Blue Sky
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CAN TELESTROKE SAVE MEDI-CAL AND MEDICARE MONEY?

Modeling the Potential Savings

Prepared for

CENTER FOR CONNECTED HEALTH POLICY

by

Trisha McMahon
Matthew Newman

July 5, 2012

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EXECUTIVE SUMMARY

Telestroke refers to the use of information technology to aid in the treatment of stroke patients. In particular, telestroke has emerged as a viable method for increasing the use of IV tissue plasminogen activator (tPA), which is an effective treatment for acute ischemic stroke that must be given within the first critical hours after symptom onset. Through use of telestroke, patients admitting at remote hospitals or those without onsite neurologists or other qualified health care providers can nevertheless benefit from early administration of tPA, which can reduce disability and death following stroke.

In spite of the potential benefits of telestroke, questions about its efficacy and cost remain. Recent research indicates that telestroke can both reduce disability and death following stroke, and do so in a cost-effective manner.[1] This 2011 study, published in the journal *Neurology,* modeled the costs associated with telestroke and compared these costs to those that would accrue without telestroke, concluding that "telestroke appears cost-effective when compared with usual care."

Although this previous research suggests that telestroke can be cost-effective, the analysis examined costs and benefits from a societal perspective, rather than from the perspective of individual health care providers or those who pay for such care (i.e. insurance companies and government programs that provide health care coverage).

This report seeks to address this gap in the research, examining the costs of telestroke from the perspective of public payers (i.e. MediCal and Medicare). To do so, it addresses the question, "would telestroke reduce costs for public payers?" in two different ways. First, we measure whether telestroke would reduce costs for current Medi-Cal and Medicare enrollees by decreasing the cost of care they receive in their lifetime after a stroke. Second, we measure whether the Medi-Cal and Medicare programs would experience savings from current and future enrollees by examining an average cohort of 100 telestroke patients.

Modeling the use of Telestroke

In order to estimate the potential costs and savings associated with use of telestroke, we constructed a model of stroke care under both telestroke and usual care scenarios. This model traces the progress of a stroke patient throughout his life, from initial admission at a hospital through stroke treatment, rehabilitation, and long term care.[2] At each stage, costs are identified for both usual care and telestroke, as are the probabilities of each outcome. For example, both the cost and probability of receiving tPA are estimated based on published research literature for both telestroke and usual care. The same process is completed for the cost and probability of being transferred to a different hospital, receiving rehabilitation treatment, or being admitted to a skilled nursing facility. Because our aim was to examine

[1] R E Nelson et al., "The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke," Neurology *77*, no. 17 (October 25, 2011): 1590–1598.
[2] Our model was based on the societal cost model developed by Dr. Nelson and his colleagues.

telestroke from a public payer perspective, we estimated the costs that a public payer would incur (as opposed to the societal costs or the costs for the health care system generally) at each stage of treatment.

Ultimately, the total costs for both telestroke and usual care were compared to determine if telestroke, in addition to being cost-effective from a societal perspective, is also cost-effective from the perspective of a government payer.

Results

Our analysis indicates that, in addition to being cost-effective from a societal perspective, telestroke also has the potential to produce cost savings for government payers. Specifically, our research suggests that Medicare could experience cost savings of $1,100 per enrollee, while Medi-Cal could experience cost savings of $2,400 per Medi-Cal only patient and $600 per dual eligible patient.[3] Our results suggest that both systems could experience savings in both the short (90-day) and long term (lifetime) timeframes.

Our research also shows that increasing access to telestroke generally has the potential result in savings for both the Medi-Cal and Medicare programs by reducing costs associated with current *and* future beneficiaries. For example, our analysis suggests that for every 100 patients that gain access to telestroke, the Medi-Cal program would save $44,000 and the Medicare program $85,000. These results indicate that Medicare and Medi-Cal experience additional savings ($29,000 and $9,000 per 100 patients, respectively) from the reduction in disability levels for patients that become eligible for these programs after the initial stroke. This post-stroke eligibility is both a result of their stroke-induced disability and non-stroke related factors such as reduced income levels or age.

These estimates are based on an analysis of the costs that each payer would incur based on current reimbursement rates and covered costs; each excludes societal costs (e.g., for informal care provided by a friend or relative), as well as costs for telestroke technology and training, which would be incurred by providers.[4] When telemedicine facility fees are taken into account these savings decrease, but do not disappear, which shows that Medi-Cal and Medicare may have an interest in increasing their support for telestroke.

Sensitivity Analysis

Our results are based on a series of assumptions, derived from our research on health care costs incurred by MediCare and MediCal, as well as results reported in the published research literature. Although these estimates are based on the best available data and research, they are nevertheless subject to uncertainty.

[3] Dual eligible refers to patients that are eligible for both Medi-Cal and Medicare.
[4] MediCal estimates include the cost of In-Home Supportive Services for eligible recipients.

In order to test the dependence of our results on individual input parameters, we conducted a sensitivity analysis, in which we varied several key input parameters across a likely range.

This sensitivity analysis suggests that, while telestroke is likely to produce cost savings to public payers under a majority of the potential outcomes, the results are sensitive to the input assumptions.

Provider Incentives

While telestroke care has the potential to save money from the standpoint of public payers, its widespread adoption will depend on the incentives that providers face with respect to making the initial investment in telestroke technology and training.

Two factors may encourage hospitals to make the investment in technology and training (and in effect absorb a portion of these costs). Hospitals might view telestroke as a marketing advantage that would allow them to recruit additional patients. In addition, by reducing the number of transfers to alternative facilities with more specialized stroke care, telestroke has the potential to increase the number of hospital days that a patient would spend in a telehealth equipped facility, thereby increasing telestroke hospital revenue.

Conclusion

This report presents an analysis of the costs of telestroke compared to usual care from the standpoint of the Medicare and MediCal programs. Our modeling suggests that both programs could experience cost savings to the extent that telestroke care is more widely adopted. Specifically, our analysis suggests that Medi-Cal would save $2,400 per Medi-Cal only patient and $600 per dual eligible patient, while Medicare would save $1,100 per patient. Both programs could experience additional savings from privately insured or uninsured stroke victims that become eligible for enrollment after the initial stroke.

Although these public health care program payers would experience cost savings, the more widespread adoption of telestroke care is dependent on the decisions of individual provider hospitals to make the investment in establishing or participating in a telestroke care system. While these providers stand to benefit financially from the adoption of telestroke, they would also face costs for technology and training. Ultimately, the more widespread adoption of telestroke care would be accelerated to the extent that some portion of the payer savings was shared with providers as an added incentive to adopt a telestroke care system.

INTRODUCTION

Telestroke has the potential to increase access to high quality stroke care, reducing disability and death for California residents, by remotely connecting stroke specialists to hospitals without on-site expertise. In particular, telestroke has emerged as a viable method for increasing the use of IV tissue plasminogen activator (tPA), which is an effective treatment for acute ischemic stroke that must be given within the first critical hours after symptom onset.

However, telestroke requires an up-front investment in remote networking equipment and training as well as on-going investments in network maintenance and staffing. These additional costs can act to slow the pace of adoption as providers and payers learn how to adopt and adapt their current practices. In addition, by extending life, tPA may actually increase health care costs even as it increases quality of life.

