Employing a Wireless Mobile Solution to Bring
Telemedicine to the Nursing Home Bedside

I) Project Purpose

The Problem: In spite of rapid medical advances and great changes in the healthcare system, access to many services in the long-term care setting continues to be difficult at times, especially in rural areas. Federal law requires that all nursing homes "provide services and activities to attain or maintain the highest practicable physical, mental, and psychosocial well-being of each resident." However, demographic and economic trends are making it extremely difficult for nursing homes to meet this fundamental federal health standard. In 1996, there were 19 million Americans 65 years of age and older (Centers for Medicare & Medicaid Services, 2001). However, this segment of our population has now reached 35 million Americans or 12.4% of the population (United States Census Bureau, 2001). By 2030, the number of Americans aged 65 or older is expected to increase to more than 70 million people, or 20% of the U.S. population (USCB, 1999). The demand for long-term care will logically increase with our aging population. In 2000, there were 1.5 million people living in 17,000 nursing homes in the United States (American Health Care Association, 2001). The U.S. Department of Health and Human Services estimated that 43% of all 65 year olds will use a nursing home at some point in their lives. Of those requiring the services of a nursing home, more than 50% will stay for over a year and more than 20% will stay for more than five years (Health Care Financing Administration, 1998). By 2050, the total number of nursing home residents will quadruple from the current 1.5 million to almost seven million people (AHCA, 2001). The price tag for these long term care services is staggering. In 2003, it is projected that federal, state, and local governments will spend almost $70 billion on nursing home care, from which the overwhelming majority of funding comes from Medicaid and/or Medicare programs.

Obviously nursing home care is a significant player in the health continuum of care. Even though increasing utilization of nursing homes is projected to lead to increased costs for state and federal governments, it should be noted that nursing homes provide *a crucial solution for the absolutely staggering costs of hospitalization for America's elderly*. Research in the 1990s speculated that nursing home care costs less than 20% of comparable length stays in hospitals. In order for nursing homes to provide care at a level that prevents costly hospitalizations while simultaneously meeting federal law of maintaining the highest possible level of patient well being, it is vital that patients have access to a wide range of clinical services. In fact, a study sponsored by the Agency for Health Care Policy and Research conducted with five key nursing home stakeholder groups found agreement on the number one indicator of nursing home services, *quality of care* (Quality of Care, 1999). Quality of care includes all clinical services to facilitate activities of daily living as well as to maximize quality of life. However, obtaining access to certain clinical services, such as a specialized physician consultation, is often impossible in a rural nursing home setting. One study, for example, found that rural providers were more likely than urban facilities to report frequent problems with lack of available services, distance to services, and long waits for appointments (Maine Rural Health Research Center, 1998). In the typical rural nursing home, a patient must be transported to the specialty physician located many miles away or to the hospital at great expense.

The Solution: Telehealth offers the means to bridge the rural nursing home resident with specialty services necessary to provide access to the quality of care required to maximize

patients' well being. More importantly, new solutions in mobile hardware and wireless networking can enable nursing homes to virtually bring physicians from around the state into each patient's room.

This proposal will link three rural Michigan nursing homes (located in Leelenau, St. Clair, and Presque Isle counties) with a total of more than 500 beds to the Masonic Pathways Teaching Nursing home with more than 400 beds located in Gratiot County. This unique teaching nursing home, being implemented in collaboration with Area Health Education Center funding and Masonic Pathways (a 450-bed continuing care retirement center in rural Gratiot County), represents one of the first of its kind in the U.S. and is similar to a teaching hospital. Specifically, MSU clinical faculty and rural-based associates (physicians, nurses, social work, and other disciplines) will oversee the provision of care to nursing home residents while simultaneously providing medical and nursing students with the opportunity to receive advanced training in the provision of nursing home services. Through this telehealth connection, nursing home patients at the three satellite facilities will also have access to the physicians and other licensed providers at the MSU Teaching Nursing Home. In addition, the three satellite nursing homes and the MSU Teaching Nursing Home will also be linked to specialty physicians (i.e., geriatric psychiatry, neurology, pharmacy, cardiology, wound care specialist/dermatology) practicing at MSU. *Appendix B* provides a map of the location of the facilities covered within this proposal, and *Appendix C* provides a diagram of the organizational service chart for this project.

