoretical constructs and analysis, and evaluation, nevertheless, extensive opportunities exist in this field for research. Studies of this nature can improve IHC applications on a number of levels and establish the differential impact they can bring to improving personal and population health. Findings will influence the usefulness and efficacy of future generations of IHC applications and minimize the possibility of adverse consequences. In addition, evidence gathered through these processes will define and guide advances in the quality of future applications.

A basic question is whether the new modalities of IHC represent a simple repackaging of existing health-related and surveillance practices but in newer, enhanced media channels, or are they truly enhancing and advancing the practices of associated health profession disciplines. At issue is whether telehealth systems can synergistically integrate multifaceted intervention, prevention, assessment, and treatment to achieve improved personal, as well as local, national, and international community health. Telehealth operations that are confined to specific single purpose (but that share information) contribute to the ultimate health improvement goals.

Synergistic and value-seeking opportunities associated with telehealth require full-spectrum assessment, intervention, and evaluation of health status and outcomes of populations. Using aspects of lifestyle choices and behaviors as an illustrative example (Fig. 5) the question posed involves the extent to which telehealth applications that focus on serving a defined population actually operate across the continuum as contributors, integrators, or transintegrators.

INTERNATIONAL PUBLIC HEALTH

Since 1995, global health networks have given priority to six project areas for testing and advancing the goals of interoperability and standardization of global health networks. The principal project areas identified also have specific countries that are leading the coordination efforts. Table 4 summarizes key aspects of selected international collaboration among developed countries.

Demographic and economic similarities

TABLE 4. SELECTED INTERNATIONAL HEALTH NETWORK APPLICATIONS

Objectives	*Coordinating bodies*	*Targeted goal(s)*
Advance a global public health network	Canada, United States, European Commission, WHO	Improved access for health professionals and institutions to publicly available information pertinent to the outbreak and control of public health hazards and infectious diseases.
Focus on cancer—improve prevention, early detection, diagnosis and treatment through global networks.	Canada, France and the European Commission	Database linkages will be used to facilitate knowledge sharing concerned with best practice for disease prevention, screening, quality control and treatment, while facilitating discussion and consultation concerning strategies and treatment protocols among hospitals and health systems.
Focus on cardiovascular disease—improve prevention, diagnosis and treatment through global networks	Italy	Database linkages will be used to facilitate knowledge sharing concerned with best practice for disease prevention, screening, quality control and treatment, while facilitating discussion and consultation concerning strategies and treatment protocols among hospitals and health centers.
Omnipresent, multilingual telemedicine surveillance and emergency services	France and Italy	Determine feasibility of creating worldwide network of public and private telemedicine centers offering ever-present multilingual services.
Standardize and create fully operational, integrated global health networks	Germany, United Kingdom, European Commission, WHO	Establish requisite approaches to ensure consistent health nomenclature, standards, privacy and security of data and efficient access tools and online translation services.
Advance international use of digitally encoded health data cards (i.e., SMART cards	France and Italy	Assess feasibility of creating portable, interoperable solutions for encoding electronic health records on data cards.

WHO, World Health Organization.
Additional information can be found at www.dfait-maeci.gc.ca/english/geo/europe/medica/report-e.htm#2.2.

among developed nations suggest sets of common challenges that would benefit from collaboration internationally. For instance, the emphasis on national health policy agendas for health promotion and disease prevention makes exceptional sense in most developed countries. There are obvious differences, however, in terms of priorities with the health and disease outbreak challenges faced by developing nations. Therefore, although international collaboration in the development and advancement of global health networks is essential, national priorities and possibilities will vary for the foreseeable future. In addition, the dimensions of health and quality of life that such efforts are attempting to influence may need greater definition. For instance, health-related quality of life indicators encompass an array of determinants ranging from health perceptions, pathology indicators symptoms, and organ system functional capacity to individual preferences, attitudes, and values.[12]

In 1996, the Cooperative Health Information Network (CHIN) initiative followed soon after with the establishment of the first telemedicine networks in Europe. The principal objective was to develop organized, technologically accessible health information networks throughout Europe. The longer term objective was to link these networks to create comprehensive, integrated health tele-informatics systems that would provide broad information services to users.

RECOMMENDATIONS

The topics listed below are intended to serve as points of reference for initiating further analysis and discussion. They encompass various domains, and present an agenda for research and policy action. The basic assumption underlying these recommendations is that increased access to reliable health information from various sources will enable individuals and communities to take effective measures to prevent disease and promote health and well-being. While it is clear that progress has been made on a number of fronts, many of the recommendations presented by Bashshur in 1995[34] concerning the metrics for evaluating the effectiveness and sustainability of telehealth/telemedicine applications are still relevant.