A recent cost-effectiveness study by researchers at the University of Utah School of Medicine provided the first evidence that telestroke is cost-effective from the societal perspective, in that it extends life and increases quality of life for stroke patients (and does so at a relatively low cost).[5] However, this research did not address the question of whether telestroke could save money for public payers of health care costs (i.e. MediCal and MediCare). To further inform the discussion, this report investigates the potential impact of telestroke on Medicare and Medi-Cal costs to determine whether or not there are cost-savings from the public payers' perspectives.

THE IMPORTANCE OF PERSPECTIVE

In order to help providers and payers improve their decision making with respect to telestroke adoption, this report addresses the question: would telestroke reduce costs for public payers?

Public payers face different costs than patients, providers, or society generally. For example, they only pay for specific types of patients: Medi-Cal covers low-income residents who are parents of young children, disabled, or elderly, while Medicare provides coverage for the elderly and disabled, regardless of income. In addition, public payers do not pay the up-front costs for technology that providers pay. And, Medi-Cal and Medicare only reimburse telemedicine providers with a small facility fee that does not depend on the underlying cost structure of remote care. They also do not incur indirect societal costs, such as family caregiver costs or lost wages from disability.

The impact of telestroke can be felt by public providers in two different ways. First, Medi-Cal and Medicare can experience an impact associated with current enrollees. That is, a Medi-Cal or Medicare enrolled patient suffers a stroke, and these programs are responsible for paying for initial stroke care as well as the subsequent health care costs that these patients incur. Second, Medi-Cal and Medicare can experience benefits and/or costs from the more widespread adoption of telestroke generally. From this perspective, telestroke improves outcomes for patients, regardless of their current enrollment in public

[5] R E Nelson et al., "The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke," *Neurology 77*, no. 17 (October 25, 2011): 1590–1598.

programs, and Medi-Cal and Medicare experience savings for current enrollees and those that become eligible in the future (e.g., as a result of stroke-induced disability). For example, a 60-year old stroke patient enters the hospital with private payer coverage and his insurance picks up the acute care costs. However, at the age of 65, this patient becomes enrolled in Medicare, and Medicare now benefits from serving a less-disabled beneficiary. In this analysis we examine both of these impacts; the first impact is called a "per enrollee" benefit and the second is called a "per telestroke cohort" benefit.

MODELING THE IMPACT OF TELESTROKE ON STROKE CARE COSTS

A patient that has suffered from an ischemic stroke incurs hospital costs for the initial inpatient treatment and hospital transfer (if needed), as well as for any immediate rehabilitation and/or skilled nursing care. Depending on the outcome of this care, patients (that survive the initial stroke) may suffer from disability and will incur annual health care costs (e.g., skilled nursing facility stays, outpatient visits, durable medical equipment, and inpatient treatment) related to this outcome for the rest of their lives. These short-term (90-day) and long-term costs will differ for patients that receive tPA and those that do not.

The main benefit of telestroke is that it increases the number of patients that receive tPA relative to usual care. Telestroke does this by providing specialist stroke care remotely to hospitals, often through a hub-spoke model in which specialists at a central (hub) hospital can remotely provide care to patients at remote (spoke) hospitals without such expertise. The size and shape of this network is important when calculating technology and staff training costs, but is not directly relevant from the public payer perspective since the payers do not directly pay for these costs.

This study builds on the impressive modeling work already completed by Dr. Richard Nelson and his research team at the University of Utah School of Medicine. Utilizing some of their published assumptions, we model the impact of telestroke on tPA use in five steps:

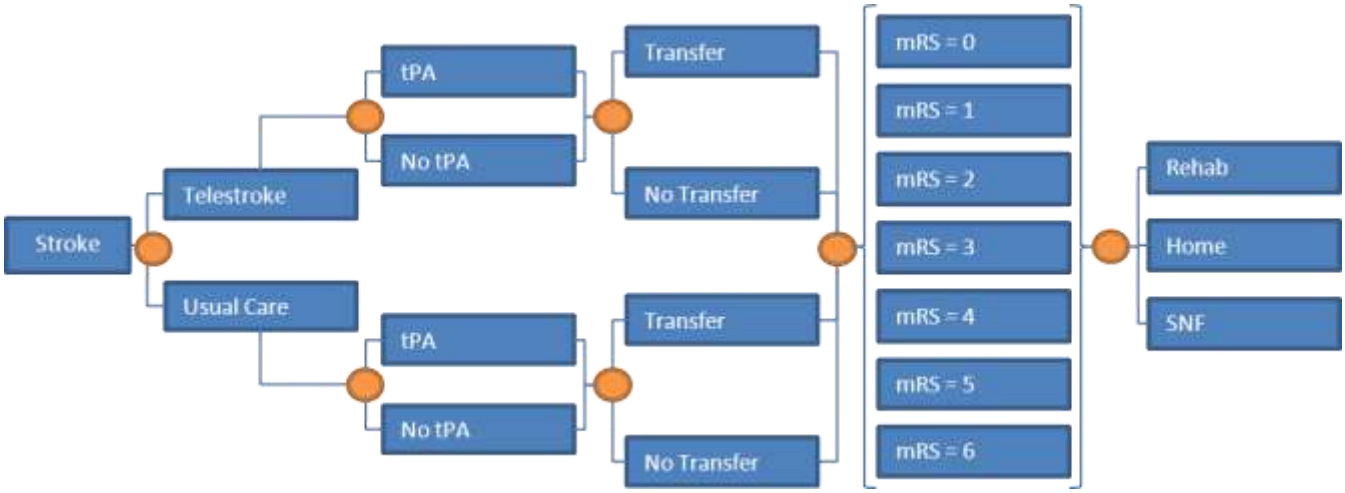
1. Model the possible outcomes following stroke, both with telestroke and usual care.
2. Estimate the costs for public payers associated with each outcome, including short and long term health care costs, rehabilitation, skilled nursing care, and in-home support.
3. Estimate the probabilities of each potential outcome, by age of patient at time of stroke.
4. Model the cost outcomes for telestroke and usual care for the average current enrollee (i.e., from the "per enrollee" perspective).
5. Model the cost outcomes for telestroke and usual care for current and future enrollees in a 100 patient cohort (i.e., from the "per telestroke cohort" perspective).

Modeling the Outcomes of Stroke

When an ischemic stroke patient presents to a hospital, the first decision of import to the model (depicted in Figure 1) is made: whether or not to administer tPA. In the telestroke scenario, 27 percent of

patients receive tPA; under usual care, only 3 percent of patients do.[6,7] Next, the physician team decides whether or not to transfer the patient to another hospital for further care. In the usual care scenario, a high percentage of patients are transferred because stroke specialist care is simply not available. In fact, 90 percent of tPA recipients get transferred and 78 percent of non-recipients do as well.[8] Under telestroke, the availability of stroke specialty care allows these transfers to decrease to 52 percent for patients receiving tPA and 28 percent for non-recipients.[9] Thus, the immediate effect of telestroke is to increase the use of tPA and to decrease the number of required transfers.

