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A COST-EFFECTIVENESS ANALYSIS OF THE
SOUTHEAST HEALTH DISTRICT'S
TELEDENTISTRY PROGRAM

BY

Heather Guthrie Peebles
Degree to be awarded: M.P.H.
Career MPH

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Print Name of Committee Chair Date

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Print Name of Committee Member Date

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Melissa Alperin, MPH, CHES Date
Chair, Career MPH Program

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Thesis Committee Chair: [David N. Westfall, M.D., M.P.H., C.P.E]

An abstract of
A Thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements of the degree of
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Abstract

A COST-EFFECTIVENESS ANALYSIS OF THE
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Poverty and a shortage of dental providers present significant barriers to obtaining dental care for residents of rural, Southeast Georgia. To address these barriers the Southeast Health District (SEHD) obtained federal grant funding to support a school-based teledentistry program. This thesis seeks to examine the cost-effectiveness of the SEHD program. One hundred sixty-four children received teledentistry services during the study.

Data was gathered about the costs of equipment, personnel, facilities, parent travel and wages. Cost-effectiveness analysis software was used to perform decision analysis, sensitivity analysis, and a tornado analysis. Some cost-effectiveness equations were performed manually (Average Cost-Effectiveness Ratio, Incremental Cost-Effectiveness Ratio and Marginal Cost-Effectiveness Ratio).An attempt was made to quantify the intangible cost of children's self-esteem based on the results of a parent survey. The analysis was performed with and without considering this intangible cost.

Teledentistry was found to be a cost-effective alternative to traditional dentistry, especially when a dollar value was assigned to the intangible cost. The results indicate that teledentistry is a feasible option for improving access to preventive dental care.

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CHAPTER 1: INTRODUCTION

Public Health Problem

According to the Centers for Disease Control and Prevention (CDC) more than one-quarter of children ages two to five and one-half of children ages twelve to nineteen are affected by tooth decay (Centers for Disease Control and Prevention [CDC], 2010a). In Georgia, more than half of all third-grade students have dental caries and more than a quarter of these students have tooth decay that is untreated (Georgia Department of Human Resources [GDHR], 2007).

Oral Health Disparities

Children from lower income families and from certain racial and ethnic backgrounds are disproportionately affected by tooth decay (CDC, 2010a). The Georgia Department of Human Resources' 'The Status of Oral Health Report in Georgia, 2007, reported that among children enrolled in Head Start, white (27%) and black (26%) children were equally as likely to have untreated dental decay (GDHR, 2007). But the report found that Hispanic children (28%) were more likely to have untreated dental decay when compared to non-Hispanic children (25%) (GDHR, 2007). Iida and colleagues extracted data from the 1999-2002 National Health and Nutrition Examination Survey (NHANES) and found that Mexican-American ethnicity and poverty were independently associated with increased risk of early childhood caries (ECC) **(**Iida, Auinger, Billings & Weitzman, 2007).

Children who reside in rural areas that lack dental providers who accept Medicaid are at an increased risk of poor oral health **(**Mouradian, Wehr, & Crall, 2000). According to Vargas and colleagues, children from rural locales were more likely not to have dental insurance, private or public, and reported dissatisfaction with their oral health when compared to their urban counterparts (Vargas, Ronzio & Hayes, 2003). The number of dentists per capita decreases as the distance from a metropolitan area increases, further inhibiting rural children's access to dental care (Vargas *et al*., 2003). Vargas *et al.* also stated that children living in rural areas are more likely to use well water, which may have low fluoride content depending on the geology of the location (Vargas *et al*., 2003) adding to the increased risk of developing dental caries.

Long-term Effects of Untreated Dental Decay

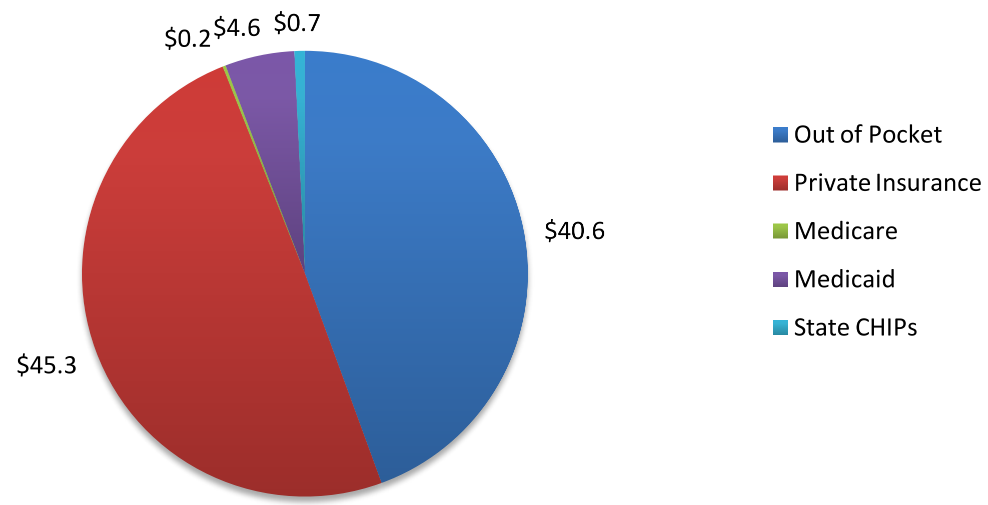
Untreated dental caries, which can lead to periodontal disease (PD), has been linked to adverse outcomes in pregnancy (Babalola & Omole, 2010). Vogt *et al.* conducted a cohort study of low-risk pregnant women (n = 32) and found that PD was a risk factor for pre-term birth (PTB), low birth weight (LBW) and pre-labor rupture of membranes (PROM) (Vogt, Sallum, Cecatti, & Morais, 2010). Poor birth outcomes are concerning because of the significant consequences to maternal and child health. Mothers are more likely to undergo a cesarean section increasing their risk of infection (CDC, 2011a). Infants born prematurely have an increased risk of mortality (CDC, 2011a). If they survive the neonatal period they are still at an increased risk of cognitive disabilities (CDC, 2011a). These factors place an additional burden on social and economic dynamics of families caring for the infants (CDC, 2011a). In 2009, the March of Dimes reported that the first year medical costs of a premature infant were $49,000 compared to $4,551 for a full-term infant (National Center for Policy Analysis, 2009). Intercepting dental caries during childhood has the potential to decrease the risk of adverse pregnancy outcomes, improving maternal and infant health and saving money.

PD has also been linked to Myocardial Infarctions (MI) (Kimmo *et al.*, 1989). A meta-analysis of observational studies found that PD was associated more often with acute cardiac episodes than chronic heart conditions (Blaizot, Vergnes, Nuwwareh, Amar & Sizou, 2009). According to the most recent National Vital Statistics Report, heart disease remains the leading cause of death in the United States (CDC, 2011b). Prevention of dental caries in childhood could reduce the prevalence of adult PD and have a positive effect on the leading killer of the U.S. population.

Burden of Poor Dental Health

The economic burden of poor dental health is tremendous. In 2009, approximately $102 billion dollars were spent on dental procedures in the United States (CDC, 2010a). Figure 1 gives the breakdown of 2006 U.S. dental expenditures.

Figure 1. 2006 U.S. Dental Expenditures (in $ billions) (Caitlin, Hartman & Heffler, 2008).



From this information one can see that public spending represents the smallest amount of expenditures, illustrating that the populations with the least access to dental care also receive the least amount of funding.

Costs are not only measured in dollars. Children miss approximately 51 million hours per year of school due to dental-related illness which equals on average 3.1 days per 100 students in a school calendar year (National Maternal and Child Health Resource Center, 2008). Poor dental health and its effect on children's diminished self-esteem have been researched but the results are not conclusive. Locker proposes that children with poor dental health early in life may have reduced self-esteem but indicates further studies need to be conducted (Locker, 2008). In his paper Locker discussed the administration of the 'Child Perception Questionnaire for 11-14 year old children' (CPQ11-14) to assess this relationship (Locker, 2008).

Interventions That Work

The Community Guide to Preventive Services published by the CDC recommends school-based and school-linked sealant programs as an evidence-based strategy for reducing dental caries in school-aged children (The Community Guide to Preventive Services [CGPS], 2002a). School-linked programs conduct application processes at school (*e.g.* patient selection, parental consent) and dental services are performed off campus (CGPS, 2002a).In addition, the CDC states that sealants are an effective way to prevent dental caries but only one-third of children ages six to nineteen have undergone this dental procedure (CDC, 2010a).

The United States Preventive Services Task Force (USPSTF) Community Guide recommendations are developed through a systematic review of available scientific data which starts with identifying all relevant studies of basic research, assessing their quality and providing a summary of the evidence (CGPS, 2002b). To assess the success of school dental programs for the reduction of tooth decay in children, the USPSTF systematically reviewed ten studies that examined the effectiveness of both school-based and school-linked programs (Task Force on

Community Preventive Services [TFCPS], 2005). The studies included children ages six to seventeen from many different areas of the country, with various social and demographic characteristics. This demonstrates generalizability of findings to school-age children in many different settings (TFCPS, 2005). Inclusion in the guide implies that these interventions are economically advantageous and should be adopted as best practices (CGPS, 2002b).

Program Description

The Southeast Health District (SEHD) has received Health Resources and Services Administration (HRSA), Office of the Advancement of Telehealth (OAT) funding to conduct a school-based teledentistry program. The goal of the SEHD teledentistry program is to provide a system of care to meet the oral health care needs of children living in three rural southeast Georgia counties: Brantley, Charlton and Clinch. The benefits to the target population are both immediate and long lasting. Children receive dental education, dental cleanings, fluoride treatments and sealants if warranted, during teledentistry clinics. If additional oral health problems are identified dentals referrals are made. Preventive dental interventions during childhood are a deterrent to complications in adulthood (CDC, 2010c). The SEHD teledentistry program also creates an infrastructure of free, accessible, preventive, oral health care services. The first year funding targets children enrolled in Brantley County elementary schools that have no established dental home.

Parents completed program applications if they desired their children to participate in the program. Services were conducted on-site at Nahunta Elementary from September 2010 to April 2011. Although the program was conducted at Nahunta Elementary children who attended Waynesville Primary, Atkinson Elementary and Hoboken Elementary were provided transportation to the teledentistry clinic site. Children received dental cleanings, examinations, x-rays and sealants. There is also a child-focused educational component accompanied by literature for parents addressing tips for good oral health. Materials are sent home in an informational packet with the child who has received services. X-rays are sent via teledentistry in real-time to pediatric dentists at Georgia Health Sciences University School of Dentistry (formerly the Medical College of Georgia, School of Dentistry) and, if required, an intraoral camera is available for more intensive examinations. Based on examination results children receive dental referrals. The referrals are tiered. Tier one referrals are to a local general dental practitioner (GDP). These referrals include services that are simple, don't involve sedation or are for older children. Tier two referrals are to a pediatric dental specialist. These referrals are made for children requiring more complex treatment or sedation. Tier three referrals are to Georgia Health Sciences University and include children who need extensive dental work, *e.g.* multiple extractions. All services provided by the SEHD teledentistry program are free, allowing referral dentists to bill third party insurers including Medicaid.

Purpose of Economic Evaluation

Generally speaking, there is a lack of evaluation research for telehealth programs. According to Garshnek and Hassell, the research base for telehealth evaluation is limited for several reasons. Improved technology is viewed as a superior approach so the need for evaluation is dismissed. Innovation creates excitement, shifting the focus from evaluation to implementation. New methods of healthcare delivery render traditional evaluation models obsolete (Garshnek & Hassell, 1999). People think improved technology is always better, excitement surrounding an innovative idea makes rigid evaluation hard to apply, uncertain research questions and methods, associated with innovations and technological glitches can sabotage the best evaluation plans (Garshnek & Hassell, 1999).

In 1995 the Clinton administration recognized the need for cost-effective, innovative healthcare solutions and the Joint Working Group on Telemedicine (JWGT) was formed (Garshnek & Hassell, 1999). One of the group's tasks was to develop a transferable evaluation framework for telehealth with a goal of, "strengthening evaluation designs and promoting comparable evaluations" (Garshnek & Hassell, 1999). One of the critical questions identified by the JWGT was the costs and benefits of the telehealth operations (Garshnek & Hassell, 1999).

Even though there has been a federal call for telehealth economic evaluations the research remains limited, especially for teledentistry. Therefore the main reason for conducting a cost-effectiveness analysis (CEA) of the SEHD teledentistry program is to add to the body of research. More specifically, the SEHD teledentistry program CEA will be used for funding reporting purposes and to improve the district's chances of obtaining additional HRSA funding.

Questions to be Answered by the Economic Evaluation

The evaluator will perform a CEA of traditional dental care versus teledentistry for children enrolled in Brantley County, Georgia elementary schools for the 2010-2011 school year. Key questions to be answered by the evaluation include the following:

- How much does it cost to provide routine dental services for children in a dental office?
- How much does it cost to provide routine dental services for children in a school via teledentistry?
- Is it more cost-effective to provide *routine dental services in dental offices versus schools?

*Routine dental services are X-rays, cleaning, fluoride treatment and sealants.

Definition of Terms

Because this evaluation uses terms that may have multiple definitions or different meanings if used in another context the following list of terms and definitions will be used in the same manner throughout the evaluation document. This list will ensure that all readers understand the document terms.

Southeast Health District

Defined as Georgia Public Health District 9-2 (Waycross) which is located in Southeast Georgia and is comprised of sixteen counties.

Southeast Health District teledentistry program

HRSA grant funded, school-based teledentistry program, conducted in elementary schools in three SEHD counties. For CEA purposes the program is defined as the teledentistry program conducted in Brantley County Elementary Schools for the 2010-2011 school year.

Teledentistry

This term is defined as the delivery of dental services utilizing videoconference technology. Dental Hygienists are at the patient site and dentists are located at a remote site. The technology transmits dental x-rays and pictures from the intraoral camera to the remote dentist.

Telehealth

The delivery of health-related services utilizing videoconference technology. These services could be preventive or curative.

Telemedicine

The delivery of curative health services utilizing videoconference technology. Examples of curative services may include psychiatric services, case management of an asthma patient or dermatologic diagnoses.

Videoconferencing

A telecommunication technology that allows two or more sites to interact simultaneously via two-way video and audio transmissions.

CHAPTER 2: LITERATURE REVIEW

Introduction

The outline of the review of the literature (ROL) will first look at studies of telemedicine programs that have included a cost evaluation component and peer-reviewed articles that discuss the cost analysis of telehealth. The second component of the ROL will review studies of teledentistry programs which include a cost evaluation component and peer-reviewed articles that discuss the cost analysis of these programs. Articles in each section will be arranged in chronological order from oldest to most recent.

The literature available addressing cost analysis of telemedicine and teledentistry is limited. The articles were selected for what they could contribute to the model for the economic evaluation of the SEHD's teledentistry program. Articles included in the ROL contain research specifically addressing disparities based on rural status, poverty level, race and ethnicity. Papers containing information on costs and benefits to be incorporated in an economic analysis of a telehealth program were also considered. Lastly, articles that dealt with quantification of intangible costs were included in the ROL since the SEHD cost-effectiveness analysis will contain such variables.

Body

Telemedicine

Lobley states that the ever increasing costs of medical care have forced society to look for more cost-effective methods for providing health care (Lobley, 1997). Telemedicine is a potential service-delivery model that can provide medical services at decreased costs. But because telemedicine has mainly been funded as special projects accountability procedures have not been the norm (Lobley, 1997). He proposed a standardized framework to assess the economics of telemedicine. In addition, the initial capital outlay for telemedicine posed a potential barrier for implementation (Lobley, 1997). For this reason the economic analysis of telemedicine is crucial so both the costs and benefits of this model can be illustrated. Lobley proposed many appropriate frameworks for telemedicine economic evaluation including the evaluation of public health, preventive medicine and patient education (Lobley, 1997). According to Lobley there are two main cost categories associated with telemedicine, capital costs and variable costs. Capital costs include the outlay for telehealth video equipment which the author recommends should be annuitized over a five year period (Lobley, 1997). The savings provided by telemedicine need to be compared to the costs associated with the next best health intervention (Lobley, 1997). This article discussed the importance of including benefits of telemedicine that are not easy to quantify such as access to quicker treatment and referrals and reduced stress related to less travel time (Lobley, 1997).

Lobley's proposal for a standardized economic evaluation of telemedicine and subsequent discussion of cost inclusions lends itself to the cost-effectiveness analysis of the SEHD teledentistry program in the following ways. First, he proposes that public health preventive programs are appropriate for economic evaluation. Second, the author provides a time frame of five years for the depreciation of telehealth equipment which the researcher will use to annuitize the SEHD equipment. Without annuitization the costs of the SEHD teledentistry program will be inflated. Finally, in order to recognize some of the intangible benefits of the program, such as participants' improved self-esteem as a result of their dental care, a parent survey, included with the teledentistry program application, will be utilized. An all-inclusive picture of the costs and benefits of the program's intangible costs, such as children's self-esteem as it relates to dental health, will be quantified by the results obtained through the parent survey.

Although the economic evaluation of telemedicine is imperative it is challenging because the technology is ever-changing, program sample sizes are typically small and conventional techniques for this type of evaluation are often times not suited for telemedicine interventions because they overlook intangible outcomes (McIntosh &Cairns, 1997). In their paper the authors described a 'cost-consequence' model for the economic assessment of telemedicine programs. This model combines aspects of traditional economic evaluation; cost analysis, cost-benefit and cost-effectiveness, in a manner that expresses a truer picture of the costs and benefits gained from telemedicine applications, by applying weights to each (McIntosh &Cairns, 1997). An example provided by the authors was that the benefits of telemedicine for individuals in rural areas who are medically underserved would be weighted more heavily than the benefits for those in urban areas who have better access to healthcare (McIntosh &Cairns, 1997). The authors also identified nine key questions to be answered by the economic evaluation and provided guidelines for assessing the need to consider these questions when performing an economic evaluation. The author's questions are as follows:

1. When should the economic evaluation be carried out?

2. Whose perspective should the economic evaluation adopt?

3. Does the introduction of telemedicine lead to an increase in the capital costs? If so, are these additional costs offset by lower annual running costs?