Evaluation

- There is an important need to investigate the effectiveness and efficiency of computerized information and network systems for consumers in relation to their participation in health and health care-related activities.
- Decisions must be made regarding information monitoring, storing and standardization. Standardized protocols should be evaluated and defined when necessary.
- Strategies are needed that address national and international health and information literacy.
- Health self-efficacy, motivation, literacy, and knowledge levels of the general public will be an important determinant of the extent to which the personal responsibility for health becomes a reality. In addition, the determinants or criteria should be used as indicators of progress in this endeavor.
- Cultural differences must be identified pertaining to telemedicine/telehealth use and associated outcomes. Criteria should be established to determine best telehealth and telemedical practices within disparate demographic, cultural, and socioeconomic populations to assure sensitivity and respect for culture, social background, and ethnic differences.
- Health status benchmarks must be established to determine the extent to which telemedicine/telehealth utilization influences health outcomes, reporting (surveillance), interventions, and evaluations of health-related applications.

Cost

- Managing the rising cost of health care and finding ways to contain them continues to be a dominant force shaping the health care system everywhere. Hence, technology-enabled approaches to service delivery must be investigated fully. Indeed, services demanded/expected by consumers must be determined and the telemedicine applications evaluated on a cost/benefit basis.
- Comprehensive cost modeling must include assessment of the costs associated with digital permanence (storage, archiving, retrieval and maintenance of digital assets, i.e., data and consumer-owned information).

Quality

- A consensus operational definition and certification of service quality must be developed and enforced to protect consumers. Certification of network providers is an important consideration for protecting clients, particularly in terms of safety and privacy. Quality parameters are necessary and must be established so consumers can report problems.
- Benefits of telemedicine must be measured against established and tested baseline health indicators and benchmarks. These evidence-based approaches would serve as valuable indicators for the value and quality of service provided by participating networks.

Privacy/legal/security/ethical domains

- The Interdisciplinary Telehealth Standards Working Group has established a set of core standards to guide telemedicine services and resources. The intent of these principles is to protect clients receiving telehealth services, to give health care professions a common ground, and to provide a basis for reviewing professional standards, clinical standards, and the need for telehealth guidelines by professions and by government agencies.[35] They provide a useful context for considering future issues.
- The assumption has been that patient medical records, regardless of form, belong to the patient, yet physicians often retain patient records and charge for copying the record for the patient. Ownership of medical record information poses an interesting and important health policy issue that is distinct from

the issue of privacy. The question of ownership of digital information (created by individuals, either through the use of interactive health communication portals or through their own record keeping) must be resolved. As individuals take a more active role in monitoring their personal health and encode such information in their own health records, the ownership of this information must be resolved.
- Legal and ethical obligations of organizations offering interactive health information applications for the public must be determined and established to meet current and future demands.

Research

- A systematic and comprehensive research agenda must be developed and supported by government agencies and health care professions for the ongoing assessment of telemedical services. Cooperative public and private funding will be necessary to underwrite the scale and duration of research needed.
- Manpower development remains a critical issue and educational programs at colleges and universities must keep pace with the evolution of global health network systems and other telemedicine applications. Increased efforts must be directed at disease prediction and mobilization/intervention before the actual outbreaks of diseases

Technology

- The convergence and compression of data and information sources and resources poses an exceptional challenge. Effective strategies for creating secure network systems and data repositories that provide and protect continuous access and confidentiality must be developed.
- Telemedicine networks must be funded, managed, and administered to provide universal access.

Additional priority areas for consideration

- Telemedicine activity around the world is developing at a rapid pace. Although these projects are being developed in relation to the needs of a specific community, overlapping goals and activities do exist. Identification and indexing of all ongoing projects within the international community is an essential starting point. An international clearinghouse of telemedicine activity needs to be developed to promote and allow for resource sharing and effective collaborative efforts.
- Telemedicine operations and systems that use multidimensional health approaches and disciplines should be identified, and outcomes based on target population goals must be assessed quantitatively and qualitatively.
- Health applications most conducive to telemedicine operations based on providers of care, patients/customers, and employer perceptions and satisfaction variables must be identified.