FIGURE 1: BASIC MODEL OF STROKE CARE AND OUTCOMES



After the tPA and transfer decisions have been made, stroke care costs depend on the disability level of the stroke patient. A patient that receives tPA is much less likely to suffer from significant disability and death than a patient that does not (this, of course, is the primary benefit of telestroke – improved patient outcomes – although cost is the focus of this report).[10] In turn, patients who are less disabled as

[6] Guntram W Ickenstein et al., "The Use of Telemedicine in Combination with a New Stroke-code-box Significantly Increases t-PA Use in Rural Communities," *Neurocritical Care* 3, no. 1 (2005): 27–32.
[7] Madeline L. Miley et al., "The State of Emergency Stroke Resources and Care in Rural Arizona: A Platform for Telemedicine," *Telemedicine and e-Health* 15, no. 7 (September 2009): 691–699.
[8] Nelson et al., "The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke."
[9] Ibid.
[10] "Tissue Plasminogen Activator for Acute Ischemic Stroke. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group," *The New England Journal of Medicine* 333, no. 24 (December 14, 1995): 1581–1587; S. Schwab et al., "Long-term Outcome After Thrombolysis in Telemedical Stroke Care," *Neurology* 69, no. 9 (August 28, 2007): 898–903.

measured by Modified Rankin scores (mRS) utilize fewer hospital resources and are more likely to be discharged to home (see **Error! Reference source not found.** for a description of mRS scores).[11,12]

FIGURE 2: MODIFIED RANKIN SCORES

As disability increases, so does the use of rehabilitation and skilled nursing facility (SNF) resources in the recovery process.[13] While rehabilitation does reduce some disability, lifetime mRS scores are highly dependent on the initial effects of stroke care and, in turn, so are lifetime medical costs. These ongoing costs include the use of all medical resources such as inpatient care, skilled nursing facilities, physician services, home health care, and durable medical equipment.[14] These costs are significantly higher for the disabled, and are modeled by adjusting the average annual cost for ischemic stroke patients by cost multipliers associated with mRS scores.[15] Figure 3 (on page 11) summarizes these assumptions about the effect of tPA on disability, discharge, and annual costs.

[11] W. Brinjikji, A. A. Rabinstein, and H. J. Cloft, "Hospitalization Costs for Acute Ischemic Stroke Patients Treated With Intravenous Thrombolysis in the United States Are Substantially Higher Than Medicare Payments," *Stroke* 43, no. 4 (December 22, 2011): 1131–1133; CA Russo and RM Andrews, *Hospital Stays for Stroke and Other Cerebrovasular Diseases.*, Health Care Utilization Project (Rockville, MD: Agency for Health Care Research and Quality, May 2008); Won Chan Lee et al., "Long-term Cost of Stroke Subtypes Among Medicare Beneficiaries," *Cerebrovascular Diseases (Basel, Switzerland)* 23, no. 1 (2007): 57–65.

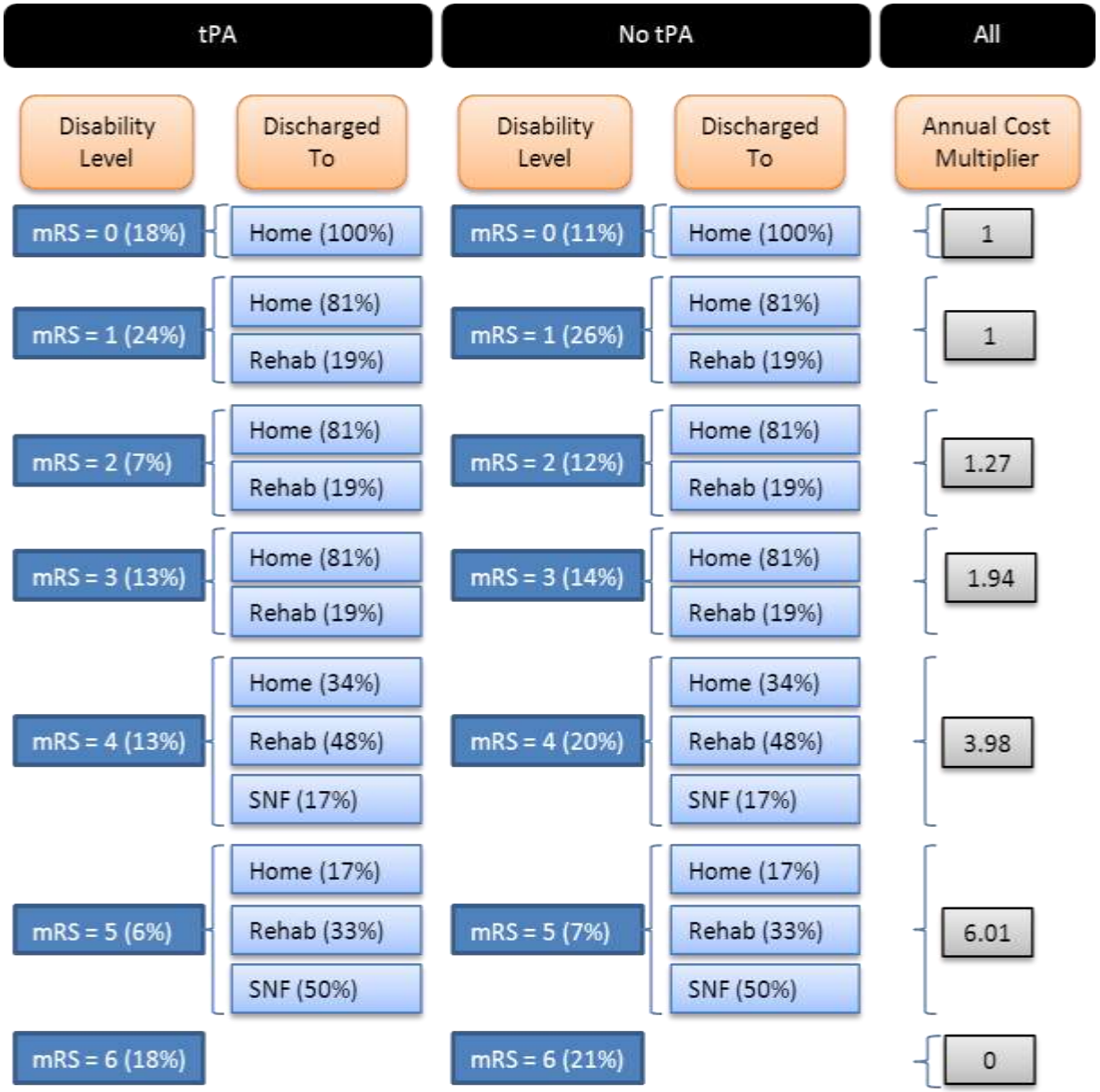
[12] Daniel Schlegel et al., "Utility of the NIH Stroke Scale as a Predictor of Hospital Disposition," *Stroke* 34, no. 1 (January 1, 2003): 134–137.

[13] Anne Deutsch et al., "Poststroke Rehabilitation: Outcomes and Reimbursement of Inpatient Rehabilitation Facilities and Subacute Rehabilitation Programs," *Stroke; a Journal of Cerebral Circulation* 37, no. 6 (June 2006): 1477–1482; Nelson et al., "The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke."

[14] Lee et al., "Long-term Cost of Stroke Subtypes Among Medicare Beneficiaries."

[15] G P Samsa et al., "Performing Cost-effectiveness Analysis by Integrating Randomized Trial Data with a Comprehensive Decision Model: Application to Treatment of Acute Ischemic Stroke," *Journal of Clinical Epidemiology* 52, no. 3 (March 1999): 259–271.

