

Technologies' Impact on Life Care Planning: A Pilot Study of Children with Cerebral Palsy

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Abstract. *This study examines the impact of two types of technology, new and replacement, on life care plans (LCPs) over time. Seven categories of the LCP are evaluated across an average fifteen year time span, Era I versus Era II. A total of fifty LCPs written for children diagnosed with cerebral palsy are analyzed in a retrospective cohort study comparing costs projections from the two time eras. Era I plans originated between 1986 and 1991 and Era II plans originated between 2002 and 2004. The following seven categories of the LCPs are examined: Wheelchair Needs, Orthotics/Prosthetics, Home Furnishings and Accessories, Aids for Independent Function, Medications, Supplies and Future Medical Care - Aggressive Treatment. Results from the research are provided and suggestions for additional studies, including the development of an approach for including the impact of technology on LCP costs projections will be discussed.*

Introduction: Technologies' Impact on Rising Medical Costs

A review of the relevant literature on technology and its impact on health care costs provides a considerable number of articles from a qualitative observational perspective but few, if any, from a quantitative research perspective. Many articles provide statistics on the share of dollars various health care industries commit to research and development (R&D). Others are willing to estimate, often with broad ranges, the share of rapidly rising health care costs attributable to technology, but seem not to examine with specificity the impact of replacement or new technology based on data obtained through scientific research. Nevertheless, the consideration of technology as part of the underlying cause of medical care costs increasing at a rate exceeding that of inflation has been part of the literature for over fifteen years. This literature review will discuss the difficulties related to researching the rising costs associated with medical technology, the hypotheses as to why the cost of medical technology has continued to contribute to a rise in medical care costs, and the implications for life care planning.

Medical technology as an entity has been described as the "...'drugs, devices, and medical and surgical procedures used in medical care and the organizations and supportive systems within which such care is delivered,' as well as inventions and innovations, namely, R&D expenditures in both the private and public sectors as proxies for changes in health care technology" (Okunade & Murthy, 2002, p. 149). Another author conceptualized medical technol-

ogy as, “encompassing all drugs, devices, processes, and procedures that enable us to deliver more sophisticated health care services” (Bloomfield, 2002, p. 419). Medical technology and its associated costs are being investigated as a primary contributor in the ever-increasing price of health care (Hirth, Chernew, & Orzol, 2000; Eastaugh, 1990; Rettig, 1994). New technologies improve health, prolong life, and enhance the quality of life (Wilensky, 1990; Rettig, 1994). But these benefits come with a cost. Eastaugh (1990) reported that technology might explain from five to forty percent of the medical cost inflation problem. According to Joseph Newhouse (as cited in Gelijns & Rosenberg, 1994), more than fifty percent of the overall increase in medical care costs (after inflation) is explained by changes in technology.

However, difficulty exists in identifying the extent to which medical technology causes increased health care cost. Research on the subject has been sparse (Okunade & Murthy, 2002). Gelijns and Rosenberg (1994) note that the U.S. pharmaceutical industry invests approximately 13 percent of yearly sales turnover and the U.S. medical device industry devotes nearly 7 percent to R&D each year. Although large funds are allocated each year to R&D, studies relating this investment to the rising cost of medical technology are few and the information difficult to obtain (Gelijns & Rosenberg, 1994). This is because technology encompassed by the definitions above is poorly understood. According to Okunade & Murthy (2002), “conceptualizing an appropriate proxy for changes in medical care technology is a difficult task” (p. 148), and, if they are even measurable at all, the relevant data are scarce. Another challenge to conducting accurate and up-to-date studies is the frequency with which medical technologies are updated, modified, and changed.

Several hypotheses have been suggested to explain why medical technology overall appears to increase the cost of health care. Once established, the utilization of certain technologies and their associated services by practitioners may increase dramatically (Gelijns & Rosenberg, 1994; Wilensky, 1990; Eastaugh, 1990; Okunade & Murthy, 2002). This may be, in part, due to fear of litigation. Some doctors fear that if any avenue is left unexplored—even if further investigation is unnecessary, they may be open to criticism (Gelijns & Rosenberg, 1994; Wilensky, 1990; Eastaugh, 1990).