REFERENCES

1. Richards TB, Croner CM, Rushton G, Brown CK, Fowler L. Geographic information systems and public health: Mapping the future. *Public Health Reports* **1999;**114:359–373.
2. Green J, Escobar F, Waters E, Williamson I. Research Agenda for Geographic Information Systems and Health, 1999. Australian Research Council's Special Research Initiatives Program.
3. Albert DP, Gesler WM, Levergood B, eds. *Spatial analysis, GIS, and remote sensing applications in the health sciences*, Chelsea, MI: Ann Arbor Press, **2000.**
4. Crist E, Cicone R. Application of the tasseled cap concept to simulated thematic mapper data. Photogrammetric Engineering & Remote Sensing **1984;**50: 343–352.
5. Kimes DS, Holben BN, Tucker CJ, Newcomb WW. Optimal directional view angles for remote-sensing missions. *Int J Remote Sensing* **1984;**5:887–908.
6. Pope KO, et. al. Identification of Central Kenyan Rift Valley Fever virus vector habitats with Landsat TM and evaluation of their flooding status with airborne imaging radar. *Remote Sensing of the Environ* **1992;**40: 185–196.
7. Colwell R, et. al., Remote sensing of cholera outbreaks, Center for Health Applications of Aerospace Related Technologies (CHAART), *geo.arc.nasa.gov/sge/health/projects/cholera/cholerarpt1.html*, 2000.
8. Beck LR, Rodríguez MH, Dister SW, Rodríguez AD, Washino RK, Roberts DR, Spanner MA. Assessment of a remote sensing based model for predicting malaria transmission risk in villages of Chiapas, Mexico. Am J Trop Med Hyg **1997;**56:99–106.

9. National Institute for Occupational Health and Safety. *A Model for Research and Training Effectiveness*. Cincinnati, OH: NIOSH, **1999.** DHHS (NIOSH) Publication No. 99–142. Available at: *www.cdc.gov/niosh/99–142.html*. Accessed July 2001.
10. Agency for Health Care Policy and Research. *Consumer Health Informatics and Patient Decision-Making*. Final Report. Rockville, MD: U.S. Department of Health and Human Services, Agency for Health Care and Policy Research, **1997.** AHCPR publication 98–N001.
11. Eng TR, Gustafson DH. *Wired for Health and Well-Being: The Emergence of Interactive Health Communication*. Washington, D.C.: Science Panel on Interactive Communication and Health, U.S. Department of Health and Human Services, U.S. Government Printing Office; 1999. Available at: www.health.gov/scipich/pubs/finalreport.htm. Accessed July 2001.
12. Clancy CM, Eisenberg, JM. Outcomes research: Measuring the end results of health care. *Science*. **1998;** 282:245–246.
13. Tambouris E, Williams MH, Makropoulos C. Co-operative Health Information Networks in Europe: Experiences from Greece and Scotland. J Med Res [serial online]. **2000;**2:e11 Available at: www.jmir.org/2000/2/e11/index.htm. Accessed July 2001.
14. The National Breast and Cervical Cancer Early Detection Program 2001. Available at: www.cdc.gov/cancer/. Accessed July 2001.
15. Association of Telehealth Service Providers. 1999 Report on U.S. Telemedicine Activity. Portland, OR: ATSP; **2000**.
16. Ilioudis C, Pangalos G. A framework for an institutional high level security policy for the processing of medical data and their transmission through the Internet. J Med Internet Res [serial online]. **2001;**3:e14. Available at: jmir.org/2001/2/e14/index.htm. Accessed July 2001.
17. Cancer in Scotland: Action for change 2001. Available at: www.show.scot.nhs.uk. Accessed July 2001.
18. A framework for national surveillance of hospital acquired infection in Scotland. 2001. Available at www.show.scot.nhs.uk. Accessed July 2001.
19. Moore A, Parr G, Logan M, Neely H, Roesner D, Dürer U. Developing a European internet and kiosk-based health information system. J Med Internet Res [serial online]. **2001;**3:e6. Available at: jmir.org/2001/1/e6/index.htm.
20. Beck LR, Lobitz BM, Wood BL. Remote sensing and human health: New sensors and new opportunities. *Emerg Infect Dis* **2000;**6217–227.
21. Malone JB, Bergquist NR, Huh OK, Bavia ME, Bernardi M, EL Bahy MM, Fuentes MV, Kristensen TK, McCarroll JC, Yilma JM, Zhou XN. A global network for the control of snail-borne disease using satellite surveillance and geographic information systems. *Acta Tropica* **2001;**79:7–12.
22. Lovell NH, Celler BG. Information technology in primary health care. *Int J Med Informatics* **1999;**55:9–22.
23. World Health Organization. Integrated disease surveillance. Available at: www.who.int/emc/surveill/index.html. Accessed July 2001.
24. World Health Organization. Strengthening disease surveillance. Available at: www.who.int/emc/healthmap/surveillance.html. Accessed July 2001.
25. Geographical Information Systems (GIS). Mapping for epidemiological surveillance. *Wkly Epidemiol Rec* **1999;**74:281–288.
26. International Activities in Tele-homecare: Background paper. Office of Health and the Information Highway Health Canada. 1998. Available at: www.hc-sc.gc.ca/ohih-bsi. Accessed July 2001.
27. Gray JE, Safran C, Davis RB, Pompilio-Weitzner G, Stewart JE, Zaccagnini L, Pursley D. Baby CareLink: Using the Internet and telemedicine to improve care for high-risk infants. *Pediatrics* **2000;**106:1318–1324.
28. Phillips VL, Temkin A, Vesmarovich S, Burns R, Idleman L. Using telehealth interventions to prevent pressure ulcers in newly injured spinal cord injury patients post-discharge. Results of a pilot study. *Int J Technol Assess Health Care* **1999;**14:749–766.
29. Po YM. Telemedicine to improve patients' self-efficacy in managing diabetes. *J Telemed Telecare* **2000;** 6:263–267.
30. Oki Y, Shiomi T, Sasanabe R, Maekawa M, Hirota I, Usui K, Hasegawa R, Kobayashi T. Multiple cardiovascular risk factors in obstructive sleep apnea syndrome patients and an attempt at lifestyle modification using telemedicine-based education. *Psychiatry Clin Neurosci* **1999;**53:311–313.
31. Zahlmann G, Obermaier M, Mertz M. Real applications of patient-related telemedical services. *Studies Health Technol Informatics* **2000;**79:20–37.
32. Chen H-S, Guo F-R, Chen C-Y, Chen J-H, Kuo T-S. Review of telemedicine projects in Taiwan. *Int J Med Informatics* **2001;**61:117–129.
33. Canada. Department of Foreign and International Trade. Telehealth in Germany. June 1998. Available at: www.dfait-maeci.gc.ca/english/geo/europe/medica/report-e.htm. Accessed July 2001.
34. Bashshur RL. On the definition and evaluation of telemedicine. *Telemed J* **1995;**1:19–30.
35. Report of the Interdisciplinary Telehealth Standards Working Group. Available at: www.arentfox.com/quickguide/businesslines/e-health/e-health_telemed/e-healthnewsalerts/telehlth/telehlth.html. Accessed July 24, 2001. For convenience, the text of the recommended standards is presented verbatim as follows:
   i. The basic standards of professional conduct governing each health care profession are not altered by the use of telehealth technologies to deliver health care, conduct research, or provide education. Developed by each profession, these standards focus in part on the practitioner's responsibility to provide ethical and high quality care.
   ii. A health care system or health care practitioner cannot use telehealth as a vehicle for providing services that are not otherwise legally or professionally authorized.

iii. Services provided via telehealth must adhere to basic assurance of quality and professional health care in accordance with each health care discipline's clinical standards. Each health care discipline must examine how telehealth impacts and/or changes its patterns of care delivery and how this may require modifications of existing clinical standards.
iv. The use of telehealth technologies does not require additional licensors.
v. Each health care profession is responsible for developing its own processes for assuring competencies in the delivery of health care through the use of telehealth technologies.
vi. Practice guidelines and clinical guidelines in the area of telehealth should be developed based on empirical evidence, when available, and professional consensus among all involved health care disciplines. The development of these guidelines may include collaboration with government agencies.
vii. The integrity and therapeutic value of the client-health care practitioner relationship should be maintained and not diminished by the use of telehealth technology.
viii. Confidentiality of client visits, client health records and the integrity of information in a health care information system is essential.
ix. Documentation requirements for telehealth services must be developed that assure documentation of each client encounter with recommendations and treatments, communication with other health care providers as appropriate, and adequate protections for client confidentiality.
x. All clients directly involved in a telehealth encounter must be informed about the process, attendant risks and benefits, and their rights and responsibilities, and must provide adequate informed consent.
xi. The safety of clients and practitioners must be ensured. Safe hardware and software, combined with demonstrated user competency, are essential components of safe telehealth practice.

Address reprint requests to:

Rashid L. Bashshur, Ph.D.
Director of Telemedicine
The University of Michigan Health System
C201 Medinn Building
1500 East Medical Center Drive
Ann Arbor, MI 48109–0825

E-mail: bashshur@umich.edu

This article has been cited by:

1. Victor Strecher. 2007. Internet Methods for Delivering Behavioral and Health-Related Interventions (eHealth). *Annual Review of Clinical Psychology* **3**:1, 53-76. [CrossRef]