FIGURE 3: EFFECT OF TPA ON 90-DAY DISABILITY AND IMPACT OF DISABILITY ON DISCHARGE STATUS AND LIFETIME COST[16,17]



Estimating the Cost of Stroke Outcomes to Medi-Cal and Medicare

Next, we estimated the cost of stroke care to both Medi-Cal and Medicare. We used the six societal cost categories developed by Dr. Nelson and his colleagues as the starting point, and then modified them to

[16] Nelson et al., "The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke."
[17] 90-Day mRS scores differ from lifetime mRS scores due to the positive impact of rehabilitation on disability status. Lifetime mRS scores are not shown here.

reflect costs for public payers, rather than societal health care costs. These cost categories include transfer, inpatient hospital, rehabilitation, skilled nursing facility, annual medical costs, and annual caregiver costs. Each cost category was adjusted to reflect costs paid by Medi-Cal and Medicare. For dual eligible patients, we assumed that short-term costs were paid for by Medicare (which is the primary payer for medically necessary services) and long-term costs had both a Medicare and Medi-Cal cost component.[18,19]

The method used to transform an estimate of societal costs into Medicare or Medi-Cal costs depended on the source of the societal cost figure that served as the starting point for our modeling. If the societal cost was based on provider costs, two basic methods were used: 1) a cost-to-reimbursement ratio for both Medicare and Medi-Cal was identified or 2) a cost-to-reimbursement ratio for Medicare was used in conjunction with a Medi-Cal-to-Medicare ratio. If the societal cost was based on Medicare claims data, we only had to find a way to translate this to Medi-Cal by accounting for any differences between Medi-Cal and Medicare coverage and applying a Medi-Cal-to-Medicare ratio.

Because of the widespread use of Medicare data to study underlying costs, many of the cost components estimated by Dr. Nelson, et. al., already reflect Medicare costs. These include the cost of short-term rehabilitation and skilled nursing facility use as well as lifetime annual medical service utilization. Thus, in order to calculate Medi-Cal costs, we estimated the ratio of MediCal to Medicare costs for each relevant cost category. For short-term inpatient rehabilitation, an analysis of the Office of Statewide Health Planning's (OSHPD) 2010 annual hospital financial data indicates that Medi-Cal's payment per day was 70 percent of Medicare's for hospital inpatient services, which includes costs for inpatient rehabilitation.[20] For short-term skilled nursing facility use in the first 90-days of treatment, our analysis of OSHPD 2010 annual long-term care facility financial data indicates that Medi-Cal paid 75 percent of Medicare's per patient day payment for these services.[21]

Calculations for long-term annual costs were more complicated since six cost components (inpatient care, hospital outpatient care, skilled nursing facility care, physician care, home health care, and durable medical equipment) make up the annual Medicare cost calculation and because Medi-Cal pays for more skilled nursing facility costs than Medicare. To account for the underrepresentation of SNF costs for Medi-

[18] Medi-Cal coverage for dual eligible beneficiaries depends on the type of dual eligible; however, generally, Medi-Cal pays for services not covered by Medicare such as transportation, dental, vision, and some mental health services; acute care and skilled nursing facility services that are delivered after the Medicare benefit is exhausted or a specific condition as not been met; share of costs, deductibles, and premiums; and long-term care provided in facilities or in personal homes.

[19] The cost figures reported in the Utah study were adjusted to reflect Medicare and Medi-Cal savings rather than building these figures up from scratch using claims data and/or reimbursement rate manuals due to the structure of the underlying model, which relies on disability scores to measure the impact of telestroke on overall costs. The available Medi-Cal public data does not allow us to estimate costs according to disability level.

[20] Based on gross patient revenue for all inpatient care (i.e., not just stroke care) in acute care dhospital financial data that includes lump-sum Medi-Cal payments to hospitals through the Disproportionate Share program as well as per patient reimbursement.

[21] Ratio is based on gross routine revenue per day. The financial data was limited to skilled nursing care and facilities with a skilled nursing facility license.

Cal, we added in costs to reflect the fact that 16 percent of lifetime stroke costs are attributable to SNF care.[22] Then, Medi-Cal reimbursement ratios were used for each of the cost components, as follows:

- The Medi-Cal-to-Medicare ratio (0.70) from the OSHPD 2010 annual hospital financial data was used for inpatient care.
- The Medi-Cal-to-Medicare ratio for outpatient care was calculated to be 0.69, based on revenue per outpatient visit for each payer from the OSHPD 2010 annual hospital financial data for outpatient care.
- The Medi-Cal-to-cost ratio was estimated to be 0.69 for SNF care. This ratio was created by comparing net provider expenses per day to net Medi-Cal revenue per day in the OSHPD 2010 annual long-term care facility financial data.[23]
- The Kaiser Family Foundation's Medicaid-to-Medicare Fee Index reports that Medi-Cal pays 56 percent of what Medicare pays for all physician services.[24]
- Meanwhile, home health care cost analyses were used to estimate that the Medi-Cal-to-Medicare ratio is 0.33 for home health care.[25]
- Finally, it was assumed that Medi-Cal costs for durable medical equipment were equal to Medicare costs since a data-based figure was not available and these costs represent less than 1 percent of the annual costs.

In total, Medi-Cal reimbursement for the lifetime annual costs of Medi-Cal only patients ended up being 22 percent less than that for Medicare patients. For dual eligibles, Medi-Cal is assumed to spend 26 percent of what it spends on Medi-Cal only patients based on research done by the Department of Health Care Services on disabled dual eligible spending.[26] Medicare is assumed to spend the same amount on duals as they do on Medicare-only patients because Medicare is the primary payer in both cases.

For transfer costs, a California-based industry analysis on ground transport was used to estimate that Medicare paid 72 percent of ground transport costs and Medi-Cal paid 25 percent; we assumed this rate applied to air transports as well.[27] For hospital costs, we first created an entirely new provider cost estimate that differed by tPA use and disability outcome. This was done because Medicare pays for stroke care with lump-sum payments based on Medicare Severity Diagnosis Related Groups (MS-DRGs) and information on the cost of and Medicare's reimbursement for tPA-specific care by disability outcome is

[22] Thomas N. Taylor et al., "Lifetime Cost of Stroke in the United States," *Stroke* 27, no. 9 (September 1, 1996): 1459–1466.
[23] This figure is based on the ratio of net patient revenue per day and total health care expenses per day. Once again the dataset is limited to skilled nursing care and facilities with a skilled nursing facility license.
[24] Stephen Zuckerman, Aimee F. Williams, and Karen E. Stockley, "Trends In Medicaid Physician Fees, 2003–2008," *Health Affairs* 28, no. 3 (May 1, 2009): w510–w519.
[25] Assumes equal use of the four provider types reported in *Medicare Home Health Care: Payments to Home Health Agencies Are Considerably Higher Than Costs*, Report to Congressional Committees (United State General Accounting Office, May 2002); *Home Health Care: A More Cost-Effective Approach to Medicaid in Illinois* (Illinois HomeCare & Hospice Council, December 2010).
[26] *Medi-Cal's Dual Eligible Population: Demographics, Health Characteristics and Costs of Health Care Services* (Research and Analytics Studies Section, Department of Health Care Services, September 17, 2009).
[27] "Medi-Cal Funding Cut Impacts Every Patient That Dials 9-1-1" (California Ambulance Association, February 2011).

available in the literature.[28] To calculate non-tPA hospital care costs, we subtracted the tPA-specific hospital care costs from average hospital care costs.[29] For tPA hospital costs, Medicare paid approximately 28 percent less than the acute care hospital costs. For non-tPA hospital costs, Medicare is estimated to pay 2.4 percent less than costs based on the overall inpatient Medicare margin in 2009.[30] Although Medi-Cal does not currently repay hospitals based on DRG system, it does use negotiated per-diem rates that are not directly related to the cost of care provided to a single patient. As such, we use the Medicare reimbursement ratio for each disability level and modify it to reflect the fact that Medi-Cal pays 70 percent of what Medicare pays for inpatient hospital care, according to OSHPD 2010 financial data.

