Teledentistry in Rural California: A USC Initiative

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Abstract

Dentistry, in a synergistic combination with telecommunications technology and the Internet, has yielded a relatively new and exciting field that has endless potential. "Teledentistry" emerges from the fusion of dental practice and technology and can take on two forms — real-time consultation and "store and forward." The first entity to put teledentistry into practice was the Army, which, in 1994, successfully undertook consultations between dentists and service personnel located more than 100 miles apart. Since then, various institutions and organizations in the United States and farther afield have practiced teledentistry, with varying degrees of success. The Children's Hospital Los Angeles Teledentistry Project, being run in association with the University of Southern California's Mobile Dental Clinic, seeks to increase and enhance the quality of oral health care that is provided to children living in remote rural areas of California, areas often severely underserved by dental health providers. The project has three phases: Phase I involves the establishment and organization of the teledentistry network; Phase II will introduce technologies to provide orthodontic consultation and treatment; and Phase III will expand the network and provide increased specialty care into further areas of California and beyond, providing services to more children in desperate need of dental health care.

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Teledentistry is a combination of telecommunications and dentistry, involving the exchange of clinical information and images over remote distances[1] for dental consultation and treatment planning. Utilizing state-of-the-art electronic applications and broadband capability, teledentistry seeks to provide and/or support dental care in areas underserved by dental practitioners, transcending social, geographic, and cultural barriers.[2,3]

Forms of Teledentistry

Teledentistry can take two forms: real-time consultation and "store and forward."[2-5] Real-time consultation involves a videoconference in which dental professionals and their patients, at different locations, may see, hear, and communicate with one another in real time using advanced telecommunication technology and ultra-high-bandwidth network connections. Store and forward, on the other hand, involves the exchange of clinical information and static images collected and stored in the telecommunication equipment. In store and forward, the dental practitioner collects all the required clinical information and digital intraoral and extraoral images and radiographs (or scanned, originally nondigital images) and forwards them for consultation and treatment planning via established networks and/or the Internet. Later, dentists are dispatched to the remote areas and treatment provided in a far more timely, targeted, and cost-effective manner.

Technological Requirements

To practice teledentistry, there are certain hardware, software, and network connection requirements. A desktop or laptop computer with substantial hard drive memory, a significant amount of RAM, and a speedy processor is essential. A digital camera, video camera, and intraoral camera are required for the capture of images. A panoramic digital X-ray unit, preferably portable, is required to provide consulting dentists with images of maximum clinical value. These radiographic systems interface with charged-coupled devices, complementing metal oxide semiconductors, or storage phosphor plates as image receptors to facilitate the acquisition of images in digital format and to greatly enhance the speed of transmission.[3]

A comprehensive data/patient management software application capable of image acquisition and storage, as well as the accumulation of clinical information and subsequent transmission of the gathered information, is highly desirable for the practice of teledentistry, although both images and narrative text may be stored and transmitted as word processing or other basic file types. Digital images for teledentistry transmission should be recorded in DICOM (digital imaging and communications in medicine) format. This is a standard developed by the American College of Radiology and the National Electrical Manufacturers Association. DICOM is a combination of the open systems interface levels developed by the International Telecommunications Union in medical imaging applications and the transfer control protocol/international protocol developed by the U.S. Department of Defense.[4] Definitions of acronyms used are presented in **Table 1**.

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There is great variation in levels and speeds of connectivity to the Internet; and this is, of course, of major significance to the practice of any of the numerous forms of telehealth. Dial-up connections, though economical, are not sufficient for teledentistry, due to limitations in quality and questionable reliability. Broadband technology, increasingly widespread and available, offers a selection of cutting-edge alternatives well suited to the needs of the teledentist and his staff. DSL (digitally subscribed line), cable and satellite modems, ISDN (integrated service digital networks) and ultrahigh-capacity T1 services, are all available for utilization as the basis of any teledentistry system.