Proven and useful advances may become the Standard of Care and therefore be viewed as required therapy. With the introduction of new technologies, some diagnoses have new definitive therapies for which a large portion of the population may not have been treated previously (Gelijns & Rosenberg, 1994).

As referenced by Eric Bloomfield (2002), Joseph Newhouse has posited five factors associated with the increase in health care expenses:

- increased insurance usage
- aging
- increase in income
- increases in supplier-induced demand
- miscellaneous factors producing problems in the service sector (p. 423)

Other authors have attributed the increasing cost to increases in the Medicare program (Wilensky, 1990); aging of the population as well as increased prevalence of age related illnesses (Okunade & Murthy, 2002); increased number of doctors per capita (Okunade & Murthy, 2002); managed care HMOs (Okunade & Murthy, 2002); and relative price of health care (Okunade & Murthy, 2002).

Implications for Life Care Planners

The implications for life care planners are important. Because life care plans (LCPs) are considered multidimensional and long-term, changes in technology can affect many areas of a LCP. The prognoses of previously untreatable medical conditions, such as end stage renal disease and AIDS, for example, have been vastly altered. These terminal illnesses now require protracted maintenance therapy (Rettig, 1994). Imaging studies such as CT scans, MRIs, and ultrasounds, generally included in the *Future Medical Care - Routine* section of a LCP, have seen expanded use due to their ability to glean important diagnostic information with minimal invasion (Goldsmith, 1994; Gelijns & Rosenberg, 1994). Moreover, advances in imaging equipment provide better imaging resolution, and more information, which also results in broader use. The section *Future Medical Care - Aggressive Treatment*, which can include a broad range of new technologies including invasive procedures, has also been affected by advancements. The intrathecal baclofen pump, spinal cord stimulator, and cochlear implants are interventions that could be included in this section and, for example, were not available to clients in our Era I population but were in Era II. All of these therapies are expensive to place and maintain, and require up to date skills and techniques, all of which are costly additions to a LCP.

Similarly, environmental control units and speech augmentation devices have affected the *Aids for Independent Function* portion of the LCP. Advances in the development of prosthetic devices, such as the myoelectric upper extremity prosthesis, have caused cost increases in the Prosthetic/Orthotic area of a LCP while even newer technologies for above knee lower extremity prosthetic components have greatly improved function as well as increased costs (Deutsch & Sawyer, 1995).

The advances mentioned are just a few of the technologies currently available. Although many of these technologies may be more expensive, some technologies can be cost saving (Eastaugh, 1990). Cost savings may be realized due to reduced complications associated with a particular disability, decreased lengths of stay should hospitalization be necessary and enhanced independence--decreasing the amount or level of support care requirements at least until age and disability combine to increase needs over time. Clearly, the overall cost of medical care is rising and is expected to continue growing. This study is designed to help determine whether replacement or new technologies influence these rising costs.

Design and Methodology

The purpose of this study was to investigate the impact over time of innovative or replacement technology on costs projected using life care planning methodology. (For those interested in learning more about life care planning, refer to *A Guide to Rehabilitation* by Deutsch and Sawyer (1995), the *Life Care Planning and Case Management Handbook* edited by Weed (2004), and the *Standards of Practice for Life Care Planners* developed by the International Academy of Life Care Planners (2002) with proposed revisions available at www.ialcp.com). The study was designed as a retrospective examination of the costs projected in seven categories of LCPs from two cohorts matched for age and diagnosis, but originating during different time periods (Era I and Era II). A total of fifty LCPs were randomly selected from the database of The Foundation for Life Care Planning Research. The inclusion criteria were:

- 1) The LCP was written for a child between the ages of one to eight with a diagnosis of cerebral palsy.

- 2) The LCP originated either in Era I (1986-1991) or Era II (2002-2004).