Finally, we estimated the amount of Medi-Cal spending on In-Home Supportive Services (IHSS) for stroke patients.[31] IHSS provides personal services such as bathing, housework, feeding and dressing to qualifying home-bound low-income elderly residents. About 99 percent of IHSS recipients receive IHSS as a Medi-Cal benefit and the average annual cost per case is $13,000.[32] However, the number of hours of IHSS care depends on disability levels, with more disabled residents being more likely to receive the maximum of 283 hours of care per month. Utilizing monthly IHSS summary data for 2011, the severely impaired cost $18,800 on average over the year while the less impaired cost $8500.[33] Patients with a lifetime mRS score of 1, 2, or 3 were assigned the less impaired costs while those with a mRS score of 4 or 5 were assigned the severely impaired costs. Finally, IHSS is available for those who are aged, blind, or disabled; therefore, dual eligibles with a score above 0 and Medi-Cal only patients with a score of 4 or 5 incur costs in our model.

Estimating the Disability Outcomes by Age

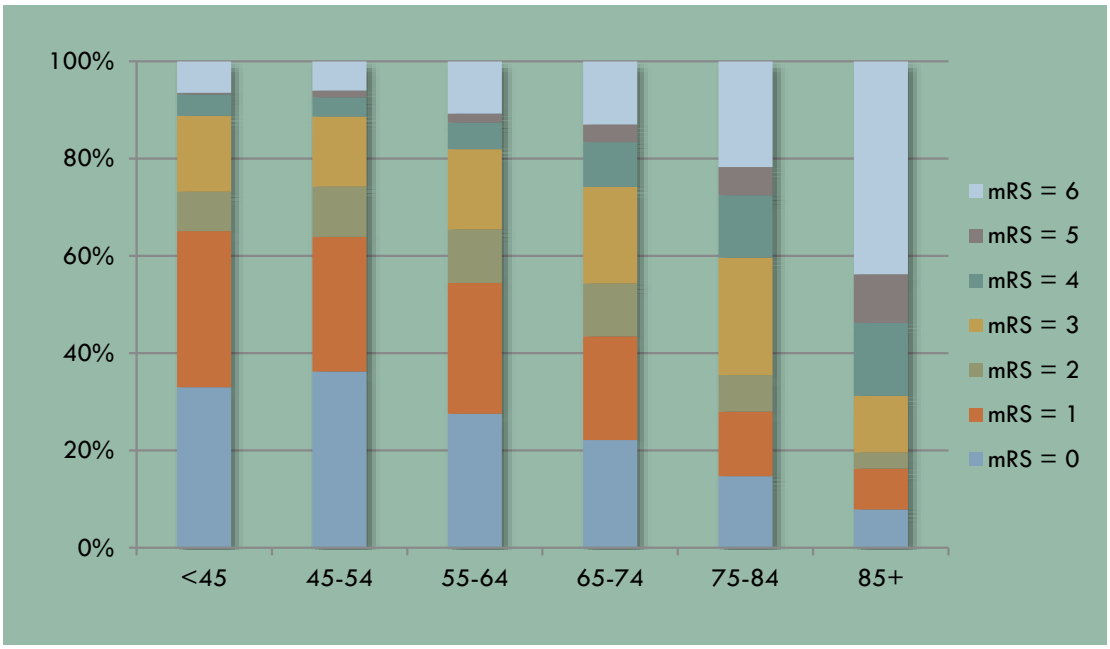
Having estimated Medi-Cal and Medicare costs, we next estimated outcome probabilities that reflect the patients covered by our public payers. Eligibility for these public programs is based on a combination of age, disability status, and income. Therefore, the average cost of stroke, which is influenced heavily by the preponderance of elderly patients, is not directly relevant for these payers (especially for Medi-Cal). To account for this, we modified the underlying disability outcomes reported in the literature to reflect

[28] Brinjikji, Rabinstein, and Cloft, "Hospitalization Costs for Acute Ischemic Stroke Patients Treated With Intravenous Thrombolysis in the United States Are Substantially Higher Than Medicare Payments."
[29] Russo and Andrews, *Hospital Stays for Stroke and Other Cerebrovasular Diseases.*; Lee et al., "Long-term Cost of Stroke Subtypes Among Medicare Beneficiaries."
[30] *Report to the Congress: Medicare Payment Policy* (MedPac, March 2011).
[31] The IHSS calculation replaces the Utah study's estimate of the societal cost of informal care giving. Many stroke patients may also incur this type of informal caregiver cost, but these costs would not be paid for by public payers.
[32] *Approach to the 2011-12 In-Home Supportive Services Budget* (Legislative Analyst's Office, January 25, 2011).
[33] Although only 3.5 out of 1000 (0.4%) of Medi-Cal beneficiaries were receiving nursing home services in 2005 according to the California HealthCare Foundation, it is unknown how this figure changes for stroke patients of various disability levels. Therefore, the model uses the percent of Medi-Cal stroke patients discharged to their home and rehabilitation at 90-days minus an additional percent of non-hospital-based SNF placements from the literature for the annual percent of Medi-Cal stroke patients remaining in their homes. Figures were deflated to reflect 2008 costs in order to match the other cost figures used in this report.

the impact of age and created estimated life expectancies for each specific age and disability level combination.

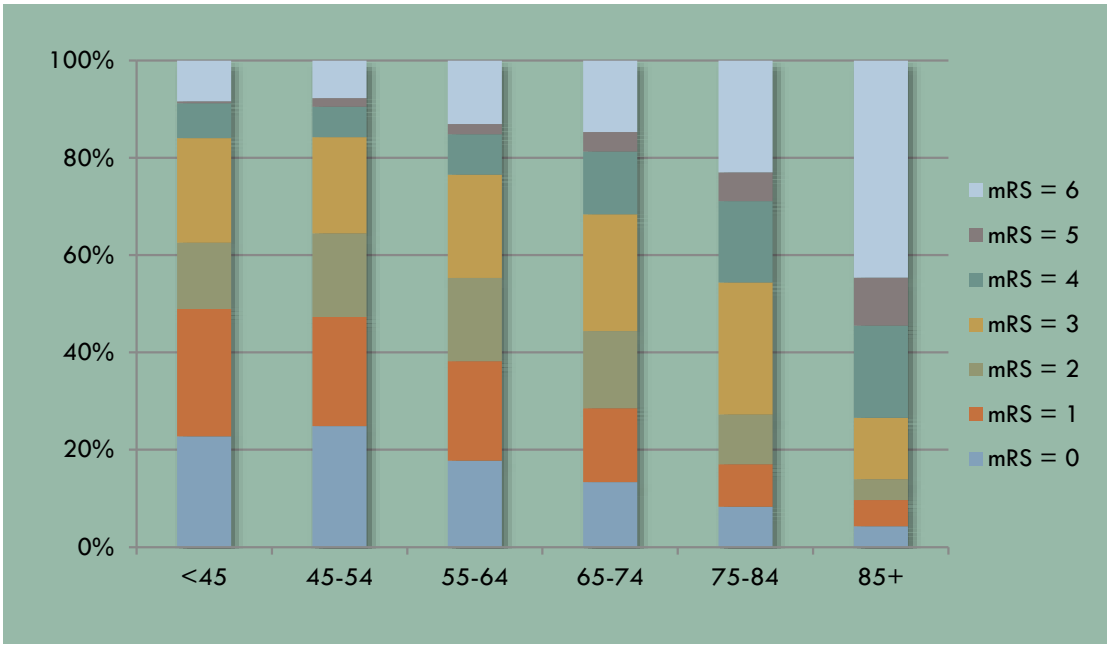
First, we created age-specific disability outcomes for recipients and non-recipients of tPA by using age-specific ischemic stroke mRS outcomes from previously published research and adjusting them to reflect the overall distribution of mRS outcomes for tPA and non-tPA recipients used in the model.[34] Essentially, younger stroke patients are more likely to have lower disability scores after stroke than older patients, and we modified our model to reflect this (see Figure 4 and Figure 5).

