Telediagnosis: A New Community Health Resource

Observations on the Feasibility of Telediagnosis Based on 1000 Patient Transactions

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By means of a two-way audiovisual microwave circuit, physicians at the Massachusetts General Hospital provided medical care to 1000 patients 2.7 miles away at the Logan International Airport Medical Station. This study reports on this service which demonstrates that telediagnosis can increase the availability of quality medical care.

Introduction

For many years two-way voice communication has been used for emergency advice to patients in remote areas. This kind of telediagnosis has been limited because it is difficult to verbalize much of the important information required for medical diagnosis.

The demand for medical care in rural areas is increasing. It is widely recognized that medical practice has become more specialized and that, of necessity, specialists must practice in areas of high population density. Thus, it is likely that the many benefits of specialized medical care will not be readily available to persons in remote areas if current health care methods are employed.

With these considerations in mind we explored the feasibility of diagnosis at a distance using two-way closed circuit television and other electronic devices. The purpose of this report is to comment on the experience obtained while delivering primary medical care to 1000 patients via this telediagnosis system. Details of the nature and costs of the required equipment will be the subject of a future communication.

The Logan International Airport Medical Station of the Massachusetts General Hospital in East Boston was chosen as the site for this experiment. This station was established to provide occupational health services to airport employees and to deliver emergency care and medical direction to travelers. During this experiment the Medical Station was staffed by nurses 24 hr per day, supplemented by in-person physician attendance during the 4 hr coincident with peak passenger flow periods. Since the inception of the Medical Station, nurse-clinicians have been responsible for the evaluation and treatment of patients who visit this facility when physicians are not in attendance. To assist the nurse in this task, she had the ready availability of physician consultation by telephone. It was thus logical to superimpose on this situation a visual communications system to study this new method of health care delivery. The

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proximity to the hospital facilitated making observations at each end of the system. The microwave transmission employed in this telediagnosis system is, of course, capable of line-of-sight transmission of much greater distance to areas where a real need for such a system exists.

Design of the Telediagnosis System

The telediagnosis system utilizes diagnostic instrumentation to reproduce closely the normal clinical setting wherein patient and doctor are in the same room.[1] The physician in the Emergency Ward of the hospital views the patient at the airport Medical Station on television receivers. The patient at the Medical Station sees his physician on a 17-inch television screen several feet in front of him. This configuration allows conversation to proceed in a normal relaxed fashion—a characteristic of "interactive" or two-way television.[2] A nurse introduces the patient to the physician and assists with the physical examination. Depending on the illness of the patient, she may remain in the consultation room during the visit or leave the room to enhance confidentiality. The standard microwave equipment utilized in the network operates in the 12-GHz band. It transmits video and two 15-KHz audio channels in each direction simultaneously. Auscultation is performed by means of an electronic stethoscope positioned by the nurse-clinician under the direction of the doctor. The patient's electrocardiogram, pulse rate, respirations, systolic blood pressure and other physiological data required by the physician can be successfully transmitted.

The Patients

During the course of this study, the nurse on duty selected patients for telediagnosis from those persons who came to the Medical Station seeking care for a medical or surgical illness. Under ordinary circumstances each would have been evaluated and treated by the nurse with an immediate or scheduled follow-up by the physician at the Medical Station. The nurse's discretion then determined throughout this study whether the patient was seen only by the nurse, by a physician in person, or by a physician via telediagnosis. The comments in this report are based on observations on the 1000 consecutive patients seen by telediagnosis from August 1, 1968, to December 27, 1969. Of these, 89 per cent were airport employees; the remainder were travelers or visitors to the airport.

Illnesses Treated via Telediagnosis

Five categories of presenting complaints, extremity pain (14.8 per cent), sprains (14.4 per cent), contusions (8.2 per cent), flank, back, or trunk pain (6.6 per cent), and general "check-up" (6.2 per cent), accounted for 50.2 per cent of the telediagnosis transactions. The remainder encompassed a wide variety of complaints including chest pain, sore throat, malaise, headache, or simply visits to obtain test results. The telediagnosis subjects in general reflected problems normally seen by physicians at the Medical Station and roughly duplicated their relative frequency. Only minor differences were noted when 500 consecutive telediagnosis patients were compared to a random sample of 500 other Medical Station patients treated during the same 18-month period. For example, telediagnosis patients were evaluated more often than patients from the Medical Station sample for extremity pain, chest pain, flank pain, and sore throat (Table 1). This discrepancy probably results from the nurse selection of the potentially more complex medical problems for evaluation by the physician at the hospital. On the other hand, fewer persons with lacerations, contusions, and eye complaints were selected by nurses for examination by the telediagnosis physician. This again reveals the ability of the nurse-clinician to handle much of the minor traumatic illness seen in this industrial environment.