To date, the handful of telehealth projects implemented in nursing homes have been limited by technological constraints. For example, equipment is typically located in a centralized room and patients have to be transported to the telemedicine room, a great challenge for bed bound or ill patients. We propose to employ an innovative solution to embed telehealth within the current structural and organizational constraints inherent in any nursing home facility. Specifically, this project will implement a wireless videoconferencing system that will let providers bring a mobile videoconferencing unit into a patient's room, comfortably connecting a patient and consultant. To accomplish this, several pieces of technology will be used to create a videoconferencing system that can be delivered without bulky carts to a patient's room:

- The first piece of the puzzle is the Tablet PC, the next step in the evolution of personal computing. Tablet PCs feature high-resolution screens that can receive input through the screen with a stylus (much like a PDA), extended battery life (4 hours or more), and are ultra-portable (.8 inches thick, 3 pounds). They also feature Transmeta's Crusoe processor, specifically designed for fast processing and long battery life.
- Second, Polycom ViaVideo personal videoconferencing software will be installed in the Tablet PCs and the camera units will connect to these Tablet PCs via a USB port. These ViaVideo units are not large, and should not hamper the mobility of the Tablet PCs to which they will be attached for the purposes of this project. The ViaVideo hardware and software support full-screen, full-motion video at up to 512kbps, at 30 frames per second. The Polycom software also enables integrated data sharing and collaboration. A Tablet PC (with a 10.4 inch screen) and a Polycom ViaVideo unit (1.6 inches high, 5.0 inches deep, and 3.5 inches wide) will easily fit on a patient's bedside stand. The Polycom camera can be moved around to pan across a patient's

body, if necessary, and the patient will be able to see the specialist via the Tablet PC on their bedside stand.

- The third piece of this system will be a wireless network operating on the industry standard 802.11b protocol. The 802.11b protocol is the most common wireless local area network (WLAN) technology in use today, and operates at speeds of 11Mbps. Wireless access points will extend the existing LAN infrastructure of these facilities, making use of existing wiring to spread access points – and thus the WLAN – across an entire nursing home facility. Steps will be taken to secure the WLAN to ensure patient privacy, including Wired Equivalent Privacy (WEP), disabling dynamic host control protocol (DHCP) addressing, and MAC address filtering.

The rural nursing homes located in Leelenau, St. Clair, and Presque Isle counties will link to the teaching nursing home in Gratiot County for clinical and teaching services. If patients at the three rural nursing homes or the teaching nursing home require consultation from a specialist not available at the teaching nursing home, they will simply link with a specialist located at Michigan State University's College of Human Medicine in Lansing, MI. A wireless network with PC Tablets will be set up at the three rural nursing homes and the teaching nursing home. The three rural nursing homes and the teaching nursing homes will use ISDN lines to connect to experts outside the facility using this system. ISDN lines running at 384kbps will provide adequate bandwidth for the videoconferencing system and provide greater security than more common cable modem and DSL broadband alternatives. The Tablet PCs will be able to videoconference over the ISDN connection from any location in the building via the 802.11b WLAN. The Tablet PCs will access a gateway, which serves to convert the IP protocol of the WLAN to the H.320 protocol used by the ISDN lines. In addition, grant funds will be employed for a desktop videoconferencing system to be placed in the teaching nursing home to be used for physician consulting and precepting to the three rural facilities. Any teleconsults with physicians at MSU in Lansing will be conducted via existing telemedicine equipment currently available at MSU's College of Human Medicine.