FIGURE 4: LIFETIME MRS OUTCOMES BY AGE FOR TPA RECIPIENTS



[34] Keun-Sik Hong et al., "Burden of Ischemic Stroke in Korea: Analysis of Disability-Adjusted Life Years Lost," *Journal of Clinical Neurology* 7, no. 2 (2011): 77.

FIGURE 5: LIFETIME MRS OUTCOMES BY AGE FOR NON-TPA RECIPIENTS



In addition, younger patients should have a longer life expectancy after stroke than older patients. Moreover, life expectancy should vary by mRS outcome so that the more disabled have a shorter life expectancy. In order to estimate the difference in life expectancy by age and disability outcome after a stroke, we applied mRS-specific mortality hazard ratios to the United States life table, which calculates the life expectancy for every age of the population.[35] The mortality hazard ratios increase as disability increases in order to reflect decreasing life expectancy and can be used to create life expectancies by multiplying them times the normal probability of dying.[36] This process allows us to estimate the expected age of death for a patient at any age for every mRS score.

Constructing a "Per Enrollee" Model

To measure the impact of telestroke on current Medi-Cal and Medicare enrollees, we modeled the cost of stroke care under telestroke and usual care for patients covered by the programs. For Medi-Cal, this included Medi-Cal only patients of all ages, as well as dual eligible patients. Strokes are distributed within each age based on national ischemic stroke hospital utilization data and multiplied times the percent of that age group that is covered by Medi-Cal.[37,38] Patients in each age group were assigned to a 90-day and

[35] Keun-Sik Hong, "Disability-Adjusted Life Years Analysis: Implications for Stroke Research," *Journal of Clinical Neurology* 7, no. 3 (2011): 109.
[36] Keun-Sik Hong and Jeffrey L. Saver, "Years of Disability-Adjusted Life Gained as a Result of Thrombolytic Therapy for Acute Ischemic Stroke," *Stroke* 41, no. 3 (March 1, 2010): 471–477.
[37] Russo and Andrews, *Hospital Stays for Stroke and Other Cerebrovasular Diseases*.
[38] Because HCUP reports ages in brackets, actual age-specific estimates are based on the distribution of the population within the age bracket. For example, 24.1 percent of strokes were experienced by patients age 45 to 64. Thus, 24.1 percent of the 1000 strokes are experienced by 45 to 64 year olds in the cohort. The 45 year olds experience 6 percent of this 24.1 percent because they represent 6 percent of the 45 to 64 population, or 1.45 percent. Age distribution within these brackets are based on 2009 California Health Interview Survey data.

lifetime mRS outcomes based on their use of tPA (see Figure 4 and Figure 5) and annual costs after the initial 90-day period are calculated for every year of remaining life for the age group. Medi-Cal only patients under 65 that experienced high disability outcomes after stroke care (i.e., a mRS of 4 or 5) would become dual eligible after two years and take on these lower per enrollee costs (with the remaining costs shifted to the Medicare program).[39] At 65, all Medi-Cal only patients become dual eligible in our model. For Medi-Cal only enrollees that were 65 or older at the time of stroke, it was assumed that they remained a Medi-Cal only patient until death. For Medicare, the population once again included patients of all ages weighted by stroke prevalence and Medicare coverage. Each patient in the model was assigned a mRS outcome based on tPA use and age, and incurred costs for the remainder of their estimated life expectancy. Current Medicare enrollees always incurred the same costs whether or not they ever became dual eligible for Medi-Cal, since Medicare is the primary payer for these patients. Total Medi-Cal and Medicare costs were calculated under telestroke and usual care and then divided by the public program's stroke population to estimate the per patient savings.

Constructing a "Per Telestroke Cohort" Model

Finally, we modeled the impact of expanded access to telestroke generally on Medicare and Medi-Cal costs. By increasing tPA use, telestroke can decrease disability and resulting health care costs for patients that become eligible for Medicare or Medi-Cal following stroke (as well as for those enrolled at the time of stroke). To estimate these costs, termed "per telestroke cohort" costs, we estimated the overall savings to each public payer resulting from the impact of a telestroke network reaching 100 additional patients regardless of insurance coverage at the time of stroke. To do this, we created a cohort of potential telestroke patients that reflects the California population of ischemic stroke patients.

The model cohort is comprised of 100 adults with an acute ischemic stroke. Stroke prevalence was distributed within each age based on national ischemic stroke hospital utilization data.[40,41] These patients were then assigned Medi-Cal, Medicare, or dual eligible coverage at the time of stroke based on the distribution of coverage for each age group in California. This coverage was used to estimate costs to Medi-Cal and Medicare for the initial hospitalization and 90-day recovery period.[42] Next, the patients in each age group were assigned to lifetime mRS outcomes based on their use of tPA (see Figure 4 and Figure 5) and annual costs after the initial 90-day period are calculated for the remaining life for the age group. The mRS outcome remains the same over the lifetime, but the number of patients remaining alive and the coverage for each age group changes as they age. The number of patients remaining alive for each age group is based on the expected age of death for each mRS outcome. The insurance coverage for each age group is based on the current coverage for stroke survivors in four age groups (<45, 45 through 64, 65 through 84, and >85) in California.[43] We model a change in insurance coverage over time because

[39] The two-year delay reflects the 24-month social security disability insurance receipt requirement for disabled Medicare eligibility.
[40] Russo and Andrews, *Hospital Stays for Stroke and Other Cerebrovasular Diseases.*
[41] See Footnote 38 for more details.
[42] 2009 California Health Interview Survey, (Los Angeles, CA: UCLA Center for Health Policy Research) .
[43] 2005 California Health Interview Survey, (Los Angeles, CA: UCLA Center for Health Policy Research)

coverage changes as stroke survivors grow older, become disabled, or lose income; generally, younger patients are more likely to be covered by Medi-Cal while Medicare and dual coverage increase as people age. Costs are discounted at 3 percent. To estimate actual cost savings, the cohort is modeled in both usual care and telestroke scenarios and the differences in costs are calculated to estimate overall savings.