To enable live videoconferencing, one might employ a widely available standalone IP/ISDN videoconferencing solution, or install a PCI codec board into the system. This is a digital signal-processing unit that converts analog input into digital on the sending end, while another codec board reverses the mechanism at the receiving end. If a live group session is desired, a multipoint control unit that bridges three or more parties is required. The codec must be able to accommodate audio and visual functions and be compliant within recommended guidelines.[3]

Legal Issues

Legal and compliance considerations are significant for all areas and types of telemedicine, including teledentistry. Largely still untested in law, and with significant variation among states, issues such as accountability, licensure, jurisdiction, liability, privacy, consent, and, of course, malpractice, are crucial to consider when attempting to establish sound foundations for telehealth practice.

Table 1

Glossary of Technological Terms in Teledentistry

Cable modem: Connection speed is typically 3-50 Mb/s over a distance of 100 km or more. The cable modem termination system can talk to all the cable modems, but the cable modems can only talk to the system. If two cable modems need to talk to each other, the system will have to relay the messages.

DICOM: The digital imaging and communications in medicine standard was created by the National Electrical Manufacturers Association to aid the distribution and viewing of medical images. A single DICOM file contains both a header (which stores information about the patient's name, type of scan, etc.), as well as all of the image data.

DSL/ADSL: Digital subscriber line/asymmetric DSL. This is a technology that exploits unused frequencies on copper telephone lines to transmit traffic typically at multi-megabit (6,000 kb/s) speeds. ADSL offers differing upload and download speeds and can deliver up to 6 Mb of data per second. This is 120 times faster than dial-up service and 100 times faster than ISDN. ADSL enables voice and high-speed data to be sent simultaneously over the existing telephone line. This service is generally offered in urban areas.

Ethernet/LAN: An Ethernet (local area network) connection is 10 Mb/s or 100 Mb/s and is used to connect many computers that can all "talk" directly to each other. Normally they will all talk with a few servers and printers, but the network is all-to-all. The distance is normally limited to less than 1 km.

ISDN: Integrated services digital network. This is a system of digital phone connections. Voice and data are carried by bearer channels (B channels) occupying a bandwidth of 64 kb/s and data channels (D channels) that handle signaling at 16 kb/s or 64 kb/s, depending on the service type. There are two types of ISDN service: basic rate interface and primary rate interface. BRI consists of two 64 kb/s B channels and one 16 kb/s D channel; this service meets the needs of most individual users. PRI is intended for users with greater capacity requirements. It consists of 23 B channels and one 64 kb/s D channel for a total of 1,536 kb/s. To establish this ISDN service, special adapters and routers are required.

OSI: Open systems interconnection is a standard description or "reference model" for how messages should be transmitted between any two points in a telecommunication network. Its purpose is to guide product implementers so that their products will consistently work with other products.

PCI codec: PCI stands for peripheral component interconnect, which is an interconnection system between a microprocessor and attached devices in which expansion slots are spaced closely for high-speed operation. Codec stands for compression/decompression. It is an algorithm, or specialized computer program, that reduces the number of bytes consumed by large files and programs. To minimize the amount of storage space required for a complicated file, such as video, compression is used; for viewing, a decompression algorithm, which "undoes" the compression, would have to be used.

TCP/IP: Transfer control protocol/international protocol is a set of protocols developed to allow cooperating computers to share sources across a network.

Satellite modem: This is the technology of choice for rural Internet users where DSL and cable services are not available. It uses two-way (upload and download) data communications. Upload speed is about one-tenth of the 500 kb/s download speed. Satellite systems are about 10 times faster than a normal dial-up modem. Cost is a major factor in employing satellite Internet systems.

T1: A T1 line can carry 24 digitized voice channels, or it can carry data at a rate of 1,544 kb/s. T1 lines carry about roughly 60 times more data than a normal dial-up modem.

Licensure

Licensure of teledentistry practice largely depends upon the state's definition of teledentistry and upon its interpretation and perception of the nature of the doctor-patient relationship therein. In 2000, 20 states enforced restrictive licensure laws requiring practitioners to obtain full licenses to practice across state lines. Alabama, Oregon, and California allowed the obtaining of a restrictive license for this practice by reciprocity; and the other 27 states and the District of Columbia had not passed any legislation requiring licensure for telemedicine or teledentistry practice (**Table 2**). Information on telemedicine state licensure today does not appear to be readily available.