The seriousness and urgency of the medical problems managed via telediagnosis were similar to those generally seen in the Medical Station sample (Table 2). There was a slight tendency of the nurse to select the more serious problems for evaluation by the telediagnosis physician and to manage the less serious problem herself. Of particular interest was that 79 per cent of the patients presented with a previously unevaluated illness.

TABLE 1—More Common Presenting Complaints of Telediagnosis Patients and Medical Station Sample

	Telediagnosis		Medical Station Sample	
Reason	No. patients	%	No. Patients	%
Extremity pain	74	14.8	8	1.6
Sprains	72	14.4	60	12.0
Contusions	41	8.2	74	14.8
Flank/back/trunk pain	33	6.6	11	2.2
Check-up	31	6.2	8	1.6
Rash	28	5.6	5	1.0
Eye irritation	27	5.4	56	11.2
Psychiatric	26	5.2	3	.6
Chest pain	23	4.6	7	1.4
U.R.I.	21	4.2	14	2.8
Sore throat	20	4.0	7	1.4
Lacerations	18	3.6	99	19.8
To obtain test results	13	2.6	9	1.8
Malaise	12	2.4	0	0
Abdominal pain	9	1.8	9	1.8
Neck pain	7	1.4	5	1.0
Headache	6	1.2	0	0
Burns	6	1.2	14	2.8
Cough	5	1.0	0	0
Nausea/vomiting	4	.8	9	1.8
Other	24	4.8	102	20.4
Totals	500	100.0	500	100.0

TABLE 2—Seriousness, Urgency, Recommendations, and Course of Action in 1000 Telediagnosis Transactions Compared to Medical Station Sample

	Telediagnosis (%)	Medical Station (%)
Seriousness		
Major*	4	4
Differential	20	5
Minor	76	91
Urgency		
Urgent†	44	31
Not urgent	56	69
Recommendation		
Off duty	31	25
Return to regular duty	53	67
Not applicable	12	8
Not categorized	4	0
Course of action		
Medical consultation alone	52	39
Medication dispensed or prescription written	34	43
Physiotherapy advised	10	10
Miscellaneous	4	8

* Major: condition could result in loss of life or possible organ impairment if not promptly cared for (cf. text).

† In opinion of physician, illness required medical attention that day or potential harm to patient would result.

Patient Acceptance

The clear consensus of the physicians and nurses directly involved is that the majority of patients are satisfied with the telediagnosis transaction. An independent assessment of patient acceptance was made by social scientists. Questionnaires were mailed to the 343 patients seen via the telediagnosis system between November 1, 1968, and April 30, 1969.* Of the 275 respondents (80.2 per cent), only 15 per cent were serious critics of telediagnosis. The majority of patients felt that their experience in seeing the physician over television was as satisfactory as seeing him in person (Table 3). Attitudes toward medicine in general accounted for about 10 per cent of the variance in attitudes toward telediagnosis. Other correlations examined (age, sex, occupation, income, education, etc.) were either insignificant or unimportant. Furthermore, after the institution of telediagnosis at the Medical Station, total patient visits have continued to increase at a rate of 18 per cent. This is similar to the average growth rate of 14 per cent over the 3 preceding years. In our opinion, the direct confidential communication possible via interactive television allows for a remarkably normal physician-patient relationship and this accounts for the ready acceptance by patients.

* Rule, J. B., and Mann, L. Personal communication. Medicine by television—the patient's response to telediagnosis.