Measurable Outcomes: The goals of this project are to (1) find cost effective ways to maximize access to clinical services for nursing home residents through a wireless, mobile solution, (2) increase the quality of care through the enhanced access, and (3) demonstrate an impact on medical outcomes for these nursing home residents. Expected outcomes include decreased hospitalizations and emergency room visits, decreased transportation costs, increased access to a wider range of services, enhanced quality of life, and improved patient and provider satisfaction. Attainment of these outcomes will be measured through three research questions:
RQ1: Is access to services quantitatively impacted and what are the outcomes?
RQ2: What is the average cost and savings associated with the creation of this wireless telehealth network?
RQ3: What are the optimal delivery procedures for this innovation and how does this service impact patient and provider satisfaction?

II) Innovation
This project looks to combine several new technologies – Tablet PCs and wireless local area networks (WLANs) – to bring health services to nursing home patients. Tablet PCs are at the cutting edge of personal computing technology, and are just now being mass-produced and

marketed to the public. Research has demonstrated that too many telehealth projects do not succeed because they ignore existing organizational and delivery practices (Whitten, Adams & Davis, 2003; Whitten & Adams, in press; Whitten & Rowe-Adjibogoun, 2002; Cook & Whitten, 2002; Whitten & Allen, 1995). Indeed, to be successful, telehealth must be designed to work within the existing mechanisms to deliver care. This is particularly salient for a context such as nursing homes where additional resources would be required for telehealth facilities, transporting bed bound or ill patients to the specialized telehealth facility, or covering the costs of providing telecommunication linkages in every patient's room. Combining the mobility and ease of use of Tablet PCs for synchronous videoconferencing with a wireless local area network will provide a new, innovative way to let healthcare experts visit nursing home patients right in their own rooms. A WLAN covering the nursing home will provide improved flexibility, enabling videoconferencing throughout an entire facility – instead of limiting it to a particular videoconferencing room. And by putting PC-based videoconferencing systems into the offices of key medical experts, the level of care available at these nursing homes will be improved as experts make consultations via the videoconferencing system. Letting an expert "visit" a nursing home patient in their room via this system when the expert is miles away would be a remarkable service to offer nursing home residents, and improve providers' ability to offer the best healthcare possible.

This project will serve as a model for other nursing homes around the country wishing to establish an efficacious wireless videoconferencing system for clinical care. Implementing a WLAN as this project does should be a relatively simple exercise at most facilities, as it simply involves setting up wireless access points that make use of existing infrastructure and LAN wiring. And as Tablet PCs become more and more common in healthcare settings, this could become a relatively simple project for a provider to implement using hardware already in use at a healthcare facility.

III) Community Involvement
Partnerships: This project is comprised of key partners enthusiastically embracing this project. This project represents a win-win solution for everyone: access to clinical services is enhanced for nursing home residents; nursing home providers' resources will be eased in the long term and; specialty providers will be able to reach out to rural patients. *Appendix D* outlines the roles and responsibilities for each partner. *Appendix E* contains a detailed list of all members of this partnership, and their role in the project. *Appendix F* provides letters of support which document the commitment of each partner. Partnership relations will be maintained through the grant period through quarterly videoconferenced meetings of the entire team; development of a team website with posted procedures and protocols, contact information for all participants, updated activities and timelines; biannual site visits by the project management team and; joint community and state presentations during the course of the project.

Community Involvement: Michigan State University has played a leading role for more than 15 years in the Geriatric Education Center of Michigan (GECM), a federally funded program to further the knowledge and skills of physicians in the care of the elderly. GECM, a collaborative initiative with other universities and providers in MI, has developed a pragmatic mission to meet its goals. For example, training programs for nursing home physicians have been implemented as an on-the-job training curriculum for eight weekends per year with an annual review of all