A careful review of the Era I and the Era II client files revealed a similarity in the medical profile of the clients and the resultant needs. All LCPs from Era I had been provided to the database by a sole life care planner in private practice. The LCPs from Era II had been provided to the database by several professional life care planners. All life care planners contributing to the database of the Foundation for Life Care Planning Research are known to adhere to the published standards of practice in the field of life care planning. Consistent with the protocol established by The Foundation for Life Care Planning Research (Sutton, Deutsch, Weed, & Berens, 2002), confidentiality of the subjects' private information was maintained by removing all subjects' names from the database and then replacing them with file identifiers that were not cross referenced to the subjects' names. During the initial search of the database, 46 LCPs that fit the inclusion criteria from Era I were identified. However, only 23 LCPs that met the inclusion criteria from Era II were identified. All 23 of the plans identified from Era II were included in the study. To adjust the sample size from Era I to approximate the sample size from Era II, a mathematical randomizer was used to select 27 of the 46 cases from Era I. The final sample size of 50 LCPs is comprised of 27 plans from Era I and 23 plans from Era II.

The total costs projected for the following categories were extracted from each of the LCPs:

1. Wheelchair Needs
2. Orthotics/Prosthetics
3. Home Furnishings and Accessories
4. Aids for Independent Function
5. Medications
6. Supplies
7. Future Medical Care - Aggressive Treatment

Items within the categories were included in the total costs for the analysis if the LCP indicated that the particular item would be purchased or replaced at least one time post age 18. Not all clients had items in every category; therefore, the number of plans analyzed by category varied. Within each of the designated categories, the costs of all included items were summed to create a total projected dollar cost per category for each subject. The total projected dollar costs for the individual categories for each LCP in Era I and in Era II were forwarded to an economist who adjusted all values to 2004 dollars. The adjustments were based on the appropriate Consumer Price Index (CPI) category for each item. Thus, the mean cost for each category in each era was established with a common unit of measurement, 2004 dollars.

In comparing the means for Era I to Era II for the designated categories of the LCP, we tested the following null hypotheses:

- H₁: There will be no significant difference between the adjusted costs of *Wheelchair Needs* between Era I and Era II.
- H₂: There will be no significant difference between the adjusted costs of *Orthotics/Prosthetics* between Era I and Era II.
- H₃: There will be no significant difference between the adjusted costs of *Home Furnishings and Accessories* between Era I and Era II.
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H4: There will be no significant difference between the adjusted costs of *Aids for Independent Function* between Era I and Era II.

H5: There will be no significant difference between the adjusted costs of *Medications* between Era I and Era II.

H6: There will be no significant difference between the adjusted costs of *Supplies* between Era I and Era II.

H7: There will be no significant difference between the adjusted costs of *Future Medical Care-Aggressive Treatment* between Era I and Era II.

Statistical Analyses

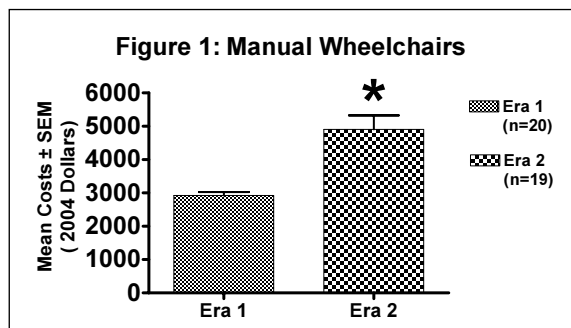
In small pilot studies such as this one, where the sample size is less than several dozen, it is difficult to determine whether the sample is drawn from a Gaussian, or normally distributed, population (Motulsky, 2003). Determination of the type of population the sample represents is important because it determines the type of statistical test that is most appropriately used for analysis of the data. This study compares the mean values from samples that are matched for inclusion criterion, but were not recruited as pairs. Therefore, normally distributed population samples would be analyzed using the parametric, unpaired student's t-test. On the other hand, a distribution that shows marked skewness or kurtosis would be better analyzed using the non-parametric Mann-Whitney U test. Parametric tests are more likely to identify small differences in the means as being significant, whereas, nonparametric tests are less likely to be affected by outlying values (Motulsky, 2003). A choice about the expected form of the data distribution from a small sample could be founded upon prior data. However, because this is a pilot study where prior data does not exist, the data sets were subjected to testing for normality even though the results may not be robust.