4. By how much will the number and level of the staff increase or decrease? Will the skill mix of staff change? If so, what are the resulting cost implications?

5. Will the cost of certain treatments for certain patient groups be increased or decreased and, if so, by how much?

6. By how much will the patient outcome be improved (if at all)?

7. Are there any non-health outcomes which should be included in the evaluation?

8. Will consultation and referral patterns change after the introduction of telemedicine? If so, what are the cost implications?

9. Will activity levels change upon implementation? Is so, how will differing levels of activity throughout the intervention affect the cost-effectiveness of the program? (McIntosh & Cairns, 1997).

Although McIntosh and Cairn's suggestions have many implications for telemedicine economic evaluations only a few will be utilized for the research at hand. The authors suggest that the costs and benefits of a telemedicine program should be viewed from all sectors of society. Based on this a societal perspective will be selected for the cost-effectiveness analysis of the SEHD teledentistry program. They also discussed the importance of annuitization of telemedicine equipment and estimated equipment life as five years and defined equipment maintenance costs as 10%, both of which will be included in the cost-effectiveness evaluation of the SEHD teledentistry program. Conduction of an Incremental Cost-Effective Ratio was also suggested by the authors and will be used to compare teledentistry to the next best intervention, traditional dentistry. The main point to be taken from McIntosh and Cairns is the current lack of telemedicine evaluation and the need for it.

In their article, Garshnek *et al.* provided an overview of the limited history of telemedicine evaluation (Garshnek, Hassell & Colonel, 1999). The bases of the previous evaluations were the safety and effectiveness of telemedicine, conducted by the Center for Health Policy and Research (Garshnek *et al.,* 1999). These evaluations were most often an afterthought and not part of the program planning process, weakening their value. The authors described the federal push for 'cost-effective health applications' in 1995 and the subsequent formation of the JWGT. Along with other duties, this group was tasked with developing standardized evaluation models, enabling comparisons across programs and applications (Garshnek *et al.,* 1999). In conclusion, the authors stated that moving forward there was a need for structured evaluation of telemedicine (Garshnek *et al.,* 1999).

The statements in this article not only illustrate federal support for economic evaluation of telemedicine programs but also clearly state the need for this type of evaluation. The author's statements and conclusion justify the cost-effectiveness evaluation of the SEHD teledentistry program.

In response to a growing pressure for cost-containment of healthcare and the potential cost savings of telemedicine there is a focus on cost-effectiveness evaluations of these programs (Mair, Haycox, May & Williams, 2000). Because of this, Mair and colleagues conducted a database search for cost-effectiveness studies of telemedicine programs using the following key terms: telemedicine, telecommunications, cost-effectiveness, cost-benefit analysis, economic and healthcare costs (Mair *et al.*, 2000). To assess the quality of the studies the researchers utilized a checklist developed by one of the authors which had been previously used to judge the value of 'pharmaco-economic' studies (Mair *et al.,* 2000). Based on the checklist the authors reached the following conclusions regarding the previous research. The hypotheses of telemedicine economic evaluations should be very specific to the program's context (Mair *et al.,* 2000). A perspective must be clearly identified and should include all parties affected by the program (Mair *et al.,* 2000). Both costs and benefits must be included in the analysis (Mair *et al.,* 2000). The studies reviewed by the researchers did not reach a consensus regarding a time line for annuitization of telemedicine equipment, so it is crucial to include future changes in costs of equipment and data transmission in the sensitivity analysis component of the economic evaluation (Mair *et al.,* 2000). The uncertainties associated with future costs prompted the authors to conclude that evaluators should conduct marginal analyses and sensitivity analyses (Mair *et al.*, 2000).

The authors' conclusions have several implications for the design of the cost-effectiveness evaluation of the SEHD teledentistry program. These areas are as follows: a research question that is specific and focused, support for the justification of selecting a societal perspective on which to base all costs and benefits of the program, the importance of and variables to include in the sensitivity analysis portion of the evaluation and the need to conduct a marginal analysis.

There are well documented health disparities between those living in rural areas and those who reside in urban locations (Shore, Brooks, Savin, Manson & Libby, 2007). Telehealth services are designed to bring healthcare services that are unavailable in medically underserved communities to the individual, eliminating the need for travel (Shore *et al.*, 2007). This study focused on the provision of telepsychiatry to Native-American veterans living on a reservation in Colorado (Shore *et al.,* 2007). Veterans were recruited from the local reservation, a population known to have life-long psychiatric disorders associated with their service time. All participants were male and had a mean age of 54 (Shore *et al.*, 2007).

Two psychiatrists administered a modified version of the Structured Clinical Interview for Diagnostic, Statistical Manual of Mental Disorders, 3rd Edition, Revised (DSM-III-R SCID) (Shore *et al.*, 2007). Participants were randomly assigned to one of two interview groups. The first received a real-time, interactive videoconferencing session, followed by a face-to-face interview. The second group received a face-to-face interview followed by a real-time, interactive videoconferencing session (Shore *et al.*, 2007).

The authors stated that they discussed costs in a manner so they could be utilized as a guide for future evaluators, prompting them to include two cost models. The first (Model 1) represented costs for the current study that utilized established telehealth clinics and the second (Model 2) included costs for the current study plus those associated with starting a telehealth clinic (Shore *et al.*, 2007). The costs associated with Model 1 were, data transmission (long distance charges and port fees), personnel (psychiatrist's fees for conducting the SCID interview), salaries (for other mental health professional capable of conducting SCID interviews but with less academic training) and travel (car rental, fuel, lodging and meals for the two psychiatrists) (Shore *et al.*, 2007). Model 2 costs included fixed costs (telehealth equipment and installation) and variable costs (transmission, personnel and travel) which would be equal to those values in Model 1 (Shore *et al.*, 2007).

Researchers found that telehealth interviews were $1,700 more expensive than face-to face interviews. A caveat to evaluators is that port fees were found to be unique to the academic host site, The University of Colorado (Shore *et al.*, 2007). When this cost was removed telehealth realized a savings of $12,153 when compared to face-to-face interviews (Shore *et al.*, 2007). The authors noted that the biggest expense associated with telehealth was the initial outlay for the equipment, inferring that increased utilization of the system drives down the cost over time (Shore *et al.*, 2007).

In addition to tangible costs, the authors discussed intangible costs. Although harder to quantify, these are costs that must be included to show a true picture of telehealth interventions. The researchers listed reduced need for travel (patient and practitioner), difficulty recruiting trained professionals in rural areas, ease of scheduling telehealth interviews and increased access to providers as intangible costs (Shore *et al.*, 2007).

Some of the limitations of the study were lack of generalizability beyond the field of mental health and the specific population, Native Americans. The study focused only on live videoconferencing contacts and used only cost as the basis for selecting telemedicine over in-person services as opposed to looking at the scientific validity of telehealth services (Shore *et al.,* 2007). But despite the limitations the researchers stated that potential cost savings of telemedicine should be further explored and encouraged replication of their analysis model to strengthen the body of empirical evidence (Shore *et al.,* 2007).

Shore *et al.* focused on rural populations assuming telemedicine could improve their access to health care. The SEHD is a rural Georgia Public Health District and the counties that receive teledentistry services are medically underserved. According to the HRSA website, Brantley County is also designated as a dental Healthcare Professional Shortage Area (Health Resources and Services Administration [HRSA], 2011). Additionally, the study details both tangible and intangible costs inclusions for economic assessment of telemedicine interventions. The framework described by the authors will be considered when designing the evaluation model for the SEHD teledentistry program.

Teledentistry

At the 1999 American Medical Information Association's (AMIA) annual symposium, Rocca and colleagues presented the United States Department of Defense Total Dental Access (TDA) project (Rocca, Kudryk, Pajak & Morris, 1999). The TDA links U. S. Army dentists with dental specialists via telehealth technology for patient consultations (Rocca *et al.,* 1999). The presentation discussed the program's evolution, advantages and disadvantages and cost-effectiveness (Rocca *et al.,* 1999). Many patients were based in remote locations which required long travel distances to specialists. The authors stated that the TDA project saved 14 of the 15 study participants a return trip to Fort Gordon, the base where the specialists were located (Rocca *et al.,* 1999). Participants reported satisfaction associated with the elimination of travel and specialist practitioners reported that they were able to make accurate diagnoses using the teledentistry equipment (Rocca *et al.,* 1999). Although the sample size was limited, the authors reported cost savings from travel reduction and work absenteeism that offset the teledentistry equipment's initial capital investment (Rocca *et al.,* 1999).

This presentation marks the first published discussion of the cost-effectiveness of a teledentistry program. The author's conclusions laid the groundwork for all future economic analyses of teledentistry projects. Since cost savings were realized, the support and expansion of teledentistry programs has continued.

The Scottish Highlands and Islands have many remote areas which are medically underserved. The researchers employed a twelve month, trial teledentistry program in two general dental practices (GDP), one located in the Orkney Islands and the other in the Scottish Highlands at Kingussie (Scuffham & Steed, 2002). The research focus was to determine if teledentistry would promote cost savings for patients, GDPs, referral dental specialists and the Scottish National Health Service (NHS), the governmental agency that funds most of the healthcare costs of Scottish citizens (Scuffham & Steed, 2002). Persons requiring referrals to dental specialists were asked if they wanted to participate in the trial program (Scuffham & Steed, 2002). The researchers compared teledentistry consultations to traditional dental services provided at two outreach clinics, one located on Orkney and one in Kingussie, and a hospital-based dental clinic located in Aberdeen (Scuffham & Steed, 2002).

Researchers divided costs into two categories, direct and indirect. Direct costs were sub-divided into variable and fixed costs (Scuffham & Steed, 2002). Direct costs were defined for patients, GDPs and the NHS and included things like travel, dental consultation time and reimbursement fees (Scuffham & Steed, 2002). Indirect costs were only realized by the dental patients and were valued as the patient's time. The authors stated that the quantification of this variable was challenging and decided to use the average gross weekly earnings for adults working in Great Britain divided by 40 hours, the average hours in a work week (Scuffham & Steed, 2002). Fixed costs included teledentistry equipment, data line fees and training. The researchers chose to annuitize the cost of the telehealth equipment and used 4 years as the expected life (Scuffham & Steed, 2002). In addition, they used a 6% discount rate for annuitizing the equipment (Scuffham & Steed, 2002).

A one-way sensitivity analysis was performed and the focus was on those variables that posed the greatest uncertainty, equipment lifetime, discount rate and their effect on the fixed costs if there was an increased workload (Scuffham & Steed, 2002). To compare the variability in costs if programs were relocated, the researchers conducted a sub-group analysis (Scuffham & Steed, 2002).

The results of the study showed that outreach dental visits were the least expensive followed by teledentistry contacts and hospital visits (Scuffham & Steed, 2002). The authors noted that the cost of the teledentistry equipment was the variable responsible for the large fixed cost per patient and could dramatically decrease as more patients used the service (Scuffham & Steed, 2002). Researchers found that the largest cost savings were associated with travel distance, implying that the more remote an area, the more cost saving a teledentistry program could be (Scuffham & Steed, 2002). The authors also discussed quick access to a specialist and reduced wait times as intangible advantages of teledentistry but the valuation of these benefits was not included in their study (Scuffham & Steed, 2002).

This study conducted an in-depth, detailed economic evaluation of a teledentistry program and can therefore be used as a comparison model for the cost-effectiveness evaluation of the SEHD teledentistry program. The sensitivity analysis focused on the future value of the teledentistry equipment, the same focus that will be utilized for the SEHD economic analysis. Additionally, the study included a discussion of intangible costs and possible ways to quantify these variables. The SEHD teledentistry program economic analysis will also include intangible costs like children's self-esteem, as it relates to dental health. Therefore the authors' discussion of these intangibles will be helpful.

The article gave a brief history of teledentistry, discussed the need for this technology, reviewed teledentistry techniques and talked about the opportunities offered by teledentistry (Dils, Lefebvre & Abeyta, 2004). The first teledentistry program was started by the United States military and stemmed from a need for specialty dental consultations in remote locations. An unexpected benefit of the military's program was practitioners' collaboration in treatment decisions (Dils *et al.*, 2004).The authors stated that teledentistry has the ability to provide access to dental care in locations that lack dental practitioners and can overcome barriers such as travel distance and limited resources (Dils *et al.*, 2004). They also estimated that 38% of U.S. rural counties do not have a dentist, citing teledentistry as a vehicle to allow rural practitioners access to urban dental specialists (Dils *et al.*, 2004). When this article was written there were two types of teledentistry, real-time videoconferencing and 'store and forward' (Dils *et al.*, 2004). Real-time videoconferencing utilizes a digital screen, video cameras and microphones at two locations, a patient location and a practitioner location. The patient location also has dental equipment which included an x-ray machine and intraoral camera for data transmission of radiographs and pictures (Dils *et al.,* 2004). Store and forward utilized the internet and the practitioner simply gathered patient data and forwarded the information via email to the specialist (Dils *et al.,* 2004). According to the authors, the opportunities for teledentistry are "enormous" (Dils *et al.,* 2004). The authors state that this technology has the ability to reduce or even eliminate dental health disparities due to lack of providers in rural areas (Dils *et al.,* 2004). The authors also mentioned that dental health providers will be able to confer with specialists, reduce isolation and ultimately provide improved, individualized dental care plans (Dils *et al.,* 2004).

The SEHD teledentistry program grant focuses on three rural Southeast Georgia counties - Brantley, Charlton and Clinch, although the cost-effectiveness analysis focuses only on Brantley County. These counties are considered rural and have only one general dental provider in each county. Based on county population these locales are designated as dental Healthcare Professional Shortage Areas [HRSA, 2011]. Because of this, residents of Brantley County must travel to neighboring counties to receive services from a GDP that accepts Medicaid patients and must travel to urban areas, like Savannah and Valdosta to obtain services from dental specialists. The minimum round trip for a GDP visit is about 45 miles and the minimum round trip distance for a specialist visit is approximately 250 miles (MapQuest.Com, 2011a). This poses an additional hardship on residents of Brantley considering 34% received Medicaid benefits in 2009 (Georgia Statistics System, 2010). The authors' support for teledentistry, and its ability to improve access for rural, impoverished individuals to dental care, supports the efficacy of the SEHD teledentistry program.

To assess the prevalence of dental caries in children ages 12 to 60 months, the researchers conducted a cross-sectional study of children enrolled in Early Head Start centers located in Rochester, New York (Kopycka-Kedzierawski, Bell & Billings, 2008). Early childhood caries (ECC) were defined using the American Academy of Pediatric Dentistry (AAPD) guidelines: the presence of greater than or equal to one decayed, missing or filled tooth surface in a child less than or equal to 71 months of age (Kopycka-Kedzierawski *et al.*, 2008). Severe early childhood caries (S-ECC) were also defined using AAPD guidelines: the presence of any sign of smooth-surface caries in children younger than three years old and greater than or equal to one cavitated, missing (due to caries), or filled smooth surface in primary maxillary anterior teeth from ages three through five (Kopycka-Kedzierawski *et al.*, 2008). The researchers utilized teledentistry equipment as the study's diagnostic tool and in each of the six participating centers they trained telehealth assistants (TA) to operate the intraoral camera (Kopycka-Kedzierawski *et al.*, 2008).

The study sample size was 162 children ages 12 to 60 months who attended Early Head Start during the years from 2004 to 2006. The sample consisted of Hispanic-Americans, African-Americans and Caucasians and all participants were either Medicaid or New York State Child Health Insurance (SCHIP) recipients (Kopycka-Kedzierawski *et al.*, 2008). The TAs obtained six images from each child and transmitted them to the Eastman Department of Dentistry, University of Rochester (Kopycka-Kedzierawski *et al.*, 2008). Once transmitted, the deidentified radiographs were scored by dental professionals. The first score indicated whether the child had caries or not and the second score classified children as either caries that were ECC or S-ECC (Kopycka-Kedzierawski *et al.*, 2008). The researchers used the variables of age, gender and ethnicity to calculate the mean caries scores, used the student's *t* test and analysis of variance (ANOVA) to assess statistical differences (*P*=.05) (Kopycka-Kedzierawski *et al.*, 2008).

43% or 69 of the 162 study participants were found to have dental caries (ECC or S-ECC) (Kopycka-Kedzierawski *et al.*, 2008). The mean score for all children with dental filled surfaces (dfs) was 1.88 (± 3.49 SD). 28 of the 69 children diagnosed with ECC were found to have S-ECC (Kopycka-Kedzierawski *et al.*, 2008). The mean dfs score for the ECC children was 4.42 (±4.18) and the mean dfs score for the S-ECC participants was 7.61 (±4.92) (Kopycka-Kedzierawski *et al.*, 2008). African-American children had the highest dfs mean score, followed by Caucasian and Hispanic-American participants, although the ethnic differences were not statistically significant (*P*=.11) (Kopycka-Kedzierawski *et al.*, 2008). As the researchers expected, older children had more caries but the differences based on age were not statistically significant (*P*=.27) (Kopycka-Kedzierawski *et al.*, 2008).

The researchers concluded that only African-American participants showed evidence of being treated for dental caries and that the remainder had untreated tooth decay (Kopycka-Kedzierawski *et al.*, 2008). They also proclaimed teledentistry as a mechanism for increasing access to dental care for those of lower socioeconomic status and cited early diagnosis, timely treatment and establishment of a 'dental home' as additional benefits of teledentistry (Kopycka-Kedzierawski *et al.*, 2008). In conclusion, the authors stated that teledentistry may be most useful in rural locations where the lack of dental providers poses a barrier to care (Kopycka-Kedzierawski *et al.*, 2008).