participants. As follow-up to the successful reception of this program, Dr. Larry Lawhorne has further developed this network of nursing facilities with active involvement in nursing facility associations and government services and regulatory agencies. As a result, the past several years have evidenced widespread requests from community practices throughout Michigan for physician education to facilitate better care for the elderly. As a part of this educational mission of the GECM, MSU recently obtained approval from the Agency of Research for Quality Care (ARCQ) for an Area Health Education Center program to launch a teaching nursing home at a rural site removed from the actual medical school, located at the Masonic Pathways facility in Alma. The establishment of this rural teaching nursing home represents significant, long-term collaborative efforts from stakeholders around the state (e.g., Michigan Association of Homes and Services for the Aging, Michigan Department of Community Health, Michigan Primary Care Association, American Medical Directors Association). In line with these longitudinal efforts to enhance services for rural elderly, these stakeholders have participated in preliminary planning efforts to launch an innovative, pragmatic telehealth solution for rural nursing homes. Preliminary planning meetings and offline correspondence resulted in the decision to pursue development of a wireless network employing Tablet PCs. This solution was developed with important input from rural facilities stressing the need for wireless and mobile technology. Project participants have agreed to attend preliminary planning meetings, assist in developing procedures, aid in technology deployment, and provide data for the evaluation of this project. Communication strategies to continue and enhance this community involvement include project website with listserv, monthly meetings for the first three months of the project, quarterly meetings for the remainder of the project, and dissemination of quarterly updates and evaluation results to date.

It is important to note that interest and support for this project extend beyond Michigan's borders. Dr. Lawhorne, project co-PI, has been tasked with leading national efforts through the American Medical Director's Association (AMDA) for research to improve the care of frail elderly at nursing homes through the country. As past president and current foundation director, Dr. Lawhorne is a prominent member of the AMDA.

Support for End Users: Project staff will implement, test, and maintain the wireless LAN at each participating nursing home. In addition, project staff will install and test videoconferencing software on Tablet PCs and coordinate any correction of equipment problems with vendor. Training in the utilization of the Tablet PC solution will be provided to key staff at each of the three satellite nursing homes and the MSU Teaching Nursing Home. The graduate research assistant for this project, Michael Mackert, has extensive experience (see biosketch in Appendix H) as a hardware and network administrator and will be able to provide ongoing technical support for the duration of the project. Finally, training will be provided for any consultant new to the use of telehealth at the specialty locations.

IV) Evaluation and Dissemination
Evaluation Plan: The strength of this telemedicine proposal is its focus on an evaluation plan that will answer vital questions far beyond the simple feasibility of this project. In order to provide information that can be utilized for future telemedicine projects, the evaluators seek to measure clinical outcomes, track expenses to analyze the cost effectiveness of this service, and

measure procedures and resources involved in establishing and delivering a full continuum of services for nursing home patients.

Evaluation Questions:
Evaluation Question 1: Appropriate Clinical Services and Outcomes
1a. What range of clinical services can be delivered via the wireless, mobile telehealth network?
1b. Do nursing home residents access more services due to wireless network telehealth system?
1c. Are there variations for outcomes for patients receiving telehealth services?
Evaluation Question 2: Cost Issues
2a. What is the average cost to provide telehealth services for the nursing home residents?
2b. What potential cost savings are there for a) the healthcare system and b) the patients?
Evaluation Question 3: Delivery of Telehealth Services via Wireless Network to Nursing Homes
3a. What procedures/protocols are necessary to provide wireless network telehealth services?
3b. Are patients and providers satisfied with the use of wireless network telehealth solution to deliver clinical services?