The D'Agostino & Pearson omnibus normality test, or if the n for the data set was five or fewer, the Kolmogorov Smirnov test, was applied prior to choosing the comparison test statistic (Miller, 2003). When both sample populations passed the same test for normality, the data analysis employed the unpaired student's t-test. If one of the sample populations, either Era I, or Era II, failed the test for normality, the data were analyzed using the Mann-Whitney U test for nonparametric unpaired data. All group comparisons were made for a two-tailed p value. An alpha (∞) level of $p < 0.05$ was considered significant for all statistical tests employed. Computer assisted analyses utilized GraphPad Prism version 4.02 for Windows (GraphPad Software, 2004).

In small sample sizes, it is always a temptation to label an extreme value as an "outlier" and delete it from the data set, thus reducing the variance of the data around the mean and making the detection of significant differences more likely. Although a statistical test for determination of the possibility that an extreme value does not belong to the same population (Grubbs' test) exists, it is not definitive (Motulsky, 2003). If it is clear that the value came from the same group as the other values, there is no justifiable reason to remove it. Unless there is a very high likelihood of experimental error or the value cannot be explained in terms of biological variability, the value should not be removed from the data set (Motulsky, 2003, pp. 26-28). As sample sizes increase, initially skewed data distributions tend to become Gaussian (Green, Benedetti, & Crowley, 2000), which tends to incorporate values within the normal distribution that were seen as "extreme" in the smaller sample sizes. No values were excluded from analysis in this study.

Results

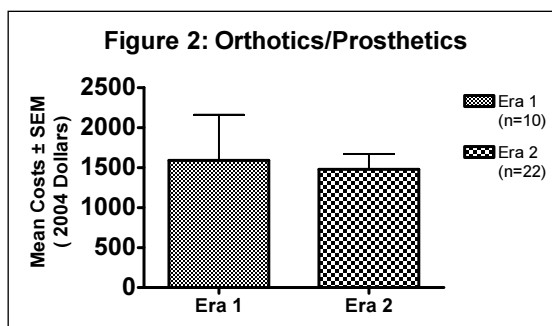
All results are expressed as mean 2004 dollar values $\pm$ the standard error of the mean (SEM).



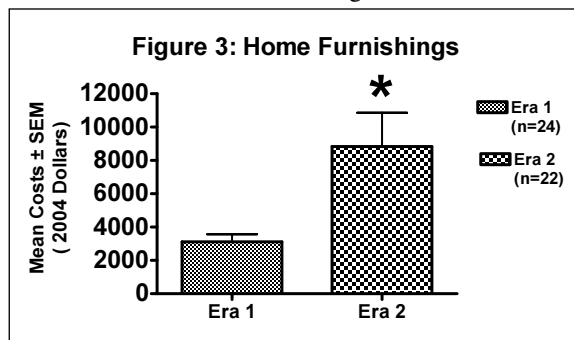
for Era I ($2,925 \pm 102.9$, $n=20$) were significantly less than the mean costs projected for Era II ($4,908 \pm 418.3$, $n=19$) with $p < 0.001$ (Figure 1). The H_1 null hypothesis is therefore rejected.

H_2 : There will be no significant difference between the adjusted costs of *Orthotics/Prosthetics* between Era I and Era II.

The *Orthotics/Prosthetics* category of the LCPs were determined not to follow a normal distribution and therefore analyzed with the Mann-Whitney U test for nonparametric unpaired data. Mean costs projected for Era I ($1,591 \pm 568.4$, $n=10$) did not differ significantly from the mean costs projected for Era II ($1,477 \pm 191.9$, $n=22$) (Figure 2). The H_2 null hypothesis was supported by the data.



H_3 : There will be no significant difference between the adjusted costs of *Home Furnishings and Accessories* between Era I and Era II.

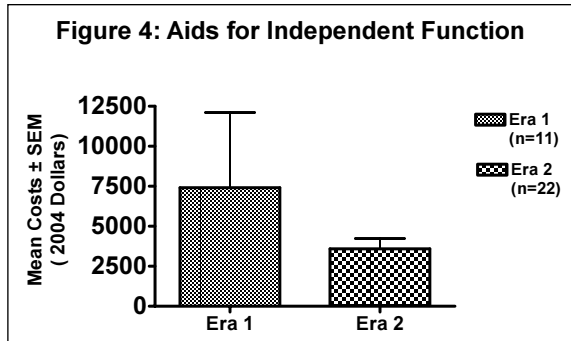


than the costs projected for Era II ($8,832 \pm 2,032$, $n=22$) with $p < 0.01$ (Figure 3). The H_3 null hypothesis is therefore rejected.