Although this study focused on younger children it still has application to the economic evaluation of the SEHD teledentistry program because of the program's location in Georgia elementary schools, which enroll Pre-Kindergarten students who are four years old and Kindergarten students, age five. The study sample included children receiving Medicaid and SCHIP benefits, mirroring the SEHD's program participants since the application process solicits children without a dental home. Even though this was not a randomized sample, it still has implications for the SEHD program based on access to dental care reimbursement. The study's sample was ethnically diverse but this diversity was found not to be statistically significant in regards to dental caries. For Brantley County, 2010 census data reveals a 94% Caucasian majority advocating for the need of a dental intervention based on the researcher's findings (U.S. Census Bureau, 2011a). In addition, approximately 40% of Brantley County residents are eligible for Medicaid (U.S. Census Bureau, 2011b). Since ethnicity was statistically insignificant, a Caucasian majority has less influence than the income of the program population. Lastly the authors' statement regarding the usefulness of teledentistry in rural areas due to lack of providers directly applies to the SEHD program which is conducted in rural Southeast Georgia counties.

Because of their remote location, dental patients in Northern Ireland were being placed on specialty dental care waiting lists for extensive time periods. Teledentistry was thought of as a possible way local dental practitioners could triage specialty referrals, improving access to care (Bradley, Black, Noble, Thompson & Lamey, 2009). The Community Dental Service of the Northern Trust in partnership with the School of Dentistry, Royal Group of Hospitals Belfast Trust set up a prototype teledentistry program. Bradley *et al.* conducted a feasibility study of this program (Bradley *et al.,* 2009).The study was conducted in 2006 from January to June to assess the feasibility of triaging referrals to specialty dental clinicians located in a Belfast hospital. Patients were locally assessed and radiographs were transmitted via teledentistry technology to the specialty dentists eliminating the need for patient travel (Bradley *et al.,* 2009).

The sample included 41 patients. Of the 41 recruited, 37 participated and all records were transmitted from the community to the Belfast hospital without error (Bradley *et al.,* 2009). 65% of the patients were diagnosed with common mucosal diseases, determined to be treatable at the community level, illustrating success of the prototype program (Bradley *et al.*, 2009). Although not formally conducted, the researchers briefly discussed variables that should be included in a cost-effectiveness analysis some of which were intangible costs, reduced patient anxiety, quick diagnosis and increased comfort associated with seeing a familiar dentist (Bradley *et al.*, 2009).

This teledentistry model is similar to the SEHD's program. Children are screened at the local level and treated in the community. Travel to specialists, if necessary, is determined through the initial teledentistry consultation, thereby eliminating unnecessary hardship on families. In addition, the researcher expects the same intangible benefits cited in the study, especially reduction of anxiety because the children are seen at school with a group of peers and there is not a dentist on site.

Friction and Chen reviewed the University of Minnesota's Teledentistry Project in their article (Friction & Chen, 2009). Started in 2004, the project links dental specialists at the university to patients in remote areas of the state who have limited access to these services (Friction & Chen, 2009). The evaluation of this project consisted of practitioner and patient satisfaction surveys. The providers expressed satisfaction with 90% of the teledentistry consultations and were satisfied that their teledentistry consultations were as good as face-to-face consultations for 94% of the videoconference visits (Friction & Chen, 2009). Patients were equally satisfied and cited convenient access to care as the greatest benefit of teledentistry (Friction & Chen, 2009). Since its inception the project has provided 24 teledentistry visits to 13 patients (Friction & Chen, 2009). The participants reported driving on average, 12 to 13 miles for teledentistry visits compared to approximately 300 miles (round trip) for a university visit (Friction & Chen, 2009). Patients also stated that seeing the dentist via teledentistry was very similar to seeing them in person and expressed appreciation for the opportunity to have easy access to specialists in their remote locations (Friction & Chen, 2009).

Participants in the SEHD teledentistry program are, on average, the same distance from pediatric dental specialists as the patients in the University of Minnesota project. For this reason the researcher expects similar expressions of satisfaction. The travel time and mileage for SEHD participants will be quantified for the cost-effectiveness analysis.

Summary

Teledentistry has been in place since 1994 but the evaluation component of programs is still lacking even though the federal administration demanded such in 1995. Teledentistry is thought to be a viable alternative to traditional dental services especially in rural areas where access to dental professionals is limited but without a strong body of literature that supports the economic benefits of teledentistry, additional and continued funding will be difficult to obtain in times when resources are increasingly competitive and diminishing.

The literature illustrates a clear benefit of telemedicine and teledentistry services for those who have limited access to care. Limited access can be due to a rural location, socioeconomics or lack of providers. Practitioners and patients perceive telehealth services as very similar to face-to-face healthcare and proclaim satisfaction and appreciation for these services. In general, telehealth programs are cost saving after adjustments for the initial capital investment for equipment is annuitized and marginal costs (benefits) are realized.

Many of the benefits associated with telemedicine and teledentistry are intangible, making them difficult to quantify, resulting in their exclusion from research. Even though it is not easy to assign a dollar amount to these variables it is imperative to do so for the economic analyses of these programs to be accurate. The inclusion of intangible costs (benefits) will offset the cost of up-front equipment investments, providing a truer picture of the advantages of telemedicine and teledentistry. In addition, the lack of a defined perspective in much of the research leads to an inaccurate portrayal of the true costs and benefits of this technology.

The SEHD teledentistry program targets elementary-school children who live in rural Georgia counties that are medically underserved. These children have limited access to dental care based on lack of providers and socioeconomics, making them perfect candidates for a teledentistry intervention. The cost-effectiveness analysis of this program will take a societal perspective, so costs and benefits of all parties involved will be represented. The intangible cost of children's self-esteem will also be part of the economic analysis so a more accurate picture of the benefits of the teledentistry program will be illustrated.

CHAPTER 3: METHODOLOGY

Introduction

This chapter will provide an overview of the methods used to conduct an economic evaluation of the SEHD teledentistry program. The purpose of this section is to describe the population in detail, the methods and procedures for data collection and analysis, the instruments used for data collection and finally to discuss the limitations of the evaluation. By doing this a step-by-step process for the economic analysis will be defined making the duplication of the procedure possible for future evaluators.

Population and Sample

Population

The program targeted Brantley County elementary school children ages four to eleven, who did not have a dental home, although no children were turned away if their caregivers completed the application packet. For the 2010-2011 school year there were approximately 1,810 students enrolled in Brantley County elementary schools (Educaction.com, 2011). According to 2010 Census data, 94% of Brantley County was White, 3% Black, 1.9% was Hispanic or Latino of any race and the remainder of the population was made up of some other race or ethnicity (U.S. Census Bureau, 2010). 27% of Brantley's children live in poverty compared to the Georgia average of 20% (County Health Rankings, 2011). According to the HRSA, Brantley County has a zero ranking when assessed as a Dental Health Professional Shortage Area (HRSA, 2011). This ranking makes Brantley County an ideal location for a community-based teledentistry program focusing on children.

Sample

164 Brantley County elementary school children received teledentistry services from September 2010 through April 2011. The Emory University Institutional Review Board (IRB) determined that this evaluation needed no IRB review.

Procedures

Introduction

The evaluator will perform a cost-effectiveness analysis of traditional dental care versus teledentistry for children enrolled in Brantley County, Georgia elementary schools for the 2010-2011 school year. A retrospective study is being conducted because the costs are being indentified after the 2009 start of the Teledentistry Program (TD).

Perspective

The funding supporting the teledentistry project is composed of societal resources, first allocated by the legislature to HRSA, and then from HRSA to successful applicants. A societal perspective is the most appropriate for this economic analysis, since the researcher is attempting to analyze the allocation of societal resources.

Timeframe

The timeframe for the cost-effectiveness analysis is technically the school year which began in August 2010 and ended in May 2011. But because teledentistry services include referrals for extensive dental care, the timeframe must include the referral process. Based on the limited number of providers in the area, distance to providers and socioeconomic barriers, the evaluator estimates the program time frame to be the application month, nine-month school year plus one year for referral and treatment which equals twenty-two months.

Analytic Horizon

Children start losing their primary teeth around age six and this process is usually completed by age twelve, with all permanent teeth in place, on average, by age fourteen (WebMD, 2009). The services provided by teledentistry will last through the time period that the child has the primary teeth that were treated in the program through the period in which they gain all of their permanent teeth. There is much research that indicates a relationship between child oral health and its influence on adult dental health, especially as it relates to gum disease (U.S. Department of Health and Human Services [DHHS], 2000). Emerging research is also showing a relationship between poor oral health and many chronic diseases such as diabetes and cardiovascular disease (U.S. DHHS, 2000).

As stated by Haddix *et al.*, "the analytic-horizon of a prevention-effectiveness study should extend over the time period during which the costs, harms, and benefits of the intervention are incurred" (Haddix, Teutsch & Corso, 2003). Based on the local barriers mentioned previously, the evaluator has chosen to take a more conservative approach to estimating the time horizon.

Because the program targets children ages four to ten years of age the time horizon can vary depending on the age when the child first received services at the teledentistry clinic. Based on the WebMD data, Table 1 illustrates the time horizon for the different age groups.

Table 1

Time Horizon Based on Age When Child First Receives Teledentistry Services (WebMD, 2009)

Age of Child	Time Horizon
Four	Ten years
Five	Nine years
Six	Eight years
Seven	Seven years
Eight	Six years
Nine	Five years
Ten	Four years

To accommodate all possible ages of entry into the Teledentistry Program, the Analytic Horizon chosen is ten years.

Costs (Tangible)

Tangible costs include direct medical and non-medical costs and indirect costs. The costs for the teledentistry program will be obtained through a working relationship with the SEHD's Telehealth Coordinator. Because of this relationship the evaluator has access to her data and vendor and community contacts. The cost of traditional dental services (TdD) will be obtained by access to the Local Dental Supervisor's dental records. Additional and comparison dental service cost information will be accessed from electronic, aggregate sources such as The Medical Expenditure Panel Survey and The Centers for Medicare and Medicaid Services. Table 2 provides a description of each of the cost categories.

Table 2

Tangible Costs and Descriptions

Type of Cost	Description
Direct Cost-Non-Medical (TD)	Telehealth Equipment (General)
Direct Cost-Medical (TD)	Telehealth Equipment-Dental (intraoral camera, X-ray)
Direct Cost-Non-Medical (TD)	T1 lines for data transmission
Direct Cost-Medical (TD)	Dental Equipment (chairs, suction/cleaning)
Direct Cost-Medical (TD)	Dental Software-allows electronic transmission of X-rays to MCG
Direct Cost-Medical (TD)	Dental Supplies (disposable exam supplies, education materials)
Direct Cost-Non-Medical (TD)	Clinic space donated by school (in-kind)
Direct Cost-Medical (TD)	Dental Staff Time: -Local Dental Supervisor (Annual Contract) -MCG (Annual Contract) -Dental Hygienist (Hourly)
Direct Cost-Non-Medical (TD)	Administrative Staff Time: -Telehealth Coordinator (30% of time, in-kind)
Direct Cost-Non-Medical (TdD)	Dental clinic space (cost for same time period)
Direct Cost-Medical (TdD)	Dental office employee wages/salaries: -Dentist -Dental Hygienist -Dental Assistant -Office Manager
Direct Cost-Medical (TdD)	Dental Equipment (chairs, suction/cleaning, X-ray)
Direct Cost-Medical (TdD)	Dental Supplies
Direct Cost-Medical (TdD)	Dental visit charge for same services provided at Teledentistry dental clinic
Indirect Cost-Prod. Losses	Travel costs for parents associated with a dental visit.
Indirect Cost-Prod. Losses	Parent wages lost as a result of child's dental visit

Costs (Intangible)

Self-esteem as it relates to children and dental problems will be quantified based on answers to a parent survey included in the program application packet. A two-part question from the "Early Childhood Oral Health Impact Scale" was modified and included in the survey (Pahel, Rozier & Slade, 2007).

Cost Adjustment

The main reason to adjust costs for this evaluation is that the majority of the expenses are associated with the cost of equipment; both telehealth and dental, which were realized at the start of the program. These costs must be annuitized to prevent the costs per child seen in the Brantley County School Teledentistry Program for the 2010-2011 school year from being artificially inflated. From the research available the average life, without need of technology upgrade, of the telehealth equipment is approximately five years (Scuffman & Steed, 2002). Dental equipment utilized for both the traditional and teledentistry programs will be annuitized according to industry standards, which on average is seven years.

Instruments

Cost Data Sources (Tangible)

Table 3 discusses in detail the instruments that will be used to assess medical, non-medical and indirect costs to be included in the CEA of the SEHD teledentistry program.

Table 3

Data Sources Used to Obtain Costs

Type of Cost	Data Source
Direct Cost-Non-Medical (TD)	Invoices from Vendor, Telehealth Coordinator
Direct Cost-Medical (TD)	Invoices from Vendor, Telehealth Coordinator
Direct Cost-Non-Medical (TD)	Monthly Invoice to SEHD, reimbursed 90% through Universal Service Funds program
Direct Cost-Medical (TD)	Invoices from Vendor, Telehealth Coordinator
Direct Cost-Medical (TD)	Invoices from Vendor, Telehealth Coordinator
Direct Cost-Medical (TD)	Invoices from Vendor, Telehealth Coordinator
Direct Cost-Non-Medical (TD)	School superintendent for info on facility cost/funding
Direct Cost-Medical (TD)	Contracts will be obtained from Telehealth Coordinator
Direct Cost-Non-Medical (TD)	Southeast Health District Human Resources
Direct Cost-Non-Medical (TdD)	Will attempt to obtain from Local Dental Supervisor, if unable will utilize an on-line resource for area commercial real estate http://www.loopnet.com/Georgia/Waycross-Commercial-Real-Estate/
Direct Cost-Medical (TdD)	Will attempt to obtain from Local Dental Supervisor, if unable will utilize an on-line resource for are dental salaries http://www.indeed.com/salary/q-Dental-Assistant-l-Savannah,-GA.html
Direct Cost-Medical (TdD)	Will attempt to obtain from Dental Program Supervisor, if unable will utilize an on-line resource http://www.bplans.com/dental_office_business_plan/strategy_and_implementation_summary_fc.cfm
Direct Cost-Medical (TdD)	Will attempt to obtain from Dental Program Supervisor and can get an estimate from Telehealth Coor. if unable will utilize an on-line resource http://www.1stmedicalsupplies.com/
Direct Cost-Medical (TdD)	Local Practice Dental Records Medical Expenditure Panel Survey http://www.meps.ahrq.gov/mepsweb/data_stats/data_overview.jsp Centers for Medicare and Medicaid Services http://www.cms.gov/home/medicaid.asp
Indirect Cost-Prod. Losses	Will be calculated based on travel distance from Brantley county to closest Medicaid accepting dentist at the state mileage reimbursement rate of .51 cents
Indirect Cost-Prod. Losses	Due to lack of dental providers and rural status wages for an eight hour day will be calculated. Ga Dept. of Labor will be utilized to ascertain the average hourly wage in Brantley County http://www.dol.state.ga.us/ Additional documentation may be obtained from U.S. Bureau of Labor Statistics http://www.stats.bls.gov/

Cost Instruments (Intangible)

The following is the question included on the parent survey to assess children's self esteem:

How often has your child, because of dental problems (pain in teeth, mouth or jaws), experienced the following:

a) Avoided smiling or laughing when around other children
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

b) Avoided talking with other children
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

The complete parent survey can be found in Appendix A.

Data Analysis

Data Analysis (Tangible Costs)

An intermediate health outcome will be used for both the teledentistry program and traditional dentistry. For teledentistry, the health outcome is the number of children seen in the teledentistry program during the 2010-2011 school year. For traditional dental services the health outcome will be the number of children seen at a dental office during the same time frame. This data will be specific to the Teledentistry Program's Dental Supervisor's dental practice, which is located in a neighboring county and accepts Medicaid patients. Although Brantley County has one dentist, the provider does not treat Medicaid recipients.

To evaluate the comparison of teledentistry services with the next most effective intervention, traditional dental services, the researcher will utilize an Incremental Cost-Effectiveness Ratio (ICER). Calculation results will be interpreted as the additional costs (or savings) realized for every child seen by the teledentistry program compared to children seen in dental offices.

Because there is such a large initial capital outlay associated with the teledentistry program a discussion on Marginal Cost-Effectiveness Ratio (MCER) is warranted. With any type of telehealth service, once the initial equipment and data lines have been installed, these costs remain constant regardless of how many clients are seen. Therefore the more people seen via telehealth the more the capital costs per patient are reduced. Results of the MCER calculation will be interpreted as the cost per additional child seen via the teledentistry program.

Data Analysis (Intangible Costs)

Although there are many definitions of self-esteem, Manny Rosenberg, the creator of the widely used Rosenberg Self-Esteem Scale (SES) defined the concept as, "a positive or negative orientation toward oneself; an overall evaluation of one's worth or value" (University of Maryland, 2011). Research has shown that self-esteem is related to positive outcomes that effect all aspects of life. In his oft-cited, 2003 British Medical Journal editorial, Michael Marmott proposed that self-esteem and health are linked (Marmott, 2003). He went on to say that low self-esteem lead to health-damaging behaviors (Marmott, 2003). Marmott discussed a Pima Indian obesity intervention that found that the experimental group which underwent a pride-based program opposed to the physical activity intervention group had better health results. According to Marmott, individuals with more autonomy and a higher self-esteem experience better health outcomes (Marmott, 2003).

In addition to overall health, self-esteem has been associated with school performance. A multitude of research activities have linked self-esteem and academic success. A longitudinal study conducted by Jimerson *et al.* compared two groups of students to assess the affect socio-emotional, behavioral and achievement characteristics had on graduation rates of children who had been held back in school and those who had not (Jimerson, Ferguson, Whipple, Anderson &

Dalton, 2002). Their results indicated personal-social functioning (self-esteem) assessed in second grade was significantly related to high-school graduation rates (Jimerson *et al.*, 2002).