PER ENROLLEE SAVINGS

Both Medi-Cal and Medicare can experience savings in two different ways. The "per enrollee" model measures the impact of telestroke on current enrollees who experience a stroke and receive care via telestroke while the "per telestroke cohort" model (discussed in the next section) reflects costs for current as well as future enrollees.

Savings per Medi-Cal patient

Our results suggest that use of telestroke would save an average of $2,400 per Medi-Cal only patient and $600 per dual eligible patient when compared to usual care. These lifetime estimates include savings in both the 90-day period of acute stroke care and rehabilitation and in the post-acute, long term period. The bulk of the lifetime savings are, however, from the annual savings experienced after the initial stroke; Medi-Cal experiences 90-day savings of just $300 for Medi-Cal only patients; costs for dual eligible patients are equal in the telestroke and usual care scenarios. In some cases, Medi-Cal savings will be reduced relative to these amounts when hospitals are able to charge a telemedicine facility fee. Currently, only patients at Critical Access Hospitals would have an additional telestroke cost of $23.[44]

How Do Our Results Compare to the Previous Research?

These results may seem to be at odds with those reported by the University of Utah researchers, which indicated $3,184 in costs in the lifetime scenario and a $402 cost per patient in the 90-day period from the societal perspective. The difference in results, however, primarily relates to the difference in the perspectives of the two models. Our analysis reflects the payer perspective, while theirs reflects the societal perspective. For example, a large part of the difference is due to the absence of technology costs from our model (since these costs are not currently directly paid for by public payers). We also estimate IHSS costs instead of informal caregiver costs, which results in a larger savings in our model. And, because public payers often pay less than the actual cost to providers for types of services, our model reflects larger savings relative to a societal perspective which counts costs rather than public payer payments. At the same time, we estimate that hospital care is more expensive for tPA under all disability outcomes relative to the previously reported research. Finally, we have modeled the costs to reflect a California specific public payer population, including estimates of stroke prevalence, disability status and program enrollment by age. The result is a more refined estimate of the annual costs such that younger people,

[44] A Critical Access Hospital (CAH) is a hospital certified to receive cost-based reimbursement from Medicare. CAHs must be located in a rural area and meet one of the following criteria: 1) be more than 35 miles away from another hospital, or 2) be 15 miles from another hospital in mountainous terrain or areas with only secondary roads. This deduction does not impact our estimated savings figures due to rounding.

who are more likely to be covered by Medi-Cal, are less likely to be disabled, but also more likely to live longer. The impact of this modeling change results in an increased estimated savings amount.

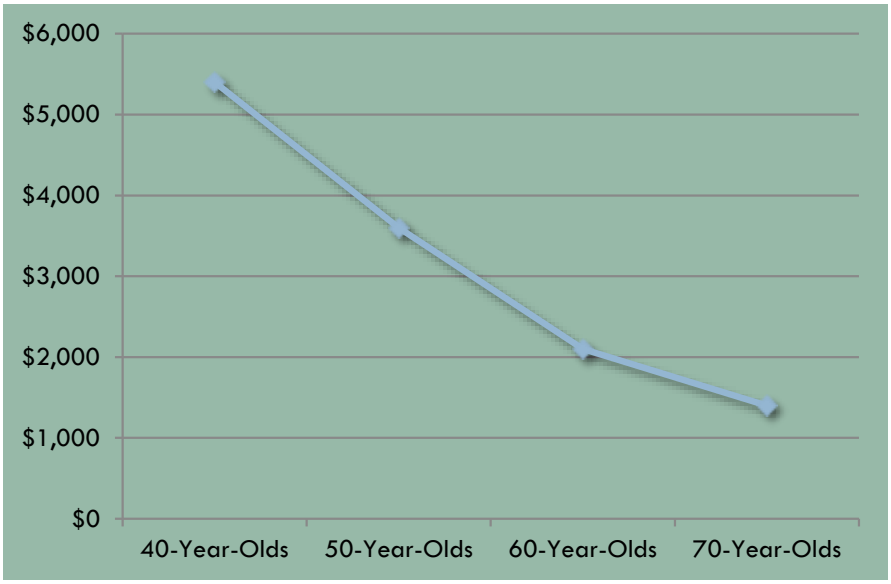
Factors that Influence the Results

Our results reflect the impact of two related, but opposing factors. Modeling the impact of age-specific disability outcomes and life expectancies results in a model that reflects less disability in the telestroke scenario, which lowers costs, as well as longer life expectancies, which increase costs. As Table 1 shows, overall costs decrease under telestroke because the reduction in costs for higher disability outcomes is greater than the increase in costs for living longer with less disability. In telestroke and usual care, the annual cost and years of remaining life are the same, but telestroke increases the percent of people with a lower disability outcome. Thus, the increase in low mRS outcomes for 50-year-olds leads to an increase in care costs. But, this is outweighed by the savings caused by the reduction in higher mRS outcomes. In other words, even though patients that receive tPA live longer (thereby increasing their lifetime health care costs), the reduction in high disability cases lowers annual health care costs. In addition, these annual cost savings are actually greater for the younger patients, who are more likely to be covered by Medi-Cal. Figure 6 delineates this trend, showing how telestroke causes $5400 in Medi-Cal savings for 40-year-olds, but only $1,400 in savings for 70-year-olds.

TABLE 1: THE IMPACT OF TELESTROKE ON ANNUAL MEDI-CAL COSTS FOR 50-YEAR-OLDS

	mrs=0	mrs=1	mrs=2	mrs=3	mrs=4	mrs=5	Total
Annual Medi-Cal Cost	$5,200	$5,200	$6,600	$10,100	$34,400	$39,000	
Years left	27	27	24	20	17	14	
Telestroke: % in mRS	29%	25%	14%	18%	5%	1%	
Usual Care: % in mRS	26%	24%	16%	19%	6%	2%	
Telestroke Cost	$40,800	$35,000	$22,400	$35,800	$30,800	$8,200	
Usual Care Cost	$36,700	$33,200	$24,900	$38,700	$34,300	$8,800	
Cost Impact	**-$4,100**	**-$1,800**	**$2,500**	**$2,900**	**$3,500**	**$600**	**$3,600**

FIGURE 6: DECREASE IN AGE-SPECIFIC ANNUAL MEDI-CAL SAVINGS IN TELESTROKE



Finally, short-term savings are lower than these annual savings, for two reasons. First, 90-day savings are not that large from telestroke compared to usual care. This is largely due to the fact that it costs more to treat patients with tPA in hospitals. Thus, even though a lower disability outcome from tPA means lower hospital care costs, when the cost of tPA administration is added, the total hospital visit cost is higher for those that receive tPA. These initial costs are, however, offset by lower costs for tPA patients during the remaining portion of the initial 90 day period.