H_1 : There will be no significant difference between the adjusted costs of *Wheelchair Needs* between Era I and Era II.

The data in the *Manual Wheelchair* category of the LCPs were determined not to follow a normal distribution and therefore it was analyzed with the Mann-Whitney U test for nonparametric unpaired data. Mean costs projected

The data in the *Home Furnishings and Accessories* category of the LCPs for both Era I and Era II passed the D'Agostino & Pearson omnibus normality test. Therefore, the student's unpaired t-test was used to compare the means. Costs projected for Era I ($3,119 \pm 450.1$, $n=24$) were significantly less

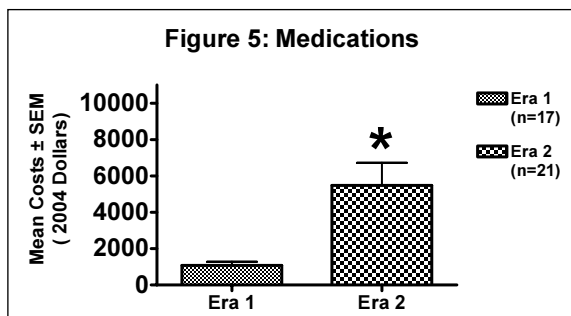


H4: There will be no significant difference between the adjusted costs of *Aids for Independent Function* between Era I and Era II.

The data in the *Aids for Independent Function* category of the LCPs were determined not to follow a normal distribution and therefore analyzed with the Mann-Whitney U test for nonparametric unpaired data. Costs

projected for Era I ($7,406 \pm 4,703$, $n=11$) did not differ significantly from the costs projected for Era II ($3,593 \pm 637.7$, $n=22$) (Figure 4). The H4 null hypothesis was supported by the data.

However, it is obvious that the variance in the data from Era I as indicated by the SEM (notice size of error bar on the graph) is quite large. A review of the individual data points revealed a single extremely high value. In support of the robustness of nonparametric tests to extreme values, the outcome of comparison of the means without the extreme value (Era I: $2,768 \pm 860.0$, $n=10$) (data not shown) was not changed from the analysis presented in Figure 4 (Era I: $7,406 \pm 4,703$, $n=11$) even though the reduction in the variance in Era I's mean allowed the data's distribution to pass the D'Agostino & Pearson omnibus normality test, thus permitting the comparison to be made using the more sensitive unpaired student's t-test. It is interesting to note that an n of 11 is small for this study, as is the n of 10 for Era I Orthotics/Prosthetics, which is the only other LCP category in this study where the difference between costs projected for Era I did not differ significantly from those projected for Era II.



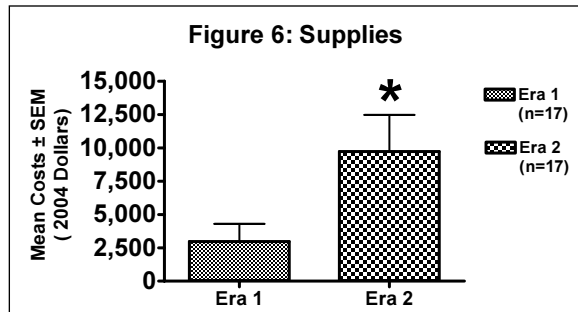
H5: There will be no significant difference between the adjusted costs of *Medications* between Era I and Era II.

The data in the *Medications* category of the LCPs were determined not to follow a normal distribution and therefore analyzed with the Mann-Whitney U test for nonparametric unpaired data. Costs projected for Era I

($1,074 \pm 208.6$, $n=17$) were significantly less than the costs projected for Era II ($5,479 \pm 1,244$, $n=21$) with $p < 0.01$ (Figure 5). The H5 null hypothesis is therefore rejected.

H6: There will be no significant difference between the adjusted costs of *Supplies* between Era I and Era II.