Data collection and analysis: The methodology for data collection and analyses will vary for each of the four research themes.
Evaluation Question 1: Access to clinical services and outcomes
1a. A telehealth note will be created for all telehealth consults to include a description of all the services provided via the telehealth wireless network. Data will be entered into database and content analyzed for frequency and range of services provided.
1b. Chart analyses will be conducted on all telehealth patients with all services, tests and treatments coded into a database. An equal number of randomly selected charts for non telehealth patients cared for in the year before the project will be analyzed in the same way. The Minimum Data Set (MDS) is a standardized survey instrument which every nursing home is required to complete for every resident by the Centers for Medicare and Medicaid. Data form the MDS (e.g., cognitive patterns, physical functioning, psychosocial well being) between the two groups will be compared for significant differences in the frequency and range of services provided for patients in both groups.
1c. Variables recorded in the nursing home chart database systems through the MDS will be extracted for telehealth patients and compared to regional and national data available to gage any differences in specific clinical outcomes, including: average length of stay, ER visits, hospitalizations, medication incidents, changes in functional assessment scores, and MDS reported changes. In addition, data will also be collected regarding employee measures such as turnover and job satisfaction. Employee measures data has a significant correlation with the quality of care for nursing home residents. Means testing will be employed to compare means of telehealth patients to traditional patients.
Evaluation Question 2: Cost issues
2a/b. The cost issue will be addressed by utilizing a costing frame previously employed in telemedicine studies (Doolittle et al., 1998; Doolittle et al., 1997). Estimates of costs obtained from this frame will be collected with data collected from participating patients as well as existing claims data from patients' charts. To track ongoing costs, a log will be maintained. Data to be logged in include: all personnel activity throughout the facility; hours devoted to the project on a weekly basis; training and educational development and provision; technical support requirements; marketing efforts. Once the project is implemented, a spreadsheet will be prepared

to include all relevant ongoing cost categories (e.g., human resources, hardware/software related; telecommunication related; space; supplies). Data on the spreadsheets will be summed by category to provide cost data. In addition, cost estimates will be provided for potential cost savings for healthcare system and the patient for projected transportation costs and inpatient services for patients receiving services via the wireless network telehealth system.

Evaluation Question 3: Delivery of Wireless Network Telehealth Services
3a/b/c. In-depth interviews will be conducted with nursing home staff members to document protocols, procedures and resources needed to provide telehealth care. In-depth interviews and brief surveys will be used to gather data from patients and providers regarding satisfaction and acceptance of telehealth, as well as information needed to improve the delivery of services via the wireless telehealth network. Thematic content analysis will be conducted on all open-ended interview data. Survey data that asks subjects to rate a question on a Likert scale will be analyzed via descriptive statistics. Key nursing home support staff will be required to keep a logbook documenting progress, challenges and obstacles of the project during planning, implementation, and maintenance. This data will be coded using content analytic procedures.

Services for this project will be coordinated through MSU School of Medicine personnel (see biosketches of Drs. Noel and Lawhorne in Appendix H). Pamela Whitten, Ph.D., associate professor in the Department of Telecommunication will coordinate evaluation activities. Dr. Whitten is a well known telehealth researcher with more than 100 peer-reviewed publications and presentations in this area, as well as a critically acclaimed telehealth book.

Dissemination: The challenges of providing access to a full range of care for nursing home residents are so timely that results from this project must be rapidly available to key stakeholders. We will certainly present ongoing results from this project via academic conferences and publications. Conferences will include meetings of the American Telemedicine Association, the American Geriatrics Society, Michigan Medical Directors Association, and the Gerontological Society of America. Papers will be submitted to journals such as the Journal of Telemedicine and Telecare, the Journal of the American Medical Directors Association, the Journal of the American Geriatrics Society, the Journal of Gerontology, and The Gerontologist. However, we also need to reach those audiences that do not commonly attend academic and/or telehealth outlets. One strategy to achieve this goal is to reach state Medicaid offices around the country, as Medicaid accounts for the lion's share of nursing home payments. Armed with data from this proposal, Medicaid providers can share this solution with nursing homes around the country. Study results will be distributed to Medicaid agencies in all 50 states through the Center for Medicare and Medicaid Services. In addition, MSU will partner with MI Medcaid officials to present study results at the National Academy of State Health Policy and other conferences attended by state Medicaid officials. An additional strategy is to share the results with the American Medical Directors Association and Area Health Education Center groups so that other U.S. medical schools can improve education and services for rural nursing home facilities. Finally, to share study data internationally, project evaluators will prepare an interactive website with project dissemination strategies and evaluation results.

V) Project Feasibility
Technical Approach: The decision was made to use Tablet PCs for this project for a number of reasons, but particularly for ease of mobility and the fact that Tablet PCs use an operating system

(Microsoft Windows XP Tablet PC Edition) that is based on the Windows XP Professional platform that has proven to be a reliable and secure operating system. A Windows-based solution is likely to create less of a burden on existing technical support staff, as Microsoft Windows is still by far the most common desktop operating system in use today and most technical support staff should be familiar with Windows.