Savings per Medicare patient

Perhaps not surprisingly, our model also finds savings for Medicare. In fact, Medicare is estimated to save $1,100 per Medicare patient. For Medicare, a larger fraction of the lifetime savings comes from the 90-day period, during which telestroke saved the program $600 per patient relative to usual care.[45]

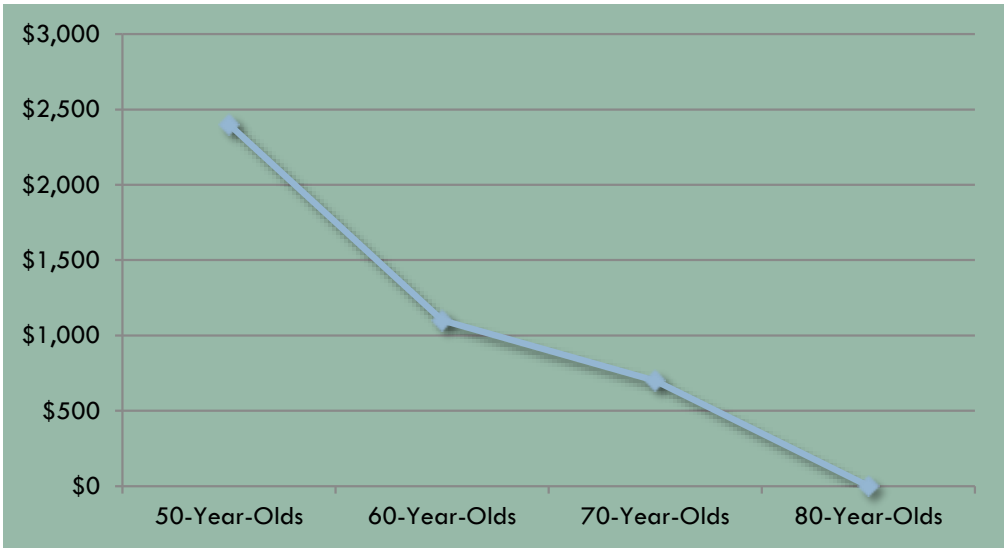
These savings are driven by the same mechanism as in Medi-Cal: disability savings outweigh increases in lifespans (see Table 2). However, the savings are actually smaller and continue to decrease for older patients (see Figure 7) so that Medicare does not experience a significant amount of annual savings from telestroke. One of the main reasons for this difference is that Medi-Cal experiences significant annual IHSS costs for the home-bound severely disabled that Medicare does not. Because of these annual savings differences and higher 90-day reimbursement ratios, Medicare actually has more savings from the 90-day period than it does in the post-stroke period.

[45] Although Medicare will pay a telemedicine facility fee of $24 for all patients, this does not change our estimate of savings due to rounding.

TABLE 2: THE IMPACT OF TELESTROKE ON ANNUAL MEDICARE COSTS FOR 50-YEAR-OLDS

	mrs=0	mrs=1	mrs=2	mrs=3	mrs=4	mrs=5	Total
Annual Medicare Cost	$6,700	$6,700	$8,500	$12,900	$26,500	$40,000	
Years left	27	27	24	20	17	14	
Telestroke: % in mRS	29%	25%	14%	18%	5%	1%	
Usual Care: % in mRS	26%	24%	16%	19%	6%	2%	
Telestroke Cost	$52,600	$45,100	$28,900	$45,800	$23,700	$8,400	
Usual Care Cost	$47,300	$42,800	$32,000	$49,400	$26,400	$9,000	
Cost Impact	**-$5,300**	**-$2,300**	**$3,100**	**$3,600**	**$2,700**	**$600**	**$2,400**

FIGURE 7: DECREASE IN AGE-SPECIFIC ANNUAL MEDICARE SAVINGS



PER TELESTROKE COHORT SAVINGS

In addition to the per enrollee costs discussed above, Medi-Cal and Medicare can experience benefits and/or costs from the adoption of telestroke generally. From this perspective, telestroke improves outcomes for patients, regardless of their current enrollment in public programs, and public payers experience potential savings from post-stroke enrollees. In essence, Medi-Cal and Medicare benefit from enrolling less disabled individuals as they become eligible for care later in life, either because of stroke-related disability, reduced income levels, age, or other factors.[46]

Medi-Cal Savings

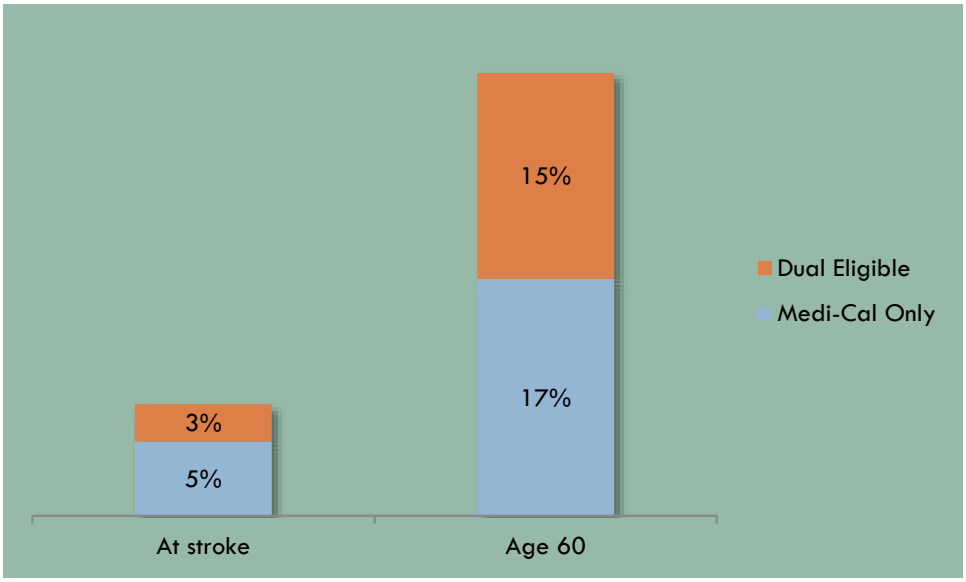
Taking the broader perspective shows that Medi-Cal would save money from increased use of telestroke by non-enrollees as well. Our model suggests that Medi-Cal would experience about $44,000 in total

[46] Instead of assuming that a certain percent of post-stroke patients in telestroke do not enroll in Medi-Cal and Medicare and decreasing the percent covered by public programs under the two scenarios, we assume that Medi-Cal and Medicare simply pay for less disabled enrollees.

savings if telestroke reaches 100 additional California residents. That's about $440 per telestroke patient.[47]

In comparison to the "per enrollee" savings, Medi-Cal saves $29,000 more for a cohort of 100 patients than it would if only the benefits of the current enrollees were calculated. In other words, Medi-Cal experiences a larger savings because more people are covered by Medi-Cal after strokes than at the time they occur. For example, as shown in Figure 8, our analysis suggests that only 8 percent of 50-year-old stroke victims are covered by Medi-Cal at the time of stroke, but almost 40 percent of them will be covered by Medi-Cal at age 60. The increase in dual eligible Medi-Cal coverage from 3 percent to 25 percent suggests that a large portion of this increase may have to do with increased disability. Thus, analyzing costs from this broader perspective results in additional estimated savings. These savings stem from the fact that Medi-Cal serves a less disabled patient population as a result of the telestroke intervention, even if some of these patients were not enrolled at the time of stroke. It's worth noting that these estimates can be considered quite conservative since they do not reflect any reduction in the size of the Medi-Cal population, just a reduction in the level of disability within this population. If we modeled a reduction in the Medi-Cal population (by removing the less disabled from Medi-Cal altogether) the savings would be larger because Medi-Cal would avoid all of the costs associated with these beneficiaries that never end up as Medi-Cal enrollees.

FIGURE 8: ESTIMATED MEDI-CAL COVERAGE FOR 50-YEAR-OLDS AT TIME OF STROKE AND AT AGE 60



Medicare Savings