Malpractice/Jurisdiction

In the event of malpractice, teledentistry practitioners can be sued in the jurisdiction of the state in which their patients reside. The malpractice issue is a major legal obstacle to overcome. As the law stands, malpractice may only occur if a doctor-patient relationship has been established. The main question is whether a doctor-patient relationship has been established within the scope of teledentistry. It is very likely that legislatures will mandate that a doctor-patient relationship does, indeed, exist in teledentistry because of the advanced technological abilities to have the patient, primary care dentist, and the consulting doctor present at the same time via video conference. Final resolution of this critical issue is likely to happen soon.

Standard of Care

The standard of care is also a key issue to be resolved. A number of issues have been raised by Golder and colleagues:[5] Is the standard of care the same in teledentistry situations as it is in a traditional person-to-person situation? What are the implications of using different standards of care for insurance reimbursement?

HIPAA

With the enactment of the Health Insurance Portability and Accountability Act, emphasis on the regulatory aspect of the electronic exchange of data has greatly increased.[6] Measures to maintain security, ensure privacy, guarantee that patient information is safely backed-up, acquire informed consent from patients using teledentistry are all focal points of HIPAA.

There has always been a general concern about the transmission of sensitive patient information over the Internet. It is imperative that practitioners of teledentistry do their utmost to ensure that patient privacy is not compromised by unauthorized entities. Encryption of the data in transit, login and password protection, user logs, and firewalls are all measures that should be employed to protect patient information. Another important aspect of electronic data is the preservation of content integrity. It is in the best interests of all those involved in health care provision — patients, providers, insurance companies, and legislative bodies — to ensure that data remains untainted. The best way to ensure this is to have regular, reliable back-up and storage of the electronic information.

Informed Consent and Teledentistry

Informed consent is an integral part of the doctor-patient relationship in any area of health care. In teledentistry, it should cover everything that would exist in a standard, traditional consent form; in addition, it should advise the patient of the inherent risk of improper diagnosis and/or treatment due to failure of the technology involved. Patients should be made aware that their information is to be transmitted electronically and the possibility exists that the information will be intercepted, despite maximum efforts to maintain security. The form should contain the name of both the referring and consulting practitioners to ensure adequate coverage for malpractice, and the consulting doctor should acquire a copy of the consent before any form of patient contact is established.[7]

Pilot Teledentistry Trials

Teledentistry has been practiced for at least five years,[3,8-10] most notably by the Department of Defense. Although most projects remain in the experimental stages, the positive outcomes and positive physician-patient experience are very encouraging.

Army

The Army conducted its first pilot study of teledentistry at Fort Gordon, Ga., in July 1994. Fifteen periodontal patients were referred for surgery. One week after surgery, each patient reported to Fort McPherson, Ga., for suture removal and intraoral imaging. At the time of suture removal, color still images were transmitted over a 9,600 baud modem from the dental clinic at Fort McPherson to Fort Gordon, a distance of 120 miles, for examination by the periodontist who performed the surgery. Of 15 patients, 14 avoided the return trip to Fort Gordon. Since then, the U.S. military has expanded teledentistry into a full-time project employed at bases worldwide.

Taiwan

Another feasibility study was undertaken between Chin-Shan group health center and National Taiwan University Hospital.[10] The hospital had originally sent a group of dental residents to Chin-Shan, a township of 17,000 people that lacked dental care resources. However, it was forced to cease operations due to cost-ineffectiveness for the provider. Instead, the hospital dispatched its teledentistry team of one resident equipped with an intraoral camera, a digital radiographic system, and a software application to transfer all the images to the hospital. Videoconferencing systems were also used for the resident to consult super-

Table 2

Legislative Status of Telemedicine Licensure By State[8]