The data in the *Supplies* category of the LCPs were determined not to follow a normal distribution and therefore analyzed with the Mann-Whitney U test for nonparametric unpaired data. Costs projected for Era I ($2,964 \pm$



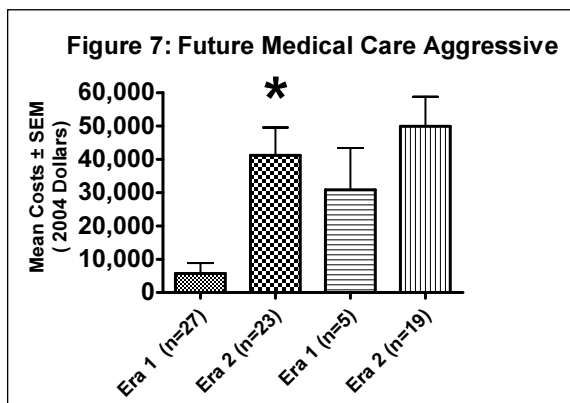
1,324, n=17) were significantly less than the costs projected for Era II ($9,725 \pm 2,750$, n=17) with $p < 0.01$ (Figure 6). The H6 null hypothesis is therefore rejected.

H7: There will be no significant difference between the adjusted costs of *Future Medical Care-Aggressive Treatment* between Era I and Era II.

The data in the *Future Medical Care-Aggressive Treatment* category of the LCPs for both Era I (n=5) and Era II (n=19) passed the Kolmogorov Smirnov normality test. Therefore the student's unpaired t-test was used to compare the means. Costs projected for Era I ($30,810 \pm 12,590$, n=5) did not differ significantly from the costs projected for Era II ($49,870 \pm 8,897$, n=19), Figure 7, the two columns on the far right. Therefore, the H7 null hypothesis was supported by the data.

A further consideration of the type of data accrued to this category suggested that considering all LCPs with zero values imputed to those plans where no Future Medical Care-Aggressive Treatment existed at the time the plan originated might be appropriate. For that reason, a companion analysis was made with Era I (n=27) and Era II (n=23). These data were determined not to follow a normal distribution and therefore analyzed with the Mann-Whitney U test for nonparametric unpaired data.

Costs projected for Era I ($5,705 \pm 3,166$, n=27) were significantly less than the costs projected for Era II ($41,193 \pm 8,351$, n=23) with $p < 0.0001$ (Figure 7, the two columns on the far left). The H7 null hypothesis is therefore rejected by the outcome of this analysis.



Discussion

Although all data from Era I and Era II were adjusted for inflation to 2004 dollars before analysis, there remains a statistically significant difference in the projected costs between Era I and Era II in most categories. This signifies, for example, that the dollars set aside for wheelchairs in 1986 through 1991, even after adjustment for inflation in this study, are insufficient to pay for a replacement wheelchair in 2004. This is based on the fact that in Era I it was not possible to account for wheelchairs now being made from exotic materials such as lightweight titanium or the development of custom seating systems. Technological advances in each category that did not exist in Era I or replacement technologies that came along subsequently provided two considerations for which costs could not be anticipated.

Manual wheelchairs have an inflation adjusted price comparison of approximately 2000 in Era I versus 4000 in Era II. If one assumed the midpoint of Era I (1988) and the midpoint of Era II (2003), this would provide a fifteen year spread between the Era's time periods. Using this fifteen-year period, it can be calculated that Manual Wheelchairs have increased at a compound average annual rate of 3.51% above inflation. Applying this fifteen-year time frame, compound average annual rate increases above inflation have occurred as shown in Table 1.

On first review, the study suggests the need to either allow for a growth rate adjustment

Table 1. Compound Average Annual Rate Increases above Inflation for 15-year Interval

CATEGORY OF LIFE CARE PLAN	AVERAGE ANNUAL RATE INCREASE ABOVE INFLATION
<i>Manual Wheelchairs</i>	3.51%
<i>Home Furnishings and Accessories</i>	7.19%
<i>Medications</i>	11.48%
<i>Supplies</i>	8.24%
<i>Future Medical Care - Aggressive Treatment</i> (mean calculated on all cases with projected costs, i.e., Era I n=5; Era II n=19)	3.26%
<i>Future Medical Care - Aggressive Treatment</i> (mean calculated with zero values imputed to those plans where no <i>Future Medical Care-Aggressive Treatment</i> existed at the time the plan originated, i.e., Era I n=27; Era II n=23)	14.09%

or provide for a "technology fund" in a LCP to cover the changes in technology that are not reflected as a function of inflation as measured by the CPI. Yet it is essential to keep in mind that this is a pilot study with low "n's" in the categories analyzed, and includes only clients with cerebral palsy. Further research is unquestionably required on other categories of the LCP and on other disabilities. The limitation section within the discussion of data will address these issues further.