Ryan *et al.*, conducted a survey of 660 middle school students attending public schools in Rochester, New York to assess the influences of relationships to parents, teachers and friends on academic success and self-esteem (Ryan, Stiller & Lynch, 1994). The researchers found that students who emulated parents and teachers had enhanced academic achievement and subsequent higher self-esteem. Students who emulated friend's actions more often had a lower self-esteem score and poorer academic performance (Ryan *et al.*,1994).

To date there has not been a research-based established link between self-esteem and dental health. Humphris *et al.*, showed evidence of a link between self-esteem and perceived oral health (Humphris, Freeman, Gibson, Simpson & Whelton, 2005). Even without a conclusive relationship, investigators continue to include self-esteem related questions in child oral –health surveys and questionnaires because of the implied connection between a child's oral health and his self-esteem. The most recognized questionnaires include the Child Oral-Health-Related Quality of Life Questionnaire for 8-10 year old children and 11-14 year old children (CPQ 8-10 and CPQ 11-14) and The Early Childhood Oral Health Impact Scale (ECOHIS) (Wogelius, Gjorup, Haubek, Lopez & Poulsen, 2009) (Jokovic, Locker & Guyatt, 2006) (Pahel, Rozier & Slade, 2007) .

Self-esteem will be quantified as the average wage for an individual with a high school diploma (or equivalent). For caregivers who respond to the top two tiers of the Likert scale (Often/Very Often), their child's self-esteem will be valued as the average wage for an individual *with* a high school diploma (or equivalent) because the child will obtain teledentistry services.

The difference between the earnings of a high school graduate and that of a non-high school graduate will be the cost value. For the CEA this intangible cost can be subtracted from the total cost of the teledentistry program, since those children who participate receive dental care and follow-up. For traditional dentistry the value of this cost will be added based on the barriers to accessing dental services in Southeast Georgia that have been previously discussed.

Sensitivity Analysis

To improve the robustness of the CEA results, a one-way sensitivity analysis will be conducted. The SEHD Teledentistry Program sensitivity analysis will take a methodological approach. This approach allows the model to be tested by varying all methods used. Methods include the evaluation's decision analysis and costs.

Limitations

Since the study is retrospective the costs are being indentified after the 2009 start of the teledentistry program and therefore data collected may not be as precise as it would be if the researcher were involved at the start of the process. The sample size of 164 is small and will undoubtedly drive up the costs of the teledentistry program. A convenience sample is being used for this evaluation and since Brantley County's ethnicity is predominantly white and located in a small Southeastern County, results may not be generalizable to the entire population of elementary school-age children. Since a parent survey is being used to assess children's self-esteem there is a potential for information bias. Parents may not want to admit that their children's self-esteem has been affected negatively due to poor dental health because the parent feels guilty or is in denial. In, addition the survey is assessing self-esteem at a young age before lack of dental care manifests itself in visible tooth decay.

Delimitations

The cost adjustment poses a possible delimitation. The teledentistry equipment annuitization time frame of five years was chosen based on the ROL findings but this is still an estimate which could potentially overinflate the costs of the teledentistry program. Average wages will be used to assess the value of the time caregivers are away from work while taking children to traditional dental services. Using an average can over or under estimate the true cost. A CEA requires a common health outcome (number of children seen) for the interventions being compared without considering the multiple health outcomes of the intervention. This method also ignores many variables that are important when making resource allocation decisions, such as social justice, fair access to care and equitable distribution of limited resources.

CHAPTER 4: RESULTS

Introduction

This chapter discusses the results of the cost-effectiveness analysis of traditional dental care versus teledentistry for children enrolled in Brantley County, Georgia elementary schools for the 2010-2011 school year. The results were analyzed systematically using several approaches. Tangible costs and the intangible cost were quantified manually. In addition, the annuitization of capital outlays and ICER and MCER calculations were also completed manually, without the assistance of CEA specific software. Decision analysis, expected value calculations, tornado analysis and sensitivity analysis were all conducted using TreeAge Pro 2.0 software.

Findings

Health Outcome

The teledentistry health outcome for the study was defined as the number of children treated at the Brantley County clinic during the 2010-2011 school year. There were 164 children who received teledentistry services during this time. The traditional dentistry outcome was defined as the number of children treated by traditional dentistry during this same time frame. A local dentist was selected as the traditional dentistry study venue based on the following variables:

- The practice is located in a rural, adjacent county making it accessible to teledentistry participants

- The dentist accepts Medicaid, further increasing this dental practice's attractiveness as a dental home for teledentistry participants
- The dentist, Jon Drawdy, DMD is also the SEHD teledentistry program's Dental Supervisor
- As the teledentistry supervisor, Dr. Drawdy is an established SEHD public health partner who has a commitment to the dental health of children
- Dr. Drawdy was willing to provide cost information (*e.g*. equipment, staffing, dental charges) for an existing rural, Southeast Georgia dental practice as opposed to solely relying on electronic, aggregate resources

204 children received traditional dentistry treatment during the study.

Tangible Costs – Teledentistry

Table 4 provides a detailed explanation of the tangible, direct, medical and non-medical costs of the teledentistry program. The teledentistry clinic is held in a classroom located in Nahunta Elementary School. The facility is donated by the Brantley County School Board and therefore is considered an in-kind contribution. Building costs were estimated at the same value as the traditional dentistry building; $10.00 per square foot per year; a value provided by Jon Drawdy, DMD. Dr. Drawdy's practice is located in a neighboring county, Ware, which is also considered rural according to the Georgia Department of Revenue (Georgia Department of Labor, 2011). Teledentistry utilities were estimated to cost .35 cents per square foot per month (.35 x 300 sq. ft. x 12) and totaled $1,260 (Sask Power, 2011). The total cost of teledentistry was $173,332 which equates to a cost of $1,056.90 for each of the 164 children that were served at the Brantley County clinic during the study time frame.

Table 4

Teledentistry Costs

Telehealth Equipment	
Telehealth Equipment (purchase price listed but total annuitized-5 years):	
Digital Sensors (3 sizes - Size 0 @ $5,459, Size 1 @ $8,059 Size 2 @ $9,388	
Remote Module 1 @ $1,637	
Intraoral Camera Kit 1 @ $2,744	
Cisco EX-90 Video Conference Desktop Unit 1 @ $11,764	
HP 4530S Lap Top 1@ $640	
HP 4530S Lap Top 3 Year Warranty 1@ $135	
TOTAL: Telehealth Equipment (annuitized-5 years)	**$7,963**
Dental Equipment	
Dental Equipment (purchase price listed but total annuitized-7 years):	
X-Ray Chair: 1 @ $2,778	
Doctor's Stool: 1 @ $278	
X-Ray Unit: 1 @ $5,037	
Service Delivery Unit 1 @ $7,037	
Autoclave 1 @ $3,889	
Mobile Lights 2 @ $2078 ea. = $4,156	
TOTAL: Dental Equipment (annuitized-7 years)	**$4,471**
Dental Supplies and Disposable Equipment	
Ultrasonic Cleaner 1 @ $345	$345
Cleaner Accessory Kit 1 @ 129	$129
Equipment Sales Tax (7%) from Patterson Dental	$4,272
General (aprons, gloves, fluoride trays, bitewings, masks, chair covers, etc.)	1,466
Dental Instruments (mirrors, scalers, explorers, syringes etc.)	$874
TOTAL: Dental Supplies and Disposable Equipment	**$7,086**
Building Cost ($10/Sq. Ft @ 300 Sq. Ft. per yr)	**$3,000**
T1 Data Transmission Lines $170/month x 12 months	**$2,040**
Utilities (Electricity, Water .35/sq. ft./month .35 x 300 sq. ft x 12 months)	**$1,260**
Salaries	
Salaries/Payroll (SEHD Payroll/Grant Funded)	
Dental Hygienists (255 hours @ $40 per hour)	$10,200
Dental Assistants (72 hours @ $20 per hour)	$1,440.00
Jon Drawdy, DMD (1 year contract $25,000)	$25,000
Case Manager (full case management @ $100/case) - 17 cases	$1,700
Case Manager (partial case management @ $25/case)- 38 cases	$950
GA Health Sciences University Dental School (1 year contract $30,000)	$30,000
Telehealth Coordinator (30% in-kind from SEHD salary + fringe)	$26,774
Teledentistry Administrative Asst (Grant paid salary + fringe for one year)	$33,650
SEHD System IT Administrator (20% in-kind from SEHD salary + fringe)	$17,798
TOTAL: Salaries	**$147,512**

TOTAL COST TELEDENTISTRY	**$173,332**
164 children seen (10/2010 - 9/2011)	
COST PER CHILD SEEN BY TELEDENTISTRY	**$1,056.90**

Tangible Costs -Traditional Dentistry

Table 5 provides a detailed explanation of the tangible, direct, indirect, medical and non-medical costs of the traditional dentistry program. To make the cost of teledentistry and traditional dentistry comparable, it was necessary to find the percentage of the similar population that was treated by teledentistry during the same time frame. From October 2010 through September 2011, the traditional dental practice treated a total of 3,248 patients. Of those patients, 204 were children ages 5-12 years, representing 6.28% of the total patient base for the study time period. 6.28% of the total traditional dentistry direct costs are equivalent to $30,536.94 (6.28% x $486,257 = $30,536.94).

Parents' lost wages and travel associated with taking children to a dental visit are considered the indirect costs of traditional dentistry. Average hourly wage for an eight hour day plus mileage at current state reimbursement of .51 cents was added to the traditional dentistry cost for each of the 204 treated. Map Quest calculated the distance between Nahunta Elementary School, the location of the Brantley County Teledentistry Clinic, and Dr. Jon Drawdy's dental practice, one of the closest Medicaid accepting dentists, as 24.76 miles, one-way (Mapquest.com, 2011b). This amount was rounded to 25 miles and a value of 50 miles was used as the distance traveled for each caregiver of a child receiving traditional dental services. The dollar value assigned to the distance was .51 cents x 50 miles = $25.50 per caregiver.

Table 5

Traditional Dentistry Costs

Equipment	
Dental Equipment (purchase price listed but total annuitized-7 years):	
Dental Operatory (inclusive to provide all services) 6 @ $40,000 each	
Panorex X-Ray 1 @ $60,000	
TOTAL: Dental Equipment (annuitized-7 years)	**$40,318**
Building	
Building Costs (Dr. Jon Drawdy, D.M.D)	
Building Mortgage ($10/Sq. Ft. @ 5000 Sq. Ft. per yr)	$50,000
Building Costs per year (taxes, repairs, misc. expenses)	$4,500
TOTAL: Building Costs	**$54,500**
Operating Costs	
Operating Costs (Dr. Jon Drawdy, D.M.D)	
Utilities, phone, internet, computer support, licenses and fees ($6,000/month)	$72,000
TOTAL: Operating Costs	**$72,000**
Salaries	
Salaries (Dr. Jon Drawdy, D.M.D, via Certified Compensation Professionals)	
Median Dentist Salary (annual)	$134,014
Dental Hygienist (annual = $62,144)	
1@ 1.0 FTE	$62,144
1@ .25 FTE	$15,536
1@ .25 FTE	$15,536
Dental Assistant (annual= $32,929)	
1@ 1.0 FTE	$32,929
Medical Clinic Receptionist (annual = $29,640)	
1@ 1.0 FTE	$29,640
1@ 1.0 FTE	$29,640
TOTAL: Annual Salaries	**$319,439**
TOTAL COST TRADITIONAL DENTISTRY	**$486,257**
3,248 patients seen (10/2010 - 9/2011)	
204 children seen (10/2010 - 9/2011)	
Percent of patients who are children 6.28% X $486,257	
TOTAL COST TRADITIONAL DENTISTRY FOR TREATING CHILDREN (Direct)	**$30,536.94**
Indirect Costs	
Parent Travel (50 miles x .51/mile = $25.50/child caregiver)	$5,202
Parent Lost wages ($12.63/hr x 8 hrs= $101 x 204 children	$20,604
Services Charges (Costs)	
Children Private Pay Charges (161 x $181.00)	$29,141
Children Medicaid Pay Charges (43 x $94.17)	$4,049.31
TOTAL COST TRADITIONAL DENTISTRY (FOR CHILDREN)	**$89,533**
COST PER CHILD SEEN BY TRADITIONAL DENTISTRY	**$438.89**

According to the U.S. Census Bureau the median earnings of Brantley County's population sixteen years and over equals $26,269 (U.S. Census Bureau, 2009). This income is equivalent to a $12.63 hourly wage and translates into a daily earning of $101. This amount was assessed for the caregivers of the 204 children who obtained traditional dentistry services.

Dental Charges

Of the 204 children seen during the study, 161 were private pay and 43 were Medicaid participants. Private and Medicaid reimbursement rates for teledentistry clinic services (cleaning/prophy exam, fluoride treatment and x-rays) were provided by Dr. Drawdy. Private pay costs were validated using the Agency for Healthcare Research and Quality's Medical Expenditure Survey, Healthcare Costs for 2008 Dental Services Expense data (Agency for Healthcare Research and Quality, 2008). Medicaid costs were validated using the Centers for Medicare and Medicaid Services State Plan Medicaid Service Reimbursement webpage information (Centers for Medicare and Medicaid Services, 2011). Table 6 provides a detailed explanation of the costs.

Table 6

Traditional Dentistry Dental Service Charges; Private and Medicaid

Service Type	Private	Medicaid
Cleaning/Prophy Exam	$107.00	$54.85
Fluoride Treatment	$34.00	$17.59
X-ray	$40.00	$21.73
TOTAL	**$181.00**	**$94.17**

Overall total charges (costs) for these services during the study year were $29,141.00 for private pay children and $4,049.31 for Medicaid children.

Annuitization

Telehealth equipment was annuitized over five years and dental equipment was annuitized over seven years as indicated in the methodology chapter. A discount rate of 3% was utilized as recommended by the U.S. Panel on Cost-Effectiveness in Health and Medicine (Haddix *et al.,* 2003). The following equations, from the CDC's Economic Evaluation Tutorial website (CDC, 2011c), were used to calculate the annuitized values for capital equipment.

First the Present Value (PV) of equipment was calculated.

$$PV = SV \times 1 / (1 + r)^n$$

SV = Scrap value
r = Discount rate
n = Length of item's useful life

Next the Equipment Annual Cost (EAC) was calculated.

$$EAC = (PC - PV) / A$$

PC = Purchase price
PV = Present value (step 1)
A = Annuity factor

The annuity factor was obtained from an Annuitization Factor table in the Haddix textbook (Haddix *et al.*,2003). Table 7 details the annuitization figures.

Table 7

Annuitization Values for Capital Equipment

TELEDENTISTRY		
Description	**Purchase Price**	**Yearly Annuitized Value**
Telehealth Equipment	$39,826	$7,963
Dental Equipment	$33,268	$4,471
TRADITIONAL DENTISTRY		
Dental Equipment	$300,000	$40,318

Intangible Cost

Three percent of the parents surveyed answered the self-esteem questions *Often or Very Often*. Three percent of the 164 sample is equivalent to five children. Detailed survey results can be found in Appendix B. According to DeNavas-Walt *et al.*, in 2010, the median, annual income for someone without a high school diploma was $21,950 compared to $32,501 for a high school graduate (DeNavas-Walt, Proctor & Smith, 2011). It can be argued that the $10,583 difference in these two incomes is an added value of receiving teledentistry services that will last throughout an individual's working lifetime, ages 18 to 62 (DeNavas-Walt *et al.*, 2011). But a conservative valuation of the intangible cost was assessed and considered the ten-year CEA Analytic Horizon and the average age of the child seen at the clinic during the study period which was nine years. Therefore, $264,575 (5 years x $10,583 x 5 children) will be considered a program benefit and subtracted from the cost of teledentistry. On the other hand, the barriers to receiving traditional dental care require that this value be added to the cost of traditional dentistry.

Haddix *et al.* argues that intangible costs should not be included in a CEA, in part because quantifying these costs is difficult and often inaccurate (Haddix *et al.*, 2003). But there are other researchers who say the opposite. In fact, they argue that CEAs must consider intangible costs such as pain, anxiety etc. (Muennig, 2002). Because CEAs have traditionally excluded these costs many preventive healthcare measures are devalued (Muennig, 2002). To acknowledge both schools of thought the ICER will be calculated and interpreted with and without the inclusion of intangible costs.

Calculations and Interpretations

Average Cost-Effectiveness Ratio

By definition, the Average Cost-Effectiveness Ratio (ACER) is the ratio of the net costs to the health outcome. Table 8 shows the ACERs for both the traditional dentistry and teledentistry programs.

Table 8

Average Cost-Effectiveness Ratios

Program	Cost	Health Outcome (# of children seen)	ACER (Cost ÷ # of children seen)
Traditional Dentistry	$89,533	204	$438.89
Teledentistry	$173,332	164	$1,056.90

Incremental Cost Ratio

The following equation was used to calculate the Incremental Cost Ratio (ICER) for the teledentistry program.

$$\text{ICER} = \frac{\text{Cost of teledentistry program} - \text{Cost of traditional dental services}}{\text{\# of children seen at the teledentistry clinic during 2010-2011 school year} \qquad \text{\# of children seen at the traditional dental practice during the 2010-2011 school year}}$$

The equation variables for the ICER without the inclusion of the intangible cost can be found in Tables 4 and 5.

Cost of teledentistry program = $173,332
Cost of traditional dental services = $89,533
# of children seen at the teledentistry clinic = 164
# of children seen at traditional dental practice = 204

$$\text{ICER} = \frac{\$173{,}332 \;-\; \$89{,}533}{164 \;-\; 204} = -\$2{,}094.98$$

The negative value of the ICER indicates that treating children via teledentistry is both cost-effective and cost saving.

The following are the variables for the ICER with the inclusion of the intangible cost.