Restrictive
Arizona
Colorado
Connecticut
Florida
Georgia
Hawaii
Illinois
Indiana
Kansas
Mississippi
Missouri
Montana
Nebraska
Nevada
North Carolina
Oklahoma
South Dakota
Tennessee
Texas
Virginia

No Action
Alaska
Arkansas
Delaware
District of Columbia
Idaho
Iowa
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
New Hampshire
New Jersey
New Mexico
New York
North Dakota
Ohio
Pennsylvania
Rhode Island
South Carolina
Utah
Vermont
Washington
West Virginia
Wisconsin
Wyoming

Reciprocal
Alabama
California
Oregon

vising dentists at the hospital for assistance with diagnosis and treatment planning, as well as for the monitoring of treatment procedures performed by the resident. This pilot project served to demonstrate the effectiveness of teledentistry in providing dental care to individuals living in a remote area and the viability of remote specialty consultations when required. At the same time, residents at the teaching institution can readily participate in the consultation at University Hospital, thus having the opportunity to experience cases that may not be commonly observed at educational settings.

Domestic Teledentistry Programs

Baylor College of Dentistry Center for Telehealth is one of the few organized, fully funded institutions pursuing teledentistry. A "grand-round" like setting was described for the teledental consultation.[3] University of Pennsylvania and Oregon Health Sciences University have similar programs. University of California at Los Angeles researchers have also conducted a pilot study involving oral medicine consultation via e-mail.[10]

Children's Hospital Los Angeles Teledentistry Project and the USC Mobile Dental Clinic

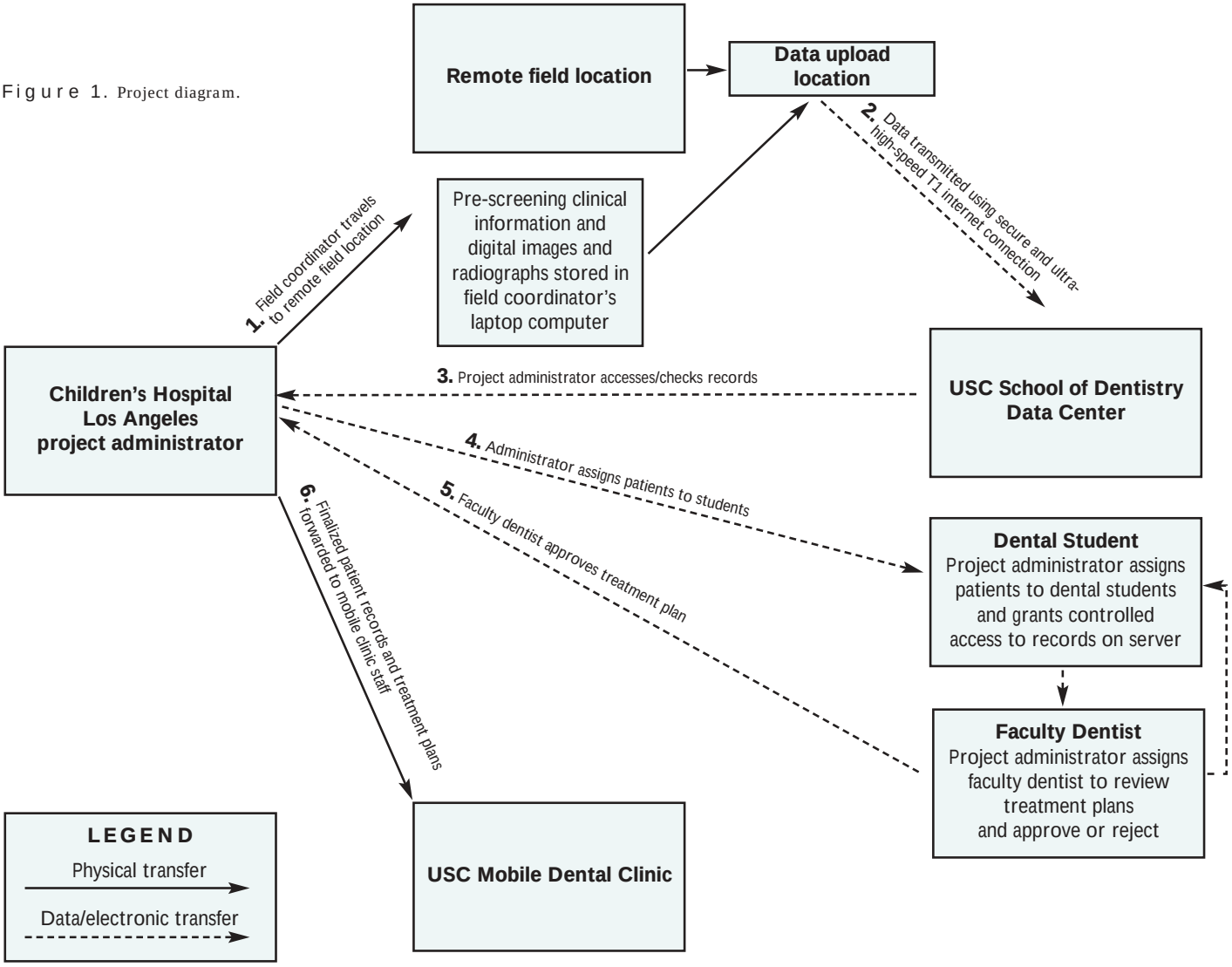
The goal of the Children's Hospital Los Angeles and University of Southern California School of Dentistry Teledentistry Project is to merge successfully with the existing USC Mobile Dental Clinic to use teledentistry technology to increase and enhance dental services for children in rural underserved areas of California. Later, the project will provide orthodontic consultation for these children and specialty consultations from all other areas of dentistry. Currently, the USC Mobile Dental Clinic, in existence since 1965, provides more than $2 million worth of dental care each year, at no cost, to children of low-income families throughout California.[11,12] It has proved to be a vital resource in addressing the oral health needs of children from areas lacking in dental practitioners, as well as proving to be an invaluable educational tool for dental and dental hygiene students from USC and UCLA. The mobile dental clinic provides oral examinations, X-rays, dental prophylaxes, nutritional counseling, fluoride treatments, sealants, amalgam and composite