Using a wireless networking technology with the Tablet PCs should let providers improve the care provided to patients at nursing homes, as the Tablet PCs (and accompanying videoconferencing system) can easily be transported to the patient's room. This is a more effective solution than trying to bring the patient to a room-based videoconferencing system located in another part of the nursing home. The Cisco wireless access points selected for this project make use of the industry standard 802.11b wireless local area network (WLAN) protocol, and should be easy to incorporate into the existing local area networks (LANs) of these nursing homes. The 802.11b protocol was chosen over the newer 802.11a protocol as 802.11a increases bandwidth at the expense of coverage – it would take many more access points to cover the nursing home using 802.11a access points. An 802.11b-based WLAN in these nursing homes will provide more than adequate bandwidth for this videoconferencing application. WLANs of this nature are becoming increasingly popular due to the ease with which they can be integrated into an existing, wired LAN. The WLAN is a seamless, wireless extension of the LAN, enabling wireless access anywhere an access point has been deployed. Maintenance of this system should be negligible once it has been deployed. The WLAN, as it is initially deployed, will have more than enough bandwidth to support these first wireless videoconferencing units. As this system is expanded, though, more access points can be added to increase the system's capacity should a particular access point – and the section of the nursing home it covers – become overloaded.

Specialists, as well as staff at the teaching nursing home, will use PC-based videoconferencing systems to consult with those caring for patients at the nursing homes. PC-based solutions are adequate for the consultants, as they will not need the added mobility afforded by the Tablet PCs.

Applicant Qualifications: A team of experienced and dedicated physicians, nurses, administrators, and support staff from four rural nursing homes will partner with Pamela Whitten, Ph.D., of Michigan State University, who has extensive experience in the administration and evaluation of telemedicine projects. Dr. Whitten has demonstrated the successful deployment, evaluation and dissemination of results through multiple telemedicine projects. She served as the primary author for a TOP evaluation report prepared for a 1999 funded telehospice project that is now posted on TOP's website as an exemplary report. In addition, Larry Lawhorne, M.D. and Mary Noel, Ph.D. from MSU's School of Human Medicine provide important experience with nursing facility care. Dr. Lawhorne has actively developed solutions to improve nursing home services for more than 15 years. Graduate students and support staff from Michigan State University will also assist with the project. Please refer to Appendices D, E, and H for more information about the formal project team.

Project Implementation and Completion: The proposed project will take 30 months to complete. Due to space constraints in the narrative section, a detailed project timeline is provided in *Appendix G*.

Privacy and Security: The security plan for this project includes both a technical and organizational perspective. Steps will be taken to secure the WLAN to ensure patient privacy, including Wired Equivalent Privacy (WEP), disabling dynamic host control protocol (DHCP) addressing, and MAC address filtering. In additional to technical steps to ensure privacy and security, this project will incorporate strict privacy and security operational guidelines required by MSU's Institutional Review Board (Human Subjects Committee). Research cannot be undertaken without this compliance. Finally, project team members from all organizations will create detailed security plan to ensure HIPAA compliance.

Sustainability: A strength of this project is the fact that it is building a service into an existing health infrastructure of providers and payers. The nursing homes already exist in full form equipped with all nursing and administrative expertise to support access to additional patient services. For example, there are nurses on staff 24 hours a day who would be able to present a patient via telehealth to a consultant. Reimbursement mechanisms are in place for Medicare patients and the Michigan Department of Community Health Medicaid office is participating as a project partner to develop Medicaid reimbursement solutions. Thus, when the grant funds for this project are completed, the nursing homes will be able to seamlessly continue the service through the use of their internal resources. In addition to the pragmatic deployment of this project in extant health systems, this project also provides great potential for sustainability because the WLAN system being installed at these nursing homes can also be used for a variety of uses in addition to those specified in this particular project.