Cost of teledentistry program = $91,243
Cost of traditional dental services = $354,108
# of children seen at the teledentistry clinic = 164
# of children seen at traditional dental practice = 204

$$\text{ICER} = \frac{\$91{,}243 \;-\; \$354{,}108}{164 \;-\; 204} = \$6{,}571.63$$

The positive value of the ICER indicates that the teledentistry program is cost-effective.

Marginal Cost-Effectiveness Ratio

The Marginal Cost-Effectiveness Ratio (MCER) reflects changes as a result of expanding teledentistry. It is appropriate to assess the MCER for the teledentistry program because of the initial large capital outlay. In addition, most of the salaries associated with the program are not based on the amount of services provided but annual contracts or salaries that are required to run the program from administrative and dental oversight standpoints. The majority of the costs are not variable and will not be affected by increasing the number of children receiving services.

The MCER will be calculated based on a 50% and 100% increase in child participation. According to the SEHD Telehealth Coordinator, children receiving initial teledentistry services have the most acute and involved dental problems (J.E. Woodard, personal communication, September 15, 2011). This is due to school nurses and teachers indentifying and advocating for these children to receive teledentistry services first (J.E. Woodard, personal communication, September 15, 2011). Children with the most serious problems require referrals that are case managed. The need for case management is expected to decrease as the program continues. For this reason the MCER case management costs did not increase at the same rate as participation. For a 50% increase in children treated, case management increased 25% and for 100% increased participation, case management increased 33%.

Diminished acuity and increased efficiency warranted a decrease in the dental hygienist and dental assistant time for the 100% MCER. The wages for these two professionals was increased 50% for the 50% expansion of the program MCER calculation and only 75% for the 100% MCER calculation. All other variable costs (general and instrument supplies) were increased 50% and 100%. Table 9 details the costs for the MCER calculations.

Table 9

MCER Teledentistry Costs

TELEDENTISTRY-50% Participation Increase	
Telehealth Equipment	$7,963
Dental Equipment	$4,471
General Dental Supplies ($1,466 + 50%)	$2,199
Dental Instruments ($874 + 50%)	$1,311
Building Cost ($10/Sq. Ft @ 300 Sq. Ft. per yr)	$3,000
T1 Data Transmission Lines $170/month x 12 months	$2,040
Utilities (Electricity, Water .35/sq. ft./month .35 x 300 sq. ft x 12 months)	$1,260
Dental Hygienists ($10,200 + 50%)	$15,300
Dental Assistants ($1,440 + 50%)	$2,160
Case Manager ($1,700 + 25%)	$2,125
Case Manager ($950 + 25%)	$1,188
Jon Drawdy, DMD (1 year contract $25,000)	$25,000
GA Health Sciences University Dental School (1 year contract $30,000)	$30,000
Telehealth Coor. (30% in-kind from SEHD salary + fringe)	$26,774
Teledentistry Administrative Asst (Grant paid salary + fringe for one year)	$33,650
SEHD System IT Administrator (20% in-kind from SEHD salary + fringe)	$17,798

TOTAL COST TELEDENTISTRY + 50% Participation Increase	**$176,239**
164 children seen + 50 % = 246	
COST PER CHILD SEEN BY 50% INCREASE TELEDENTISTRY	**$716.42**
TELEDENTISTRY-100% Participation Increase	
Telehealth Equipment	$7,963
Dental Equipment	$4,471
General Dental Supplies ($1,466 + 100%)	$2,932
Dental Instruments ($874 + 100%)	$1,748
Building Cost ($10/Sq. Ft @ 300 Sq. Ft. per yr)	$3,000
T1 Data Transmission Lines $170/month x 12 months	$2,040
Utilities (Electricity, Water .35/sq. ft./month .35 x 300 sq. ft x 12 months)	$1,260
Dental Hygienists ($10,200 + 75%)	$17,850
Dental Assistants ($1,440 + 75%)	$2,520
Case Manager ($1,700 + 33%)	$2,261
Case Manager ($950 + 33%)	$1,264
Jon Drawdy, DMD (1 year contract $25,000)	$25,000
GA Health Sciences University Dental School (1 year contract $30,000)	$30,000
Telehealth Coordinator (30% in-kind from SEHD salary + fringe)	$26,774
Teledentistry Administrative Asst (Grant paid salary + fringe for one year)	$33,650
SEHD System IT Administrator (20% in-kind from SEHD salary + fringe)	$17,798
TOTAL COST TELEDENTISTRY + 100% Participation Increase	**$180,531**
164 children seen + 100 % = 328	
COST PER CHILD SEEN BY 5100% INCREASE TELEDENTISTRY	**$530.40**

The following equation was used to calculate the MCER.

$$\text{MCER} = \frac{\text{Cost of teledentistry program expansion} - \text{Cost of teledentistry program}}{\text{\# of children seen at expanded teledentistry program} - \text{\# of children seen at original teledentistry program}}$$

Equation for a 50% increase in child teledentistry participation:

$$\text{MCER} = \frac{\$176{,}239 - \$173{,}332}{246 - 164} = \$34.45$$

Equation for a 100% increase in child teledentistry participation:

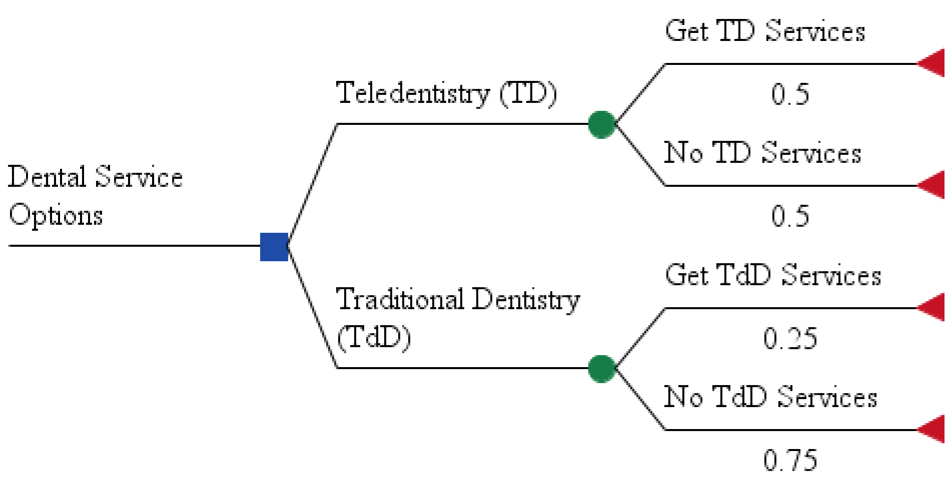
$$\text{MCER} = \frac{\$180{,}531 - \$173{,}332}{328 - 164} = \$43.90$$

These values indicate that expanding the teledentistry program is cost-effective and can be achieved with minimal increases in program expenditures. A 50% increase in participation reduces the cost per child by 32% and a 100% increase reduces the cost per child by 48%.

Decision Analysis

TreeAge Pro 2.0 was used to conduct a decision analysis and subsequent expected value (EV) calculation. Decision analysis is conducted to assist policy makers in making decisions regarding what interventions to implement (Haddix *et al.*, 2003). EV is calculated so that uncertainties (different interventions) can be compared to one another. The alternative with the best EV maximizes utility or value (Haddix *et al.*, 2003). A decision tree was constructed within the software. As shown in Figure 2 the decision node question was defined as Dental Service Options. The two treatment choices were teledentistry and traditional dentistry. Each choice had one chance node with two possible events; a treat event or a no treat event. Each event ended in a terminal node. The cost for each terminal node equals the cost per child for each intervention and varied depending on the inclusion or exclusion of the intangible cost. These values are shown in subsequent figures.

Figure 2. Decision Analysis Tree (TreeAge Pro 2.0, 2011).



The probability for the branch of the teledentistry treat option was 0.5 and was also 0.5 for no treat. These probabilities were selected because parents could either grant permission for their child to obtain teledentistry services or not. The cost for the teledentistry terminal node for treatment was $1,056.90, the teledentistry cost per child treated. The cost for the terminal node for no treatment was zero.

The probability for the branch of the traditional dentistry treatment option was .25 and was .75 for no treatment. These probabilities were selected based on The Georgia Dental Association's (GDA), "2010 White Paper" and Georgia's poverty levels. The GDA stated that 41.9% of families with an income of 200% to 400% of Federal Poverty Level (FPL) visited the dentist at least one time in a year and only 26.5% of those at 100% or less FPL had an annual dental visit (Georgia Dental Association, 2010). In 2009, 46% of Georgians had an income at 200% to 400% of FPL and 21% were at 100% or below (State Health Facts.org, 2009a). The following equation was used to calculate the traditional dentistry probabilities for the decision tree.

$$(46\% \times .419) + (21\% \times .265) = .25 \text{ probability of obtaining traditional dental services}$$

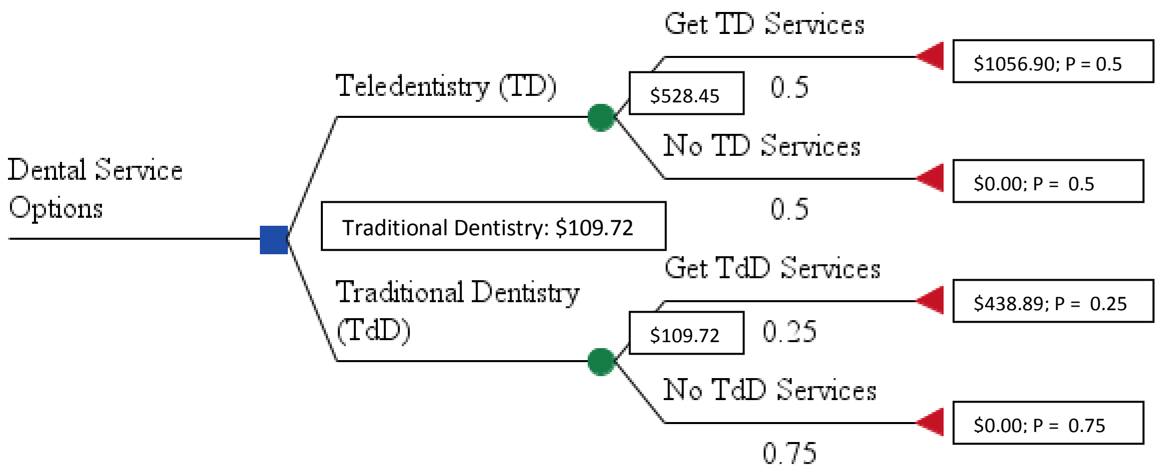
$$1 - .25 = .75 \text{ probability of } \textit{not} \text{ obtaining traditional dental services}$$

The cost for the traditional dentistry terminal node for treatment was $438.89, the traditional dentistry cost per child treated. The cost for the terminal node for no treat was zero.

Decision Analysis without Intangible Cost

The results of the EV calculation are shown in Figure 3. TreeAge Pro 2.0 selected traditional dentistry as the dental option providing the best utility ($109.72 versus $528.45 per child) when the intangible cost of children's self-esteem was excluded.

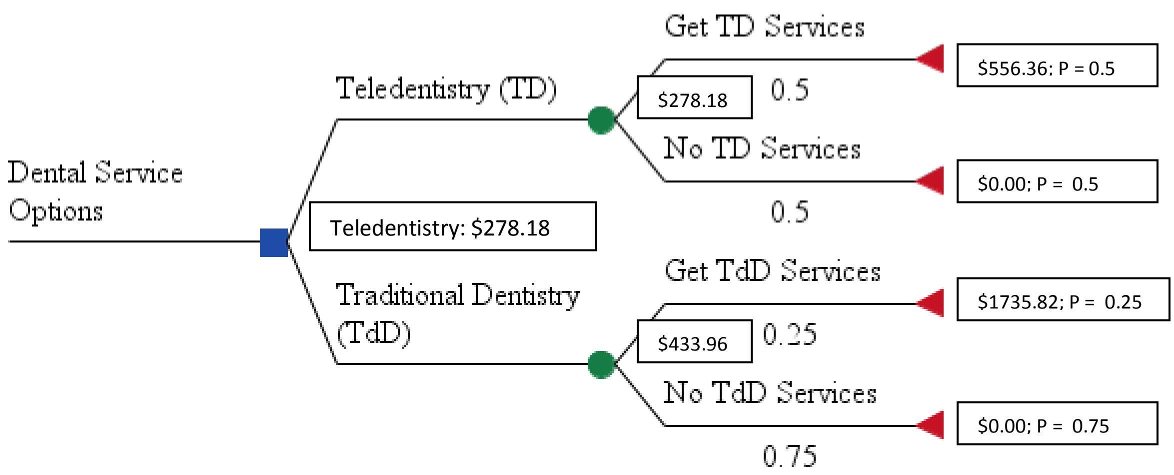
Figure 3. Decision Analysis Tree with Expected Value Results; without Intangible Cost (TreeAge Pro 2.0, 2011).



Decision Analysis with Intangible Cost

The results of the EV calculation are shown in Figure 4. TreeAge Pro 2.0 selected teledentistry as the dental option providing the best utility ($278.18 versus $433.96 per child) when the intangible cost of children's self-esteem was included. Inclusion of the cost and/or benefit of children's self-esteem made the teledentistry program have a higher utility or value.

Figure 4. Decision Analysis Tree with Expected Value Results; with Intangible Cost (TreeAge Pro 2.0, 2011).



Sensitivity Analysis

TreeAge Pro 2.0 was also used to conduct the sensitivity analysis. This type of analysis was conducted to test the inputs of the decision model for which there is uncertainty (Muennig, 2002). Single variables are tested over a range of plausible values in a one-way sensitivity analysis (Muennig, 2002). A tornado analysis allows each variable with uncertainty to be sequentially tested using a one-way sensitivity analysis, providing a ranking of the different variables in order of their overall influence on the magnitude of the model's EV or outputs (Muennig, 2002). The dental options decision analysis model was tested using a tornado analysis which subsequently provided one-way sensitivity analyses of all model variables. Parameters that the researcher was less confident about were assigned a wider range of test values and those that the researcher was more confident about were assigned a smaller range of test values (Muennig, 2002). Muennig states that, "when a particular strategy remains dominant over the range of tested values for the input with uncertainty the model is said to be robust" (Muennig, 2002).

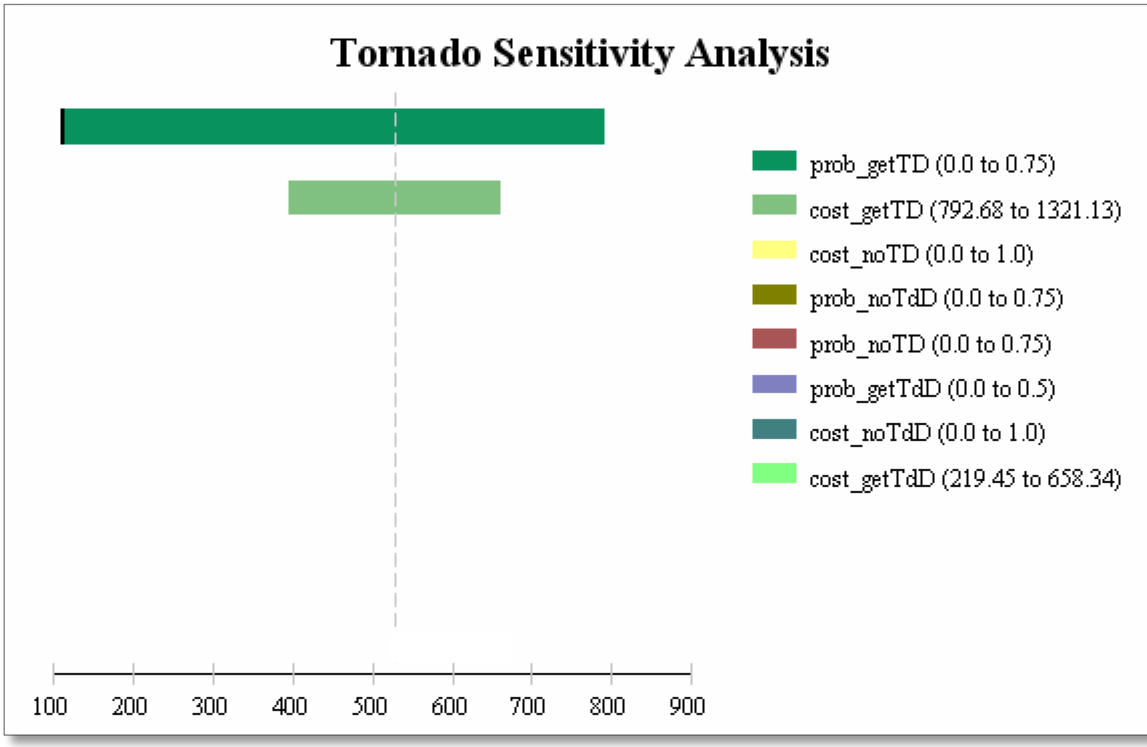
Probability ranges remained constant for the tornado analysis of the decision models that included and excluded the intangible cost. The probability of getting teledentistry services was changed to 0.75 (range: 0.00 to 0.75) and the probability for not getting these services was decreased to 0.25 (range: 0.00 to 0.75). This range was numerically necessary to incorporate the probability value of 0.25. Even though parents had a yes or no option for their children to participate in the teledentistry program it can be assumed that more than half of the caregivers would want their children to obtain dental services at school. This assumption was made because the services are free, beneficial and convenient. Traditional dentistry probabilities were obtained from aggregate data (U.S. Census and Georgia poverty rates) and not from individual participant data. For the tornado analysis the probability of getting traditional dentistry services was increased to 0.5 (range: 0.00 to 0.5) and decreased to 0.5 (range: 0.00 to 0.5) for not getting these services.

Sensitivity Analysis without Intangible Costs

The cost for the teledentistry intervention was changed by 25% (range: $792.68 to $1,321.13) to allow for variability in estimated input costs. Since the majority of costs were obtained from vendors and payroll data the 25% is less than the cost variation of 50% (range: $219.45 to $658.34) for traditional dentistry. The largest assumption made for teledentistry was the cost and utilities of the school facility. The larger variability for the cost of traditional dentistry is mainly associated with the estimated indirect costs (parent’s wages and travel). Median wages and average travel distances justify testing a larger cost increase.