TABLE 3—Responses of 274 Telediagnosis Patients to a Mail Questionnaire

In general, how would you rate the quality of care that most doctors provide?*
- 21.5% Excellent
- 64.7% Adequate
- 8.7% Less than adequate
- 2.6% Poor
- 2.2% I'm not sure
- 0.4% (No answer)

How satisfactory was your own experience in seeing the doctor over television?
- 7.3% More satisfactory than if I had seen him in person
- 61.8% About as satisfactory as if I had seen him in person
- 20.0% Slightly less satisfactory than if I had seen him in person
- 10.2% Much less satisfactory than if I had seen him in person
- 0.0% I'm not sure
- 0.7% (No answer)

How good an understanding of your medical problem do you think the television system provided for the doctor?
- 8.0% Much less understanding than if I had seen him in person
- 20.4% Slightly less understanding than if I had seen him in person
- 61.5% About the same understanding as if I had seen him in person
- 4.4% More understanding than if I had seen him in person
- 4.7% I'm not sure
- 1.1% (No answer)

How comfortable did you feel in seeing the doctor over television?
- 9.5 More comfortable than if I had seen him in person
- 61.8% About as comfortable as if I had seen him in person
- 18.9% Slightly less comfortable than if I had seen him in person
- 9.1% Much less comfortable than if I had seen him in person
- 0.4% I'm not sure
- 0.4% (No answer)

* This refers to "in person" medical care, not to telediagnosis.

Observations on the Validity of Diagnosis by Telediagnosis

Numerous variables in the diagnostic process as performed in the daily practice of medicine do not readily allow controlling in rigorous scientific fashion. Physician and patient variability has been shown to be large even when medical history taking has been standardized to a written questionnaire.[3] Indeed, when patient variability is nonexistent, as in diagnostic radiology, observer variability is still great.[4] Thus it would be very difficult to compare diagnosis made directly with those made by telediagnosis using physicians of equal competence. In the sense of a controlled double blind study, the feasibility of a large segment of the practice of medicine has not been demonstrated. Accordingly, we chose to study feasibility in this study by obtaining the opinion of the responsible physicians and nurses and that of an independent observer as well as by analysis of the components of medical diagnosis.

Independent Assessment

The first 200 patients examined via the telediagnosis link were also examined in person by a physician at the Medical Station on the same day. This provided independent evaluation of the medical care delivered by telediagnosis.

The telediagnosis physician (Table 4) tended to be a harsher judge of his own ability to provide a satisfactory diagnosis in the initial 200 cases than was the physician who directly saw the patient. In our opinion, this reflects physician caution in using the new instrumentation. Despite this hesitancy on the part of the telediagnosis physician, the comparative analysis showed that he was able to analyze the patient and arrive at a proper disposition of the patient. In 96 per cent of the cases, the direct observer, after examining the patient, concluded that his own disposition would not be significantly different. Formal use of the observer physician was then discontinued except for purposes of improving diagnostic techniques. Two per cent of the remaining 800 transactions were not feasible according to the judgment of the telediagnosis physician. The current state of electronic technology with respect to the components of medical diagnosis accounted for most of these failures. It is recognized that in the absence of nurse selection the number might have been larger. These observations prompted selected studies of the accuracy of specific techniques of medical diagnosis at a distance as well as experiments to improve equipment design.

Components of Medical Diagnosis

During this study we made observations on medical history, physical examination (especially with regard to inspection and auscultation), interpretation of roentgenograms, and certain laboratory examinations via this microwave system. History taking, even with regard to personal information contained in psychiatric interviews, is readily done by the telediagnosis physician. Mutual visualization of even the subtleties of facial expression and posture allows the medical interviews to proceed in a manner quite familiar to both patient and physician.

Many aspects of the physical examination, particularly those which depend on inspection, are easily and accurately performed. The complete range of motion of any part of the body, the body habitus, the presence of swelling, and the details of surface anatomy are determined with little difficulty. With the ability to magnify images of parts of the body, such as the eye, illustrated in Figure 1, it is obvious that much information of diagnostic importance can be easily obtained, e.g., pupillary reaction, ocular motion, presence or absence of ptosis.

To study the process of inspection in more detail, we chose to examine the accuracy of dermatological diagnoses by television utilizing a test situation designed to focus on the main variable of interest to us; namely, the ability of dermatologists to inspect skin lesions via closed circuit television. To study this, 75 color transparencies of skin lesions were selected from the files of the Dermatology Service of the Massachusetts General Hospital, using the sole criterion that it was possible in the opinion of one dermatologist to make a diagnosis on viewing the slide. Slides were projected on a screen. This projected image recorded by a television camera was placed in view simultaneously on a television screen. Each dermatologist was asked to view each of the 75 slides first on the black and white television monitor. He was allowed to ask what color a given lesion was but was not provided with any other clinical information. After the television diagnosis was recorded, he then viewed the projected slide image and again recorded his diagnosis.