A number of additional insights were made that will aid in the design of the next level of research. Within the wheelchair section there were clients in both Era I and Era II who did not have a recommendation for a wheelchair. This was due to their ambulatory status. In each section of the LCP analyzed, only those client plans which contained a cost projection were included. In addition to these analyses, *Future Medical Care - Aggressive Treatment* included a total set of LCPs encompassing those for which no future costs were projected. In reviewing the files for Era I, only five of twenty-seven clients had recommendations versus nineteen of twenty-three in Era II. In addition, of the four remaining clients in Era II, most had already had aggressive medical intervention prior to the onset of the LCP. In the Era I files, the majority of the clients faced the same medical conditions and requirements as the Era II clients, but the technology available in Era II was either not yet developed or not yet approved by the FDA for use with clients with cerebral palsy.

Future research should also take into consideration the impact technology may have on lowering risk factors for health care complications. Although complications are not generally part of LCP cost projections, technological advances, particularly in the *Future Medical Care - Aggressive Treatment* category, may well be expected to mitigate future health care exigencies. In this study, one occurrence (in the Aids for Independent Function category) was noticed where replacement technology actually lowered costs. Although this one incidence did not substantially impact the mean for the category, in a world in which technology is accelerating the growth in medical costs, it is an important observation.

Study Limitations

In any discussion of the data analysis, a review of the study limitations must be undertaken. This study is intended as a pilot research project and the small size of the study population necessarily leads to limitations in study conclusions. However, the results lead to a clear conclusion that additional research on the impact of technology is necessary and justified. Furthermore, a clear need exists for the development of either a technology "factor" or a technology "table" not dissimilar to the CPI for each applicable category of the LCP. The categories of the LCP analyzed in this study are not necessarily the only categories subject to research for impact by technology. Each disability will need to be examined in a separate research project although a single design should be developed and applied consistently in a series of prospective longitudinal studies. The studies need to be longitudinal in nature because of the constantly changing nature of both new and replacement technology. Only a prospective longitudinal study can capture the nature of the technological advances and the economic trends of compound average annual growth rates as they occur and change over time. This study is limited to revealing that new and replacement technologies do have an impact in certain categories of the LCP, while not appearing to impact other categories. In those categories in which there appears to be an impact, there is an indication of a compound gross adjusted growth rate above inflation. However, more research across a larger population and a longer period of time is needed to confirm these figures.

Conclusions

This pilot study confirms the conclusion of the many articles reviewed in the literature that assert technology is indeed a significant contributor to rising medical costs. The most informative conclusion which can be drawn from both the statistical and economic analysis of the data accumulated in this study is that new and replacement technologies have an economic impact on many of the recommendations developed in LCPs for children with cerebral palsy. It is likely that other technological advances have a similar impact on other categories of the LCPs developed for children with cerebral palsy and for adults with cerebral palsy as well as LCPs developed for clients with other disabilities. However, without specific research in each area of disability and for each client population, this is not knowable. Extrapolation of the conclusions of this pilot study to other categories within LCPs for children with cerebral palsy or to adults with cerebral palsy or to other disabilities is clearly unethical. It is important to confine the implications of this study to the population studied, children with cerebral palsy, but, having said that, it does also confirm that any research in this area must include both new and replacement technology. The CPI demonstrates that most categories of medical costs are rising at a rate greater than inflation and the literature suggests that technology is a factor in that rise (Okunade & Murthy, 2002; Eastaugh, 1990). This pilot study is an important initial inquiry to the impact of technologies on the future costs of medical care, and indicates a considerable amount of additional research is essential to develop the tools to plan adequately for clients' needs in the future.

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