A graphical expression of the tornado analysis is depicted in Figure 5. According to the TreeAge Pro 2.0 user manual a wide bar indicates that the associated variable has a large potential effect on the expected value of the model created by the user.

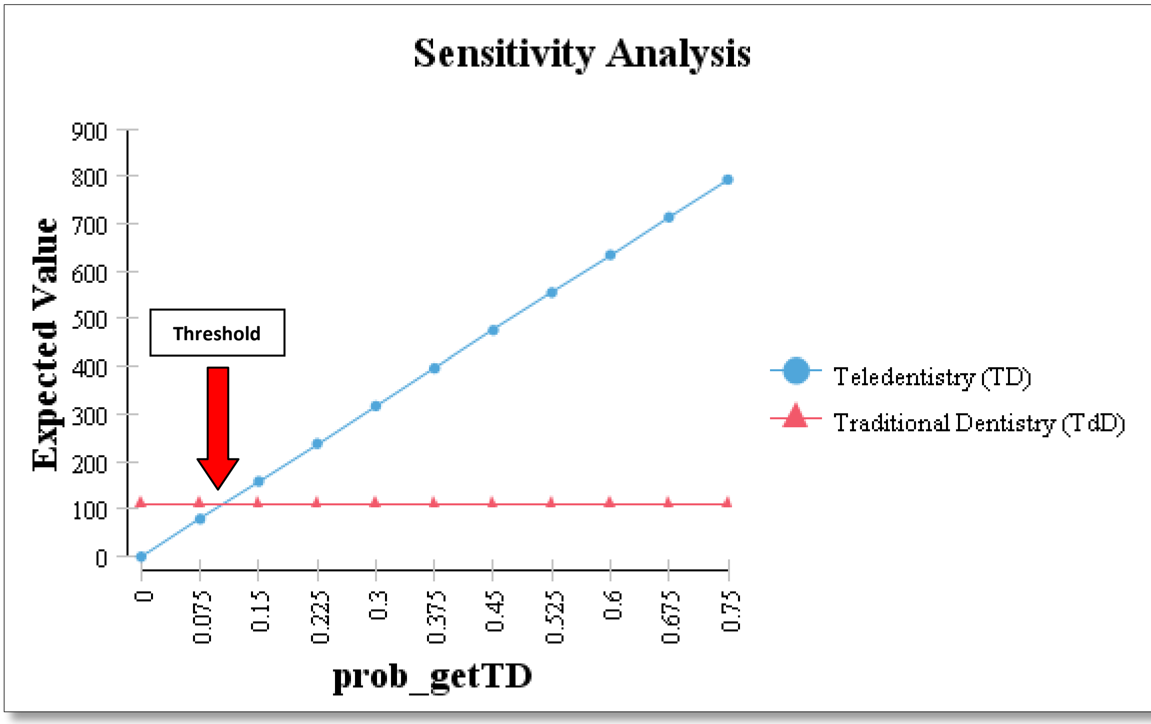
Figure 5. Tornado Diagram without Intangible Cost (TreeAge Pro 2.0, 2011).



The tornado results indicated that there were two variables having the most potential to affect the expected value of the model, the probability of getting teledentistry services and the cost of teledentistry. Because of the width of the bar, probability had the most influence. The results show that changes to the remaining variables will not influence the model value, implying the original parameter values were plausible, contributing to the model's robustness.

Figure 6 contains the results of the one-way sensitivity analysis for the probability of obtaining teledentistry services. The Y-axis represents the EV of the intervention. The EV refers to each arm of the decision tree and each value associated with that arm. The X-axis represents the range of probabilities for which the model was tested.

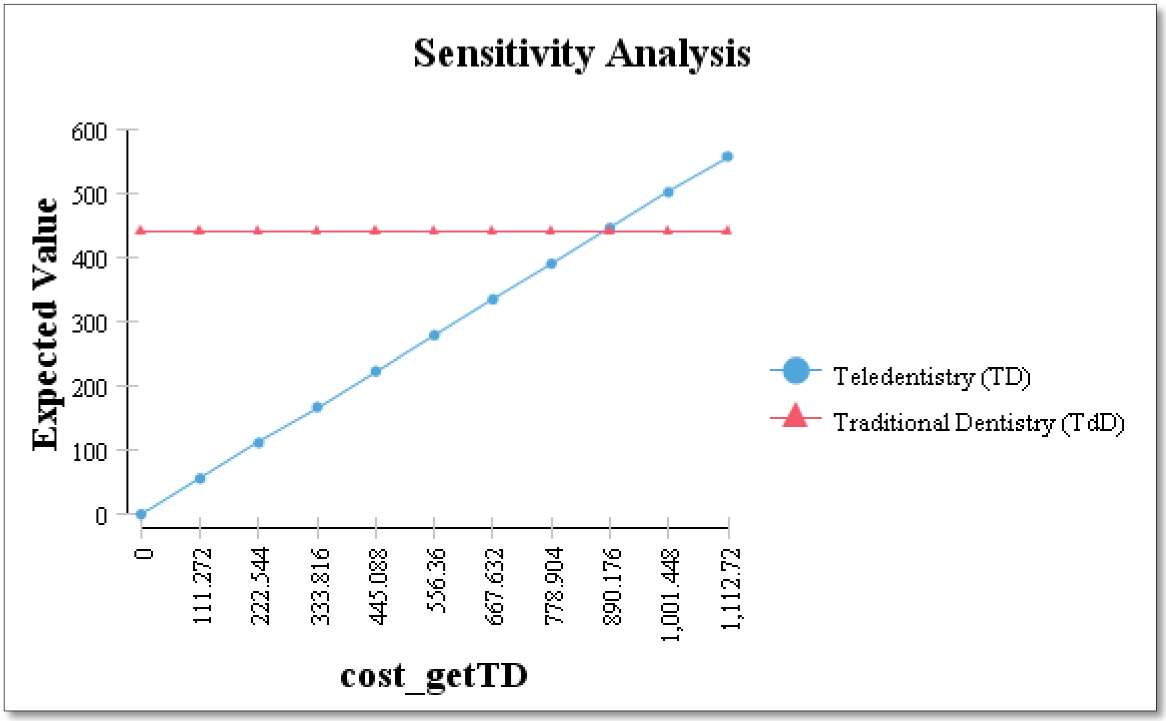
Figure 6. One-Way Sensitivity Analysis-Probability of Getting Teledentistry without Intangible Cost (TreeAge Pro 2.0, 2011).



As the probability of participation in teledentistry increases, so does the EV of the intervention. This implies that the true value of teledentistry may be cost-effective but not cost saving. The red arrow in Figure 6 designates the threshold value; defined as the point at which traditional dentistry becomes more cost-effective than teledentistry (Muennig, 2002). For this individual one-way sensitivity analysis the threshold value is a probability of approximately 0.1.

The results of the one-way sensitivity analysis for the cost of obtaining teledentistry services are shown in Figure7. As expected, increasing the cost of teledentistry services resulted in an increased EV. The threshold value for this analysis is $890.18, the cost for intervention services where traditional dentistry becomes more cost-effective than teledentistry.

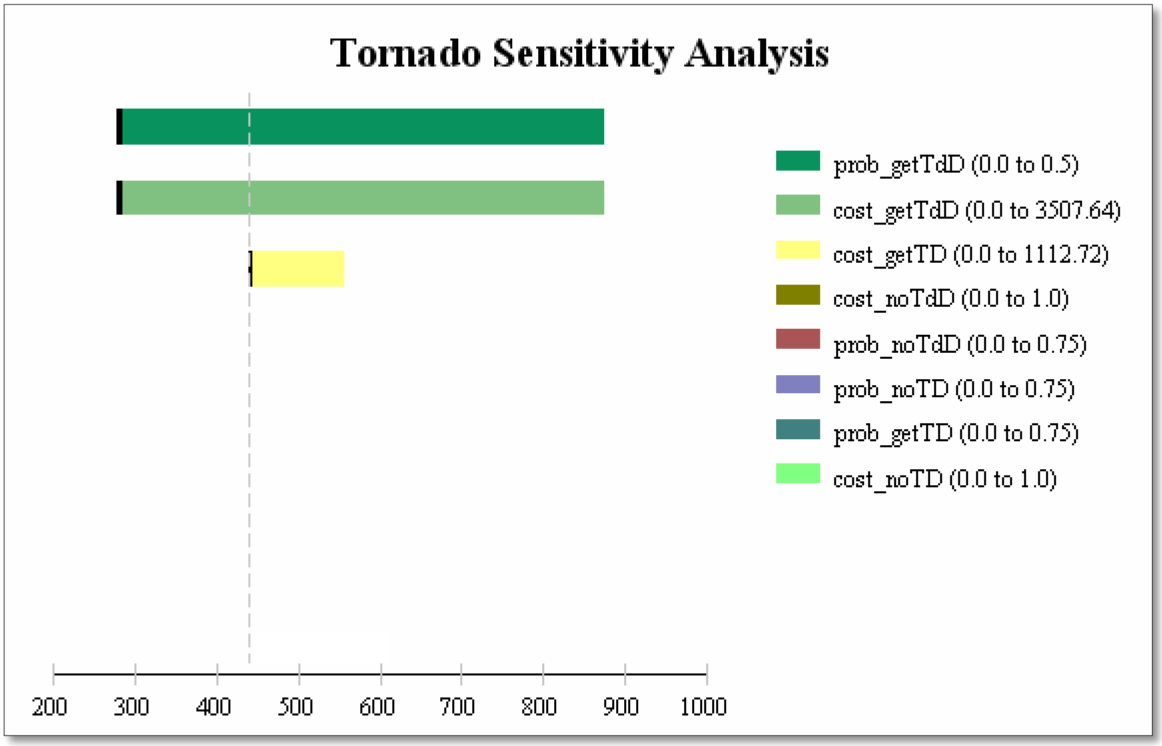
Figure 7. One-Way Sensitivity Analysis-Cost of Getting Teledentistry without Intangible Cost (TreeAge Pro 2.0, 2011).



Sensitivity Analysis with Intangible Cost

Figure 8 illustrates the results of the tornado analysis conducted with the intangible cost included. Because the parameter with the greatest uncertainty is the intangible cost, the program cost was varied by 100%. For teledentistry the range was, $0.00 to $1,112.72 and for traditional dentistry the range was $0.00 to $3,507.64.

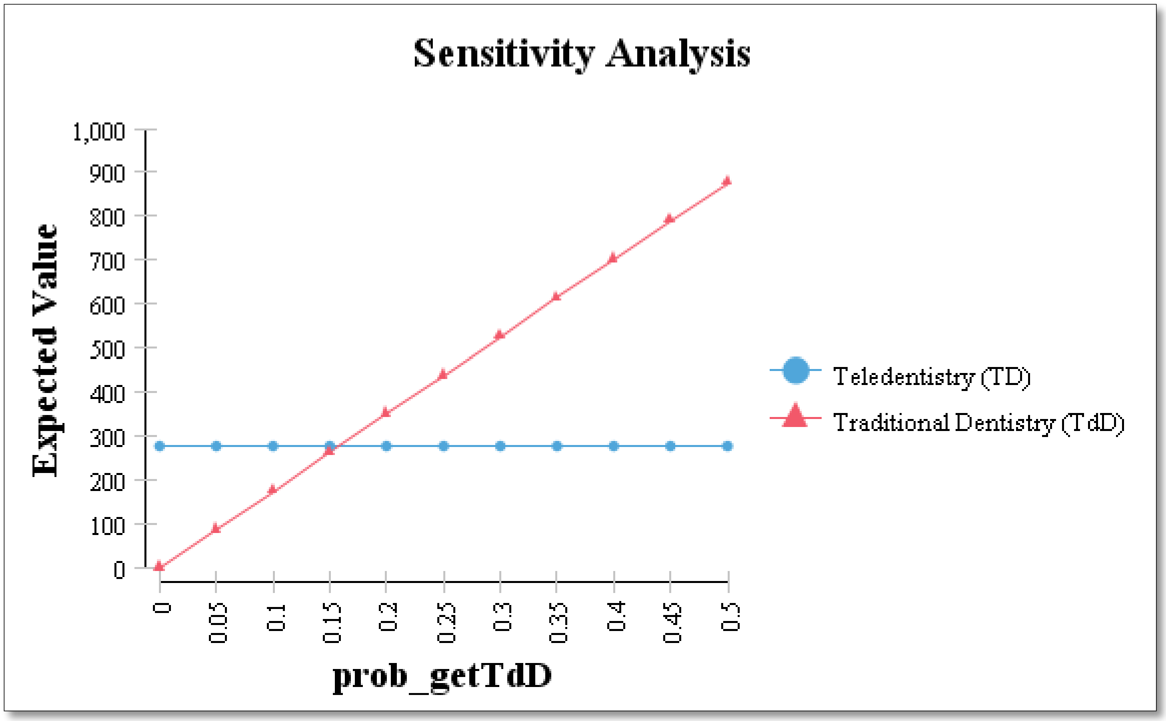
Figure 8. Tornado Diagram with Intangible Cost (TreeAge Pro 2.0, 2011).



The tornado results indicated that there were three variables that had the most potential to affect the expected value of the model: the probability of getting traditional dentistry services, the cost of traditional dentistry, and the cost of teledentistry. Because of the width of the bars, probability and cost of obtaining traditional dentistry have the most influence. The results show that changes to the remaining variables will not influence the model value, implying the original parameter values were plausible, adding robustness to the model.

Figure 9 depicts the results of the one-way sensitivity analysis for the probability of obtaining traditional dentistry services including the intangible cost.

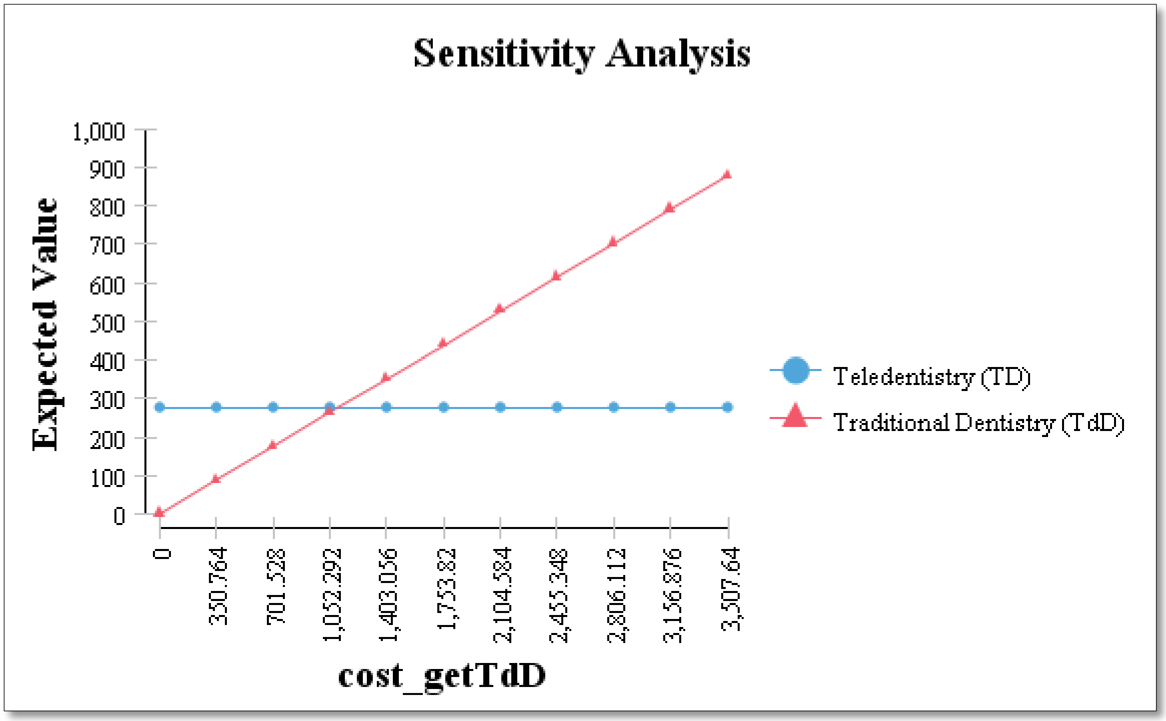
Figure 9. One-Way Sensitivity Analysis-Probability of Getting Traditional Dentistry with Intangible Cost (TreeAge Pro 2.0, 2011).



As the probability of traditional dentistry attendance increases the EV does also. The threshold value is 0.15- the probability where it is more cost-effective to provide teledentistry services as opposed to traditional dentistry services.

The results of the one-way sensitivity analysis for the cost of obtaining traditional dentistry services including the intangible cost are represented in Figure 10.