restorations, stainless steel crowns, endodontic treatment for primary teeth, extractions, and minor oral surgery. Currently, the mobile clinic is forced to refer out orthodontic treatment, endodontic treatment on permanent dentition, and other subspecialty treatment to external practitioners in the area. These treatments often do not take place due to financial and cultural reasons. The way in which the teledentistry project will enhance the activities of the mobile clinic is described in the following text and in **Figure 1**.

Project Outline

In Phase I of the project, two to three weeks in advance of the mobile clinic's visit to a particular area, a field coordinator will travel to that location to collect and forward patient's clinical information and digital images, in fully HIPAA compliant manner, to the teledentistry servers that will reside in the data center at USC School of Dentistry. Thereafter, dental students who serve at the mobile clinic, using advanced patient management software, will review the patient information, diagnose conditions, and make treatment recommendations. These treatment plans will then be reviewed by faculty dentists, who will either approve the recommended plan or make further treatment suggestions. The finalized treatment plans will be forwarded to the staff of the mobile clinic who can then greatly streamline the patient flow into the clinic in the field, eliminate field screening days, ensure the clinic is fully stocked with required equipment and supplies, and schedule visits from faculty dental specialists.

Figure 1. Project diagram.



All these factors will serve to increase the number of children able to be seen by the clinic and the nature and quality of the treatment provided.