The majority of diagnoses made by television were as accurate as those made by direct viewing of the projected slide (Table 5). Television diagnosis was less accurate than direct viewing in five cases for Observer 1 and one case for Observer 2. A surprising finding was that each observer was more accurate by television than by the direct viewing of projected slides in two cases.

An additional 54 slides were examined both by a color and a black and white television camera. Diagnoses were as accurate by black and white television as they were by color television in 42 cases. In no case was an incorrect diagnosis made by color that was correct by black and

TABLE 4—Participating Physicians' Evaluation of Disposition of First 200 Telediagnosis Patients

	Telediagnosis Physician (%)	Direct Observer (%)
Satisfactory*	64.5	96.5
Minor reservations	30.0	1.5
Major reservations	4.0	1.0
Not satisfactory	1.5	1.0

* Response to the question: Was a reasonable disposition of the patient made?

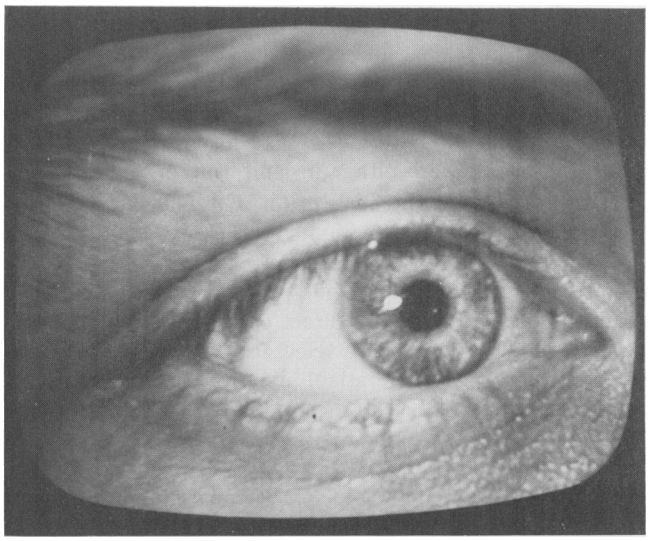

figure 1 Magnification of eye for telediagnosis.

TABLE 5—Comparison of Diagnoses Based on Black and White Television and Same Directly Viewed Projected Color Slides versus Proven Clinical Diagnosis

Telediagnosis	Direct Slide Diagnosis	Observer 1	Observer 2
Correct*	Correct	46	63
Incorrect	Incorrect	18	4
Correct	Incorrect	2	2
Incorrect	Correct	5	1
Omitted for technical reasons		4	5
Total		75	75

* Same as clinical diagnosis.

white, whereas two slides were diagnosed correctly by color television which were incorrectly diagnosed by black and white television.

To provide perspective with regard to the utility of television in dermatological diagnosis, the same 75 slides were also interpreted by two internists who were not specially trained in dermatology. These interpretations were made only by direct viewing of the projected slides. Whereas the two dermatologists interpreted 85 per cent and 68 per cent correctly, the two internists correctly diagnosed 33 per cent and 31 per cent, respectively. This suggests that actual consultation via a television would be likely to be helpful.[5]

The degree of accuracy of diagnosis of the slides in this study is artificially low because neither the medical history nor the nonvisual characteristics of the lesions were known at the time of the diagnosis.

To study auscultation of the heart, 25 subjects were selected to include patients with heart murmurs and normal controls. They were examined using a standard stethoscope and the telestethoscope. The observer was unaware of the status of the subject with respect to "patient" or "control" at the time of the teleauscultation. All murmurs of grade II/VI or more were easily and accurately described using the telestethoscope. Several of the grade I/VI murmurs were not heard. The cause for this was not apparent.

Percussion and palpation are not yet as easily performed at a distance. Currently, reliance on the nurse-clinician is necessary to make observations which depend on these diagnostic methods. In a telediagnosis system, the physician retains the ability to direct and supervise the performance of this kind of task. He can observe the exact location of abdominal tenderness elicited by palpation performed by the nurse-clinician. He can evaluate the manner in which any diagnostic maneuver is performed (e.g., how a positive psoas sign was elicited or the McMurray test performed).