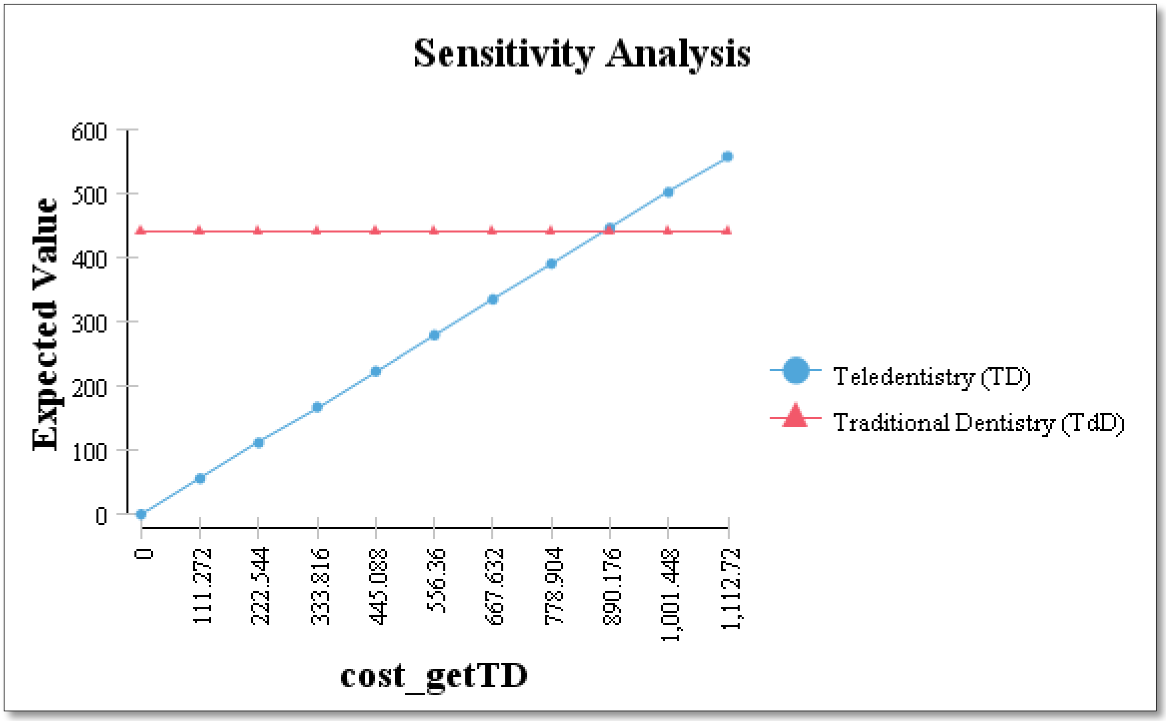
Figure 10. One-Way Sensitivity Analysis-Cost of Getting Traditional Dentistry with Intangible Cost (TreeAge Pro 2.0, 2011).



The increasing cost of traditional dentistry across the values is associated with an increased EV. The threshold value was calculated at $1052.29, the cost where teledentistry becomes more cost-effective than traditional dentistry.

Figure 11 represents the results of the one-way sensitivity analysis for the cost of obtaining teledentistry services with the intangible cost included.

Figure 11. One-Way Sensitivity Analysis-Cost of Getting Teledentistry with Intangible Cost (TreeAge Pro 2.0, 2011).



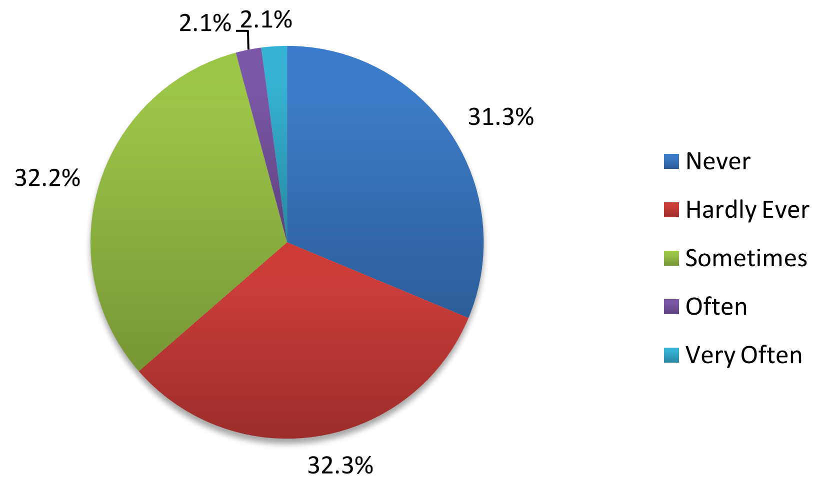
As expected the increasing cost of teledentistry across the values is associated with an increased EV. But the threshold value was calculated at $890.18, a value which is greater than the calculated cost of teledentistry with intangible cost included ($556.36). This implies that teledentistry is both cost-effective and cost saving.

Additional Survey Results

The majority of the survey results were not included in the CEA but do have implications for future dental interventions in rural Georgia. For that reason the parents' answers to survey questions were tallied. Individual answers were quantified as a percent of the total number of answers for each question. Results are portrayed in graphical form to enhance understanding.

Figure 12 depicts the pain associated with dental problems in the children who received Brantley County elementary school teledentistry services.

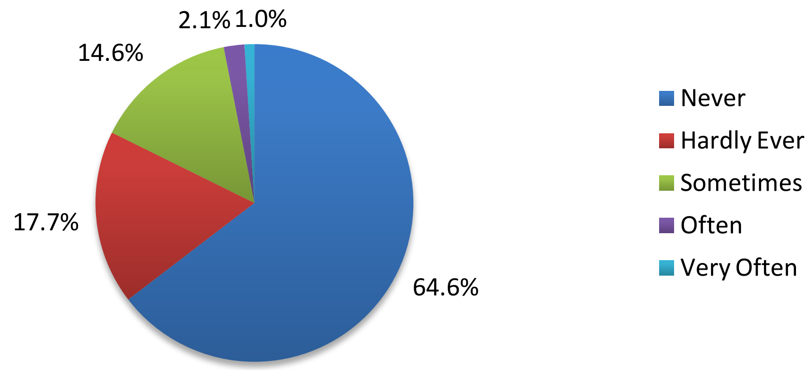
Figure 12. Results of Parent Survey Question #1, How Often has Your Child had Pain in the Teeth Mouth or Jaws?



63.6% of the respondents indicated that their child rarely had pain associated with dental issues but 36.4% of respondents indicated their child did have pain related to dental problems. Even though the majority of parents denied mouth pain, the percentage that acknowledges the condition is remarkable. A 2.1% response rate to *very often* indicates a serious need for an easily accessible, free, preventive program like teledentistry.

Figure 13 represents the results of parents' answers about whether children have been absent from academic settings as a result of dental issues.

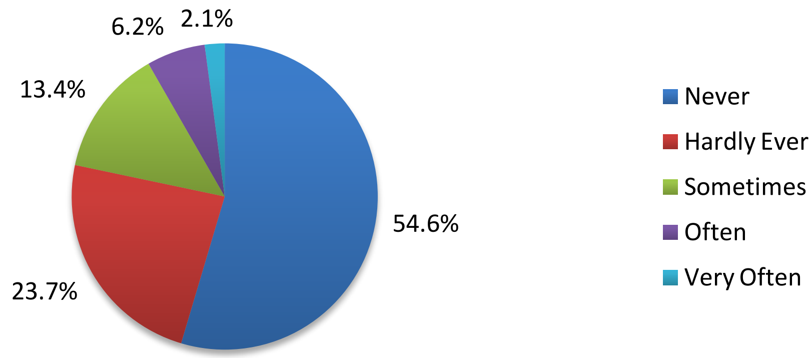
Figure 13. Results of Parent Survey Question #2a, How Often has Your Child, Because of Dental Problems Missed Preschool, Daycare or School?



The overwhelming majority of caregivers, 64.6%, denied absenteeism as a result of dental problems. But the remaining respondents, 35.4%, acknowledged their child's school attendance had been influenced by dental issues. A 2.1% response rate for *often* and 1% for *very often*, although small, are still significant enough to illustrate the need for alternative dental services, ideally school-based.

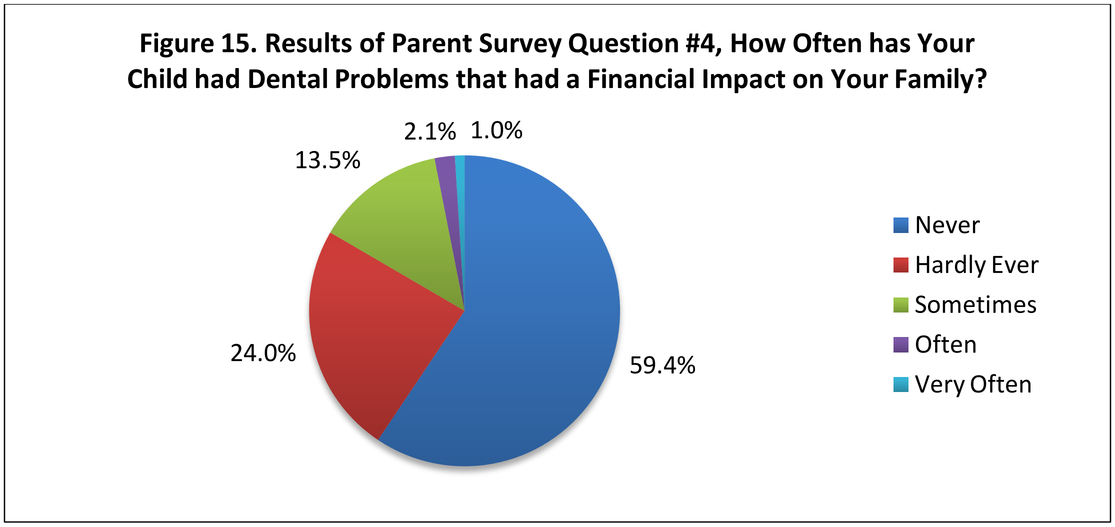
The results of parents' answers to family members' absenteeism from work as a result of children's dental problems are shown in Figure 14.

Figure 14. Results of Parent Survey Question #3, How Often Have you or Another Family Member Taken Time Off of Work Because of Your Child's Dental Problems?



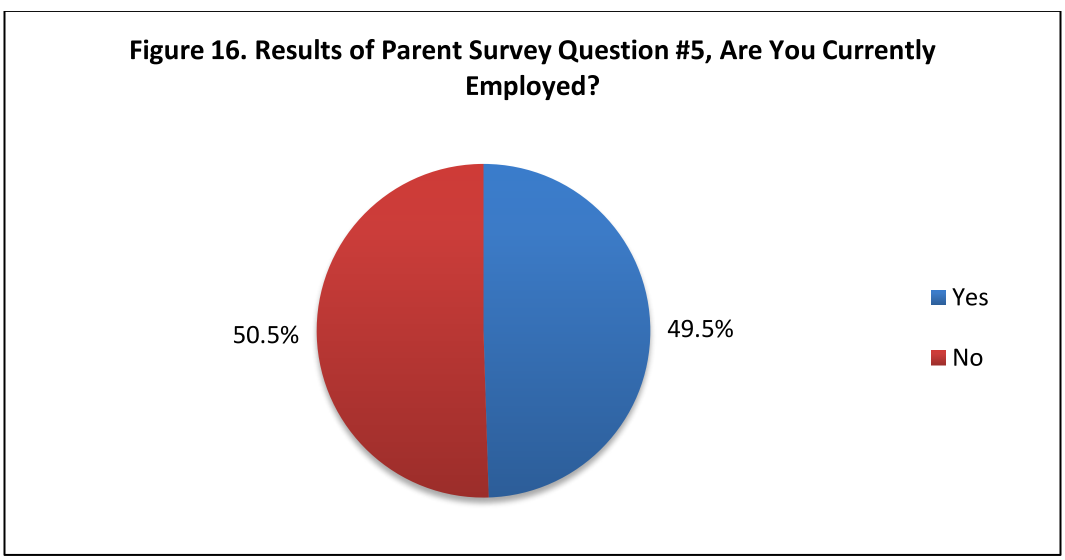
Although 54.6% of caregivers denied missing work, the remainder acknowledged absenteeism to a varying degree. This can have a detrimental effect on a family’s income especially if the parent does not get paid for time off from work.

Parents’ answers to how children’s dental problems have impacted finances are depicted in Figure 15. The majority of those surveyed replied that finances had *never* been impacted (59.4%), compared to only 16.6% who responded that their finances had been impacted to some degree.



These results are somewhat unexpected but may be explained by dental coverage. Thirty percent of Georgia's children have Medicaid or PeachCare coverage (StateHealthFacts.org, 2009b) and approximately 45% of Georgia's residents have private dental insurance (Georgia Dental Association, 2010).

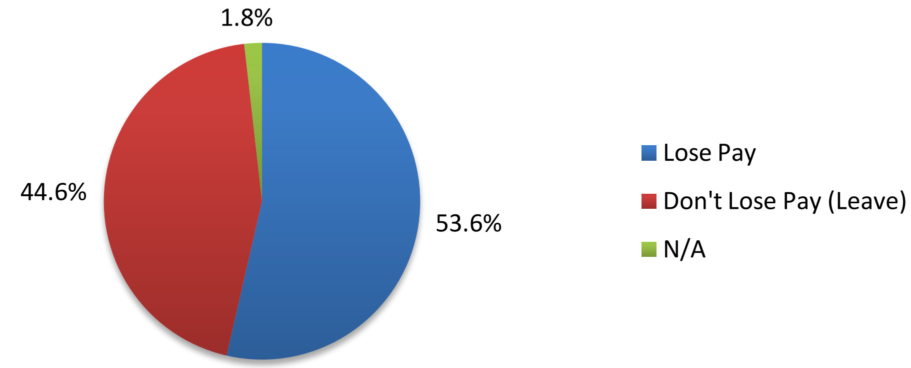
Approximately half of the individuals surveyed were employed while half were not. Exact results are shown in Figure 16. The question did not differentiate between voluntary



unemployment and non-voluntary. So the impact of unemployment may be overstated. To obtain a more accurate unemployment count, future surveys should clarify the reason for unemployment.

The results of the survey question that addressed whether parents get paid when they take time off from work are shown in Figure 17. Most respondents (53.6%) reported that they cannot use leave when taking their child to dental care and as a result lose pay.

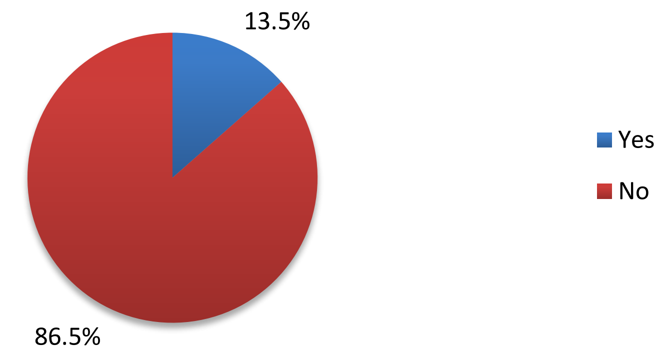
Figure 17. Results of Parent Survey Question #6, If You are Employed do You Lose Pay When You Have to Take Your Child to the Dentist or can You Take Leave?



These results showcase one of the greatest benefits of the teledentistry program. Children receive preventive dental services during school hours preventing caregivers' need to miss work.

Figure 18 shows that 13.5% of parents surveyed said they had taken their child to the emergency room (ER) because of dental problems. This rate is alarming considering the higher costs associated with emergency visits as compared to preventive dental care.

Figure 18. Results of Parent Survey Question #7, Have You Ever Taken Your Child to the Emergency Room Because They had a Dental Problem?



Pettinato *et al.* conducted a three-year comparison of Medicaid reimbursement for ER treatment versus preventive treatment for dental care (Pettinato, Webb & Seale, 2000). They found that on average ER services were ten times more costly than preventive care ($6,498 versus $600) (Pettinato *et al.*, 2000).

Other Findings

There are some issues regarding the variables and parameters of the study that require explanation. Those are the absence of sealants as a treatment option for the teledentistry program and the selection of a one-year time frame for the CEA, as opposed to a school year. In addition, some of the results of equations and analysis necessitate explanation. These include the negative value for the ICER calculation including the intangible cost and the results of the one-way sensitivity analysis of the probability for participation in teledentistry.

The teledentistry Dental Supervisor, Jon Drawdy, DMD opted not to provide sealant treatments during the teledentistry clinics. According to Dr. Drawdy, the most recent studies indicate that sealants are currently not as clinically indicated as they were at one time, especially for a population who, for the majority, already showed signs of tooth decay (J. Drawdy, personal communication, October 9, 2011). For this reason, sealant costs and benefits were excluded from the CEA.

A time frame of one year (October 2010 through September 2011) was selected for the analysis instead of the 2010 - 2011 school year teledentistry program period (October 2010 through April 2011), as previously stated. Although this may overestimate the cost for the teledentistry program, the change is justified. Even though children may not have received services during the expanded period, the cost of the equipment, facility, utilities and wages of salary and contract staff were on-going. In addition, the Dental Supervisor and Telehealth Coordinator were conducting meetings with school staff, case management continued and support staff provided services to the program.

The ICER calculation including the intangible cost resulted in a positive value, implying teledentistry was cost-effective but not cost saving. The researcher expected the inclusion of the intangible cost to enhance the cost savings of the teledentistry program. In fact, when the decision tree was created in TreeAge Pro 2.0 for models including and excluding the intangible cost, results were more closely in line with the researcher's expectations. TreeAge Pro 2.0 selected traditional dentistry as the intervention with the most utility when the intangible cost was excluded and selected teledentistry as the intervention that provided the most value when the intangible cost was included.

The one-way sensitivity analysis results for the probability of obtaining teledentistry services excluding the intangible cost showed that as the probability of getting services increased so did the EV or cost. These results appear straightforward; increasing program participation usually results in higher costs. But, in theory, this should not be true for teledentistry, because the cost of the initial capital outlay remains constant, regardless of the number of individuals who receive services. This is another illustration of why the inclusion of intangible costs is so vital to the accurate cost assessment of preventive medical services.

Summary

When conducting a CEA it is not possible to include all options or to enumerate all consequences. Additionally, although data was extensively researched there is still the possibility it may not be correct. Therefore a sensitivity analysis was conducted to evaluate the robustness of the proposed CEA model. All sensitivity analysis threshold results, with the exception of the cost of getting teledentistry services, were less than the original model value. These results imply that the model, including treatment probabilities and costs, was robust and therefore accurate. Although difficult to quantify, the inclusion of the intangible cost was crucial to illustrating the true value of the teledentistry program. If this cost was not included, teledentistry would have been undervalued and the costs would have been overestimated.