Furthermore, since the equipment and data flow utilized by the project will overlap the systems employed at USCSD, the project will offer previously impossible educational opportunities to dental and dental hygiene students. Clinical consultation aside, HIPAA compliant de-identified patient data may also be used as course material to expose students to various aspects of rural dentistry and increase their knowledge of pediatric oral health care. Currently, the pediatric requirements at teaching institutions are minimal; graduates must gain experience through self-learning and /or postdoctoral residencies. One reason for this is that pediatric patients are known to be behaviorally challenged, and there is little or no facility to train dental students in this aspect of treatment provision. Through the Children's Hospital Los Angeles/USC Teledentistry Project, students and faculty dentists can focus on assessing the patient's oral needs via the computer without needing to be attentive to behavioral issues. Following clinical consultation, when in the field, the student/faculty team can then devote more attention to the management aspects of the child's behavior, feeling assured that they have thoroughly diagnosed the oral disease and developed an appropriate plan of treatment. Furthermore, the direct student interaction and consultation with faculty dentists, via e-mail and patient management software, is a critical aspect of the project, allowing for real treatment planning of real patients. Follow-up on patients, currently difficult for the mobile clinic to sustain, will be far easier with the permanent electronic medical record the project will create for each patient. A single field coordinator can return to the area of the original prescreening to monitor changes in the oral health status following mobile clinic treatment, updating the patient records through the teledentistry system. The child can then be referred to local dentists for specific treatment or await the return of the mobile clinic to the area.

In Phase II, the project will introduce technologies to provide orthodontic consultation and treatment through the mobile dental clinic. Orthodontic consultation can point toward the need for preventive measures or actual treatment.

In fact, many orthodontic problems may be prevented or alleviated if the problems are recognized and addressed early enough. For this reason, the American Association of Orthodontists recommends that every child have an orthodontic consultation by the age of 7. The specific details of the plans for orthodontic consultation through the Children's Hospital Los Angeles/USC Teledentistry Project will be discussed in another article.

After the successful implementation of Phases I and II, the foundations will have been firmly laid for the expansion of the Children's Hospital Los Angeles/USC Teledentistry network as well as other specialty services, into more underserved areas in California.

Anticipated Accomplishments

It is anticipated that the Children's Hospital Los Angeles/USC Teledentistry Project will:

1. Improve dental health in underserved communities through education, early diagnosis, treatment, and prevention, all aided by the increased access and operational efficiency made available through the use of teledentistry technology.

2. Reduce oral health disparity. Oral health disparity has been identified by the U.S. surgeon general as a key issue demanding attention by dental health practitioners.[13] Limited access to care is one of the primary factors leading to the great disparity. Through teledentistry technology, it is hoped that this disparity can be decreased by the provision of comprehensive dental care to areas with a shortage or absence of dentists. Teledentistry can also greatly reduce the distances patients must travel to receive dental care.

3. Expedite the triage process by assigning patients to different treatment categories before the arrival of the USC Mobile Dental Clinic. This will free up significantly more patient contact time for the clinic to provide care on site.

4. Improve inventory and supplies management. Knowledge of the anticipated treatment procedures will greatly assist the stocking, handling, and ordering of dental inventory and supplies. This advanced knowledge will be particularly useful if specific instruments or supplies are required. A key goal of the project is to reduce inventory and supply burden yet improve preparedness.

5. Advance dental education for students. Students will enjoy virtual, "hands-on" experience in the diagnosis and treatment planning of pediatric cases. With advance information on the procedures to be performed, students can be more prepared by practicing and reviewing relevant course material.

Teledentistry can greatly reduce the distances patients must travel to receive dental care.

This project will take place within California under the licenses of Children's Hospital Los Angeles and the USC School of Dentistry.

While other organizations are using teledentistry to promote oral health and specialty consultation to those who already have good access to primary dental care, the Children's Hospital Los Angeles/USC Teledentistry Project is unique in that it has the additional component of organized mobile dental clinics, able to travel to remote areas with little or often no access to dental professionals.

The ensuing possibilities are truly enormous. The data and experience to be gleaned from the initial phases of the project will set the stage for more advanced uses of teledentistry, such as therapeutics and emergency care. Additionally, teledentistry approaches may hold the potential to address many of the problems related to access, cost, efficiency, and the general quality of dental care in California and the United States. A successful outcome of this project will lead to implementation of teledentistry at other USC Mobile Dental Clinic sites and will create an ever-expanding network, with Children's Hospital Los Angeles and USC School of Dentistry as its hub, directed toward improving dental care in underserved communities regionally, nationally, and internationally. CDA

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