Routine laboratory studies can be performed in the peripheral telediagnosis station. Specimens not requiring emergency study can be sent to central laboratories, as is now common practice in many areas. In situations where first hand information is desirable, the telemicroscope can be employed. The peripheral blood smear and the urine sediment can be clearly visualized by this instrument (Figures 2 and 3). The lack of color in the current system can be offset by proper communication between the remote examiner and the nurse. When necessary, electrocardiograms can be transmitted by microwave with less than a 2 per cent variation in magnitude of the recorded wave form.

To assess the accuracy of interpretation of roentgenograms via this system 100 posteroanterior and lateral chest radiographs were selected from the files of a hospital specializing in the care of patients with tuberculosis. The films were placed on a standard view box at the Medical Station. The interpretations of a panel of three observers, located in the emergency ward of the hospital, were compared with those of the hospital radiologist. There was no disagreement between the classifications made in 77 per cent of the cases. Intraobserver variability was assessed by comparing direct interpretations of the hospital radiologist with those he made 6 months later by television. There was no disagreement between his direct interpretation and those

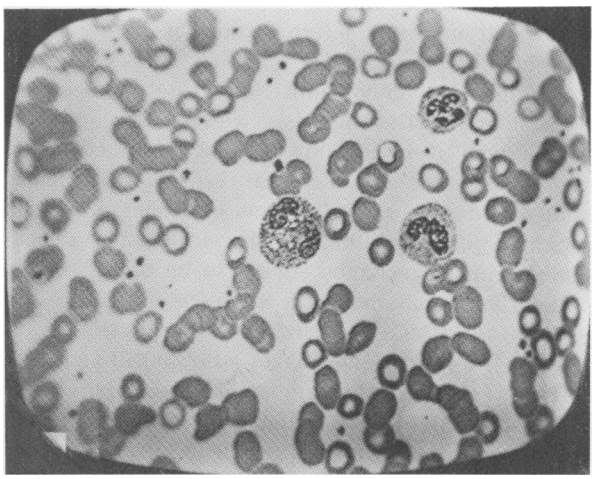

figure 2 Peripheral blood smear visualized by telemicroscope.

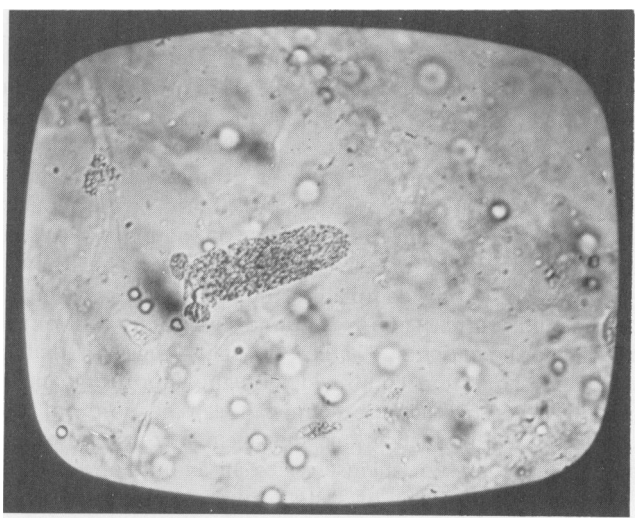

figure 3 Urine sediment visualized by telemicroscope.

TABLE 6—Ten Most Common Presenting Complaints of a Hospital Outpatient Clinic Compared to the Telediagnosis and Medical Station Patient Complaints

	Hospital Clinic		Telediagnosis		Medical Station	
	No. patients	%	No. patients	%	No. patients	%
1. Abdominal pain/discomfort	57	8.5	9	2.7	9	3.7
2. Extremity pain/discomfort/weakness	53	7.9	74	22.0	8	3.3
3. Headache/discomfort	46	6.9	6	1.8	0	0
4. Chest pain/discomfort	45	6.7	23	6.8	7	2.8
5. Tiredness/weakness/malaise	35	5.2	12	0.9	8	3.3
6. To obtain test results	29	4.3	13	3.9	9	3.7
7. Dizziness	29	4.3	3	0.9	11	4.5
8. Back pain/discomfort	25	3.7	15	4.5	4	1.6
9. Nausea/vomiting	24	3.6	4	1.2	9	3.7
10. Cough	23	3.4	5	1.5	0	0
Totals	366	54.5	164	46.2	65	36.6

made by television in 90 per cent of cases. In our opinion these observations compare favorably with the observer disagreement in direct interpretation of chest roentgenograms noted by others.[4,6]

Currently, the major limitations to telemedicine are in the realm of physical diagnosis. Newer techniques can be developed but it is not now feasible to practice certain forms of medicine at a distance. Gynecological palpation cannot be done currently. The practicing physician is commonly put in a situation wherein he must select the diagnostic maneuvers most likely to be useful and often functions in the absence of a complete evaluation. In this regard telediagnosis is not always less accurate than direct diagnosis. If a practitioner makes a house call and neglects to bring his electrocardiogram and microscope, he is unable to diagnose myocardial infarction or renal colic as accurately as can be done by this telediagnosis system.

Application

To provide perspective on the relevance of this experience to the practice of medicine in other settings, the presenting complaints of 500 consecutive telediagnosis patients were compared to a sample of Massachusetts General Hospital outpatients.[7] Although the medical problems seen at the Logan Medical Station were thought to be less serious than those seen at the parent institution, the discrepancy was not as large as expected. The 10 most common presenting complaints found in 54.2 per cent of the hospital outpatients were found in 46.2 per cent of the telediagnosis patients (Table 6). This suggests that a telediagnosis system combined with the apportionment of certain tasks to the nurse-clinician can be used for the initial medical evaluation and management of many of the patients who present themselves to an ambulatory medical care facility. This type of system must, of course, be tried in other settings to explore its full potential and limitations.

Conclusions

In a setting such as herein described, telediagnosis is feasible. A telecommunications system with a professional nurse serving as a clinician can be used to increase the availability of medical care. The technology required is currently available. This kind of system can help bring special knowledge and skills to remote as well as less remote but medically disadvantaged areas. The challenge to those interested in patient care is to find ways to translate the feasible into the real.

Summary

Physicians at the Massachusetts General Hospital provided medical care to 1000 patients 2.7 miles away at the hospital's Logan International Airport Medical Station using a two-way audiovisual microwave circuit. Evaluation of diagnosis and treatment of the nurse-selected patients was made by participating personnel and independent physician observers. Analyses of the accuracy of the microwave transmission of specific components of medical diagnosis were also made. Inspection, auscultation, and interpretation of roentgenograms and microscopic images were readily performed despite the intervening distance. Percussion and palpation were done by the nurse-clinician. Rapport between the physician and his patient was readily established. This study demonstrated that telediagnosis, meaning diagnosis at a distance can be used to increase the availability of quality medical care.

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APHA CONFERENCE ON VIRUSES IN DRINKING WATER TO BE HELD IN MEXICO, JUNE 9–12

An invitational conference on the public health hazards of viruses in water will be sponsored by APHA June 9—12, 1974, in Mexico City. The meeting has been made possible by a grant from the Carborundum Company of Niagara Falls, N.Y.

Objectives of the conference, as determined by an APHA planning committee, are to: bring together and update information on whether viruses are an ecological and public health problem in water; identify the "state of the art" of isolating and identifying viruses in water, including the sensitivity of recovery in polluted waters; exchange information on studies and methods currently in progress; and exchange information to determine which specific viruses constitute a public health problem.

Members of the planning committee, representative of university, health department, and federal regulatory interests, include Berg; Howard Bodily, PhD, professor of microbiology, Brigham Young University, Salt Lake City; Lennette; Joseph Melnick, PhD, professor and chairman, department of virology and epidemiology, Baylor College of Medicine, Texas Medical Center, Houston; and Theodore Metcalfe, PhD, professor of virology, University of New Hampshire, Durham.

The three-and-a-half day conference will feature technical papers, followed by group discussions, focusing on problems associated with both viral contamination and viral assay of water supplies. The conference structure will enable participants to determine a set of recommendations during the meeting on viruses in water. Conference organizers expect the meeting to result in the unification and updating of current knowledge and research efforts in the field; a review and delineation of the research techniques and methods used to recover viruses from water; the development of a roster of researchers and laboratories involved in studies of viruses in water.

Attendance at the conference will be limited to 150 invitees, selected from the leading scientists and engineers in the world. For further information about the conference, contact Richard L. Wade, PhD, the project's director, and director of APHA's Department of Program Services, at Association headquarters.