Parent survey results alone indicate the need and cost-effectiveness and cost saving potential of the teledentistry program. But survey results cannot be the only assessment tool for program implementation when resources are diminishing. It is imperative to compare programs that employ different strategies with the same health outcome goal to decide which has the most value to society. This comparison can only be accomplished through conducting a cost-effectiveness analysis.

In conclusion, poverty and a shortage of dental providers present significant barriers to obtaining dental care for residents of rural, Southeast Georgia. Teledentistry was found to be a cost-effective alternative to traditional dentistry, especially when a dollar value is assigned to certain intangible costs.

CHAPTER 5: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Introduction

The purpose of this chapter is to provide an overall summary of the CEA of traditional dental care versus teledentistry for children enrolled in Brantley County, Georgia elementary schools for the period from September 2010 through October 2011. The results of the analysis will be used to draw conclusions about the teledentistry program's utility for the provision of preventive dental care to the underserved population. In addition, the results will be examined to assess the sustainability of the program. Furthermore, a discussion of limitations and delimitations of the study and how they were addressed will be included. Finally, recommendations will be made for future cost analysis studies of the program and the possible impact to this area of research.

Summary of Study

According to the Department of Human Resources "2007 Status of Oral Health in Georgia Report, "poor oral health is one of Georgia's most pressing public health problems" (GDHR, 2007). Children living in rural areas of Georgia are disproportionately affected by dental problems due to limited access to care. The main barrier to dental care is lack of dental providers in rural, Southeast Georgia. To provide a safety net for its constituents the SEHD applied for and obtained a HRSA grant to implement a school-based teledentistry program.

As part of the grant evaluation and to assess the practicality of teledentistry services a cost-effectiveness analysis of the program was conducted. The cost and healthcare outcome (number of children who received services) was compared to the cost and healthcare outcome of a local dental practice (traditional dentistry). In an attempt to illustrate all costs and benefits to society, an intangible cost, children's self-esteem, was included in the analysis.

Results were obtained by manually conducting common cost-effectiveness equations and by utilizing TreeAge Pro 2.0 software for the decision analysis and sensitivity analysis. The calculations showed that the teledentistry program is both cost-effective and cost saving when compared to traditional dentistry. The decision and sensitivity analyses showed that traditional dentistry had the best expected value (utility) when the intangible cost was excluded but teledentistry had the better expected value when the intangible cost was included. The sensitivity analysis illustrated that the intervention probabilities and estimated costs of both programs were realistic and therefore the overall cost-effectiveness analysis model was robust.

Conclusion

The major finding of the analysis was that teledentistry is cost-effective when compared to traditional dentistry. Cost-effectiveness does not necessarily mean that an intervention is also cost saving but that it has the best value. Although the cost per child treated was higher for teledentistry, the ICER calculation indicated this program was cost-effective. The MCER calculation illustrated the point that expansion of the teledentistry program reduced the cost per child significantly. CEA results are used to provide guidelines for what public health programs should be implemented and how resources should be allocated (Haddix *et al.*, 2003). The decision analysis allowed the inclusion of the probability of treatment and favorable results hinged on the inclusion of the intangible cost. Traditional dentistry was selected as the favored intervention when the intangible cost was excluded and teledentistry was selected when the cost/benefit of children's self-esteem was included. In the past it was sufficient to show that a medical intervention provided a benefit (Haddix *et al.*, 2003). But in an environment of diminishing public health resources, programs must demonstrate they can provide a value for the resources used (Haddix *et al.*, 2003).

A sensitivity analysis validates the model assumptions and reduces the possibility of bias resulting from researcher assigned values (Muennig, 2002). For this CEA, the variables requiring validation included the intervention probabilities, information obtained from aggregate data (income, travel rates), traditional dentistry costs, and survey results used to quantify children's self-esteem. Inclusion of a sensitivity analysis as part of CEA results is essential so the analysis can be added to existing economic analysis literature.

Implications

The ability to illustrate the cost-effectiveness of the SEHD teledentistry program adds credibility and transparency for not only the funders (HRSA) but legislators and the general public. In an economy in which governmental agencies are under increased scrutiny, the ability to demonstrate economic responsibility justifies programmatic funding. The cost analysis results also show that the SEHD has been a good steward of the grant funding and will put the district in a better position to receive additional and on-going funding. The analysis of teledentistry provides SEHD leadership with information to decide if the program is worthy of continued resource allocation.

The inclusion of an intangible cost made the pivotal difference in the CEA results. This, coupled with many researchers stating that economic evaluators are undervaluing prevention services by excluding intangible costs, is the most important implication for public health practice realized from this study. Including intangible costs in CEAs is a difficult task. If researchers continue to ignore this cost, public health prevention initiatives will remain undervalued as will the field of public health. Public health has a history of inadequate program evaluation. By including cost analysis, when appropriate, public health practitioners can not only justify interventions but can discontinue those that don't make economic sense.

Recommendations

Limitations

There were several limitations identified before data collection was completed. These were lack of precision of costs due to the retrospective nature of the study, the small sample size of students receiving teledentistry services, the fact that the sample was one of convenience and the potential shortcomings of the parent survey.

Because the equipment cost data was obtained retrospectively, after the start of the teledentistry program, the cost of the Brantley county equipment, purchased in late 2009 was compared to that purchased for the expansion site in mid-2011. The pricing of the equipment had not varied by much. In fact, some 2011 prices actually decreased. For this reason there was no cost adjustment made for inflation.

Only 164 children received teledentistry services during the study. This is a relatively small sample but represented 8.3% of the elementary school enrollment for Brantley County which was approximately 1,982 for the 2010-2011 school year (Brantley County Chamber of Commerce, 2011). Dillman *et al.* state that recommended sample sizes for a population of 2000 at a confidence level of +/- 5% for a five answer Likert scale is 219 (Dillman, Smyth & Christian, 2009).

The sample was not random. Parents elected to have their child receive services or not. The sample is also not necessarily generalizable based on the lack of diversity in Brantley County. But Brantley's percent of children living in poverty, 27%, is greater than the Georgia average of 20% and much greater than the national average of 11% (County Health Rankings, 2011). These figures support the results of the survey being representative of rural locales in Georgia, which generally have higher poverty levels.

All surveys have an inherent bias. The individual can choose not to answer truthfully (Dillman *et al.*, 2009). This becomes especially probable when the questions are sensitive in nature (Dillman *et al.*, 2009). Only 3% of the parents surveyed reported their child having decreased social functioning (avoiding smiling or laughing; avoiding talking to other children) as a result of dental problems. An option for increasing the accuracy of future survey results is to conduct personal interviews with parents. Although interviews are time consuming and more costly, reducing anonymity may provide more truthful answers.

The readability level of the survey was calculated at a 26 on the Flesch-Kincaid Grade Level Test using the Microsoft Word 2007. This score is well above the recommendations made in the CDC publication, “Simply Put: A guide for creating easy-to-understand materials” (CDC, 2010b). The CDC does not provide an exact grade level for surveys in the guide. Instead they cite U.S. health literacy rates of only 12% (CDC, 2010b). The parent survey may have obtained more accurate results if the readability level had been reduced. The survey questions relating to self-esteem were only slightly modified because they were extracted from The Early Childhood Oral Health Impact Scale (ECOHIS) questionnaire. The ECOHIS is a validated instrument well recognized for its assessment of the effect of dental health on children's social and psychological functioning (Pahel *et al.*, 2007). Using a non-validated survey written at a lower grade level, although easier to understand by parents, would have created an additional, unique bias.

Delimitations

Possible delimitations of the CEA were identified at the beginning of the study. These included costs of teledentistry equipment even though they were annuitized, utilization of average wage data for caregivers time away from work while taking children to traditional dentistry care, and the inherent flaws of a CEA.

The threshold and sensitivity analysis ultimately tested the assigned cost of teledentistry equipment and caregivers' average wages over a range of values. The threshold analysis results showed that teledentistry costs could potentially adversely affect the model results when children's self-esteem was excluded but was not identified as an influencing variable when the intangible cost of children's self-esteem was included in the analysis. The value assessed for parents' wages had no effect on the model.

Conducting a CEA provides a lot of information about the economic value of services but fails to address many of the questions public health officials may consider when allocating resources. For instance, CEAs provide a 'snap-shot' of a service but fail to quantify benefits or costs for those who were excluded. For example, the dental status and access to dental care of home-schooled children in Brantley County is not considered. Also, the SEHD's teledentistry program is funded by a federal grant, and the CEA does not take into account whether these funds could have been better utilized in another location.

Recommendations for the SEHD Teledentistry Program

Further analysis of the cost-effectiveness of teledentistry is needed. As the grant activities expand and more children receive school-based dental services, the additional health outcome (number of children receiving services) will increase the value of the intervention. To enhance the argument for preventive dental services of this type, it is also recommended that the SEHD continue collecting intangible cost data regarding children's self-esteem and consider expanding the data collection to include other intangible costs. For example, according to the SEHD Telehealth Coordinator, one of the advantages of teledentistry is the reduced amount of anxiety and fear children experience when compared to traditional dentistry (J.E. Woodard, personal communication, September 15, 2011).

Recommendations for Future Studies

Public health is under increased pressure to illustrate that interventions are beneficial and effective. By excluding economic analyses, where applicable, the practice is doing itself a disservice. The economic analysis of health interventions is in its beginning stages (Haddix *et al.*, 2003) but should still be an important component of programmatic evaluation. To assist public health practitioners, economic evaluation should be included as a program assessment option in evaluation resources.

The goal of public health is to provide the best services with the highest utility possible. CEA is not an exact measurement of utility but this type of evaluation is a step forward in the legitimization of preventive care. By adding an economic analysis component to prevention research and evaluation, public health can advocate for the necessity of the discipline's activities and garner support from policy makers.

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Appendix A:
Parent Survey

Parent Questionnaire

Problems with teeth, mouth and jaws can affect the well-being and everyday lives of children and their families. For each of the following questions please put a check mark (√) next to the response that best describes your child's experiences or your own. Consider the child's entire life from birth until now when answering each question. Check the answer that best describes your child. If a question does not apply, check "Never".

1. How often has your child had pain in the teeth, mouth or jaws?
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

2. How often has your child, because of dental problems (pain in teeth, mouth or jaws), experienced the following:

a) Missed preschool, daycare or school
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

b) Avoided smiling or laughing when around other children
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

c) Avoided talking with other children
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

3. How often have you or another family member taken time off of work because of your child's dental problems?
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

4. How often has your child had dental problems that had a financial impact on your family?
___Never ___Hardly ever ___Sometimes ___Often ___Very Often

Please answer the following questions.

5. Are you currently employed? (Check Yes or No) _____ Yes _____ No

6. If you are employed, do you lose pay when you have to take your child to the dentist or can you take leave? (Check one) _____ I lose pay _____I can take leave and don't lose pay

7. Have you ever taken your child to the emergency room because they had a dental problem (pain in teeth, mouth or jaws)? (Check Yes or No) _____ Yes _____ No

Appendix B:
Parent Survey Results

Parent Survey Answers									
#	q 1	q 2 a)	q 2 b)	q 2 c)	q 3	q 4	q 5	q 6	q 7
1	never	never	never	never	hardly ever	hardly ever	yes	lose	no
2	sometimes	sometimes	hardly ever	hardly ever	hardly ever	sometimes	no		yes
3	never	never	never	never	never	never	yes	lose	no
4	sometimes	never	never	never	never	never	yes	lose	no
5	sometimes	never	hardly ever	hardly ever	never	never	no	leave	no
6	hardly ever	never	never	never	never	hardly ever	yes	lose	no
7	sometimes	sometimes	never	never	hardly ever	never	yes	leave	no
8	often	sometimes	never	never	sometimes	hardly ever	no		yes
9	sometimes	never	never	never	hardly ever	never	no	leave	no
10	sometimes	never	never	hardly ever	never	sometimes	no		no
11	never	never	never	never	never	never	no		no
12	hardly ever	never	never	never	never	never	yes	leave	no
13	hardly ever	never	never	never	hardly ever	hardly ever	yes	leave	no
14	never	never	never	never	never	sometimes	yes	lose	no
15	very often	sometimes	hardly ever	hardly ever	very often	very often	yes	leave	no
16	never	never	never	never	never	never	yes	lose	no
17	sometimes	never	never	never	never	never	no		no
18	never	never	never	never	never	never	no		no
19	hardly ever	never	never	never	never	never	no		no
20	sometimes	hardly ever	sometimes	hardly ever	sometimes	sometimes	no		yes
21	hardly ever	never	sometimes	hardly ever	sometimes	often	yes	lose	no
22	never	never	never	never	never	never	no		no
23	hardly ever	never	never	never	never	never	yes	lose	no
24	sometimes	never	never	never	never	never	yes	lose	no
25	hardly ever	never	never	never	never	never	yes	leave	no
26	hardly ever	never	never	never	hardly ever	hardly ever	yes	leave	no
27	sometimes	sometimes	never	never	often	sometimes	no		yes
28	sometimes	never	never	never	hardly ever	hardly ever	no	leave	no
29	hardly ever	never	never	never	never	never	yes	leave	no
30	never	never	never	hardly ever	hardly ever	hardly ever	yes	lose	no
31	sometimes	never	never	never	hardly ever	hardly ever	no	leave	no
32	never	never	never	never	never	never	no		no
33	sometimes	never	hardly ever	hardly ever	sometimes	sometimes	yes	lose	no
34	sometimes	sometimes	never	never	hardly ever	often	no		no
35	sometimes	never	never	never	never	never	no		no
36	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	no		no
37	never	never	never	never	never	never	no		no
38	sometimes	sometimes	hardly ever	hardly ever	sometimes	hardly ever	no		yes
39	never	hardly ever	hardly ever	never	hardly ever	never	no	lose	no
40	hardly ever	never	never	never	never	never	yes	lose	no
41	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	never	yes	leave	no
42	hardly ever	sometimes	never	never	never	never	no		no
43	sometimes	sometimes	never	never	never	never	no		yes
44	hardly ever	never	never	never	never	never	yes	lose	no

45	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	yes		yes
46	never	never	never	never	never	never	yes		no
47	often	sometimes			sometimes	hardly ever	no		no
48	sometimes	hardly ever	hardly ever	hardly ever	hardly ever	sometimes	no		no
49		never	often	never	sometimes	sometimes	yes	lose	no
50	hardly ever	hardly ever	sometimes	sometimes	very often	never	no		no
51	sometimes	often	never	never	often	never	yes	lose	yes
52	hardly ever	hardly ever	never	never	never	never	yes	leave	no
53	hardly ever	never	never	never	never	never	no		no
54	hardly ever	hardly ever	sometimes	hardly ever	hardly ever	hardly ever	no		no
55	hardly ever	hardly ever	never	never	never	never	yes	leave	no
56	hardly ever	hardly ever	never	never	never	hardly ever	no		yes
57	hardly ever	never	never	never	never	never	no		no
58	never	never	never	never	never	hardly ever	yes	leave	no
59	never	never	never	never	sometimes	hardly ever	yes	lose	no
60	sometimes	never	never	never	hardly ever	sometimes	no		no
61	never	never	never	never	never	never	yes	leave	no
62	never	never	never	never	never	never	yes	leave	no
63	hardly ever	never	never	never	never	never	yes	leave	no
64	sometimes	never	never	never	sometimes	never	yes	lose	no
65	never	never	never	never	never	never	no		no
66	hardly ever	never	never	never	never	sometimes	no		no
67	hardly ever	hardley ever	never	never	never	never	no		no
68	sometimes	sometimes	hardly ever	hardly ever	sometimes	hardly ever	yes	lose	no
69	hardly ever	never	never	never	hardly ever	hardly ever	yes	lose	no
70	never	never	never	never	never	never	no		no
71	never	hardley ever	hardly ever	hardly ever	sometimes	never	no	lose	no
72	sometimes	sometimes	sometimes	never	never	never	no		no
73	never	never	never	never	never	never	yes	lose	no
74	never	never	never	never	never	never	yes	leave	no
75	never	sometimes	never	never	sometimes	sometimes	no	leave	no
76	hardly ever	never	hardly ever	never	never	never	no		no
77	never	never	sometimes	never	never	hardly ever	yes	lose	no
78	never	often	hardly ever	hardly ever	hardly ever	hardly ever	yes	lose	no
79	sometimes	sometimes	never	never	sometimes	never	no		yes
80	very often	never	never	never	hardly ever	never	no		no
81	hardly ever	never	never	never	never	never	yes	leave	no
82	sometimes	never	hardly ever	hardly ever	often		no		
83	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	yes	leave	no
84	never	never	never	never	never	never	no		no
85	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	hardly ever	yes	leave	no
86	never	never	never	never	never	never	yes	lose	no
87	sometimes	never	never	never	hardly ever	never	no		no
88	hardly ever	never	never	never	never	never	yes	leave	no
89	sometimes	hardly ever	never	never	never	never	no		yes
90	sometimes	hardly ever	sometimes	hardly ever	often	hardly ever	no	lose	yes
91	sometimes	never	never	never	never	never	yes	lose	no
92	never	never	never	never	never	never	yes	lose	no
93	sometimes		often	often	often	sometimes	no	lose	yes
94	sometimes	very often	never	never	often	sometimes	no	lose	no

95	never	never	never	never	never	never	yes	leave	no
96	never	never	never	never	never	never	yes	lose	no

Survey Answers by Percent of Total										
	Q1	Q2a	Q2b	Q2c	Q3	Q4		Q5	Q6	Q7
NEVER	31.3%	64.6%	72.9%	76.0%	54.6%	59.4%	YES	49.5%	53.6%	13.5%
HARDLY EVER	32.3%	17.7%	17.7%	21.9%	23.7%	24.0%	NO	50.5%	44.6%	86.5%
SOMETIMES	32.3%	14.6%	7.3%	1.0%	13.4%	13.5%				
OFTEN	2.1%	2.1%	2.1%	1.0%	6.2%	2.1%				
VERY OFTEN	2.1%	1.0%	0.0%	0.0%	2.1%	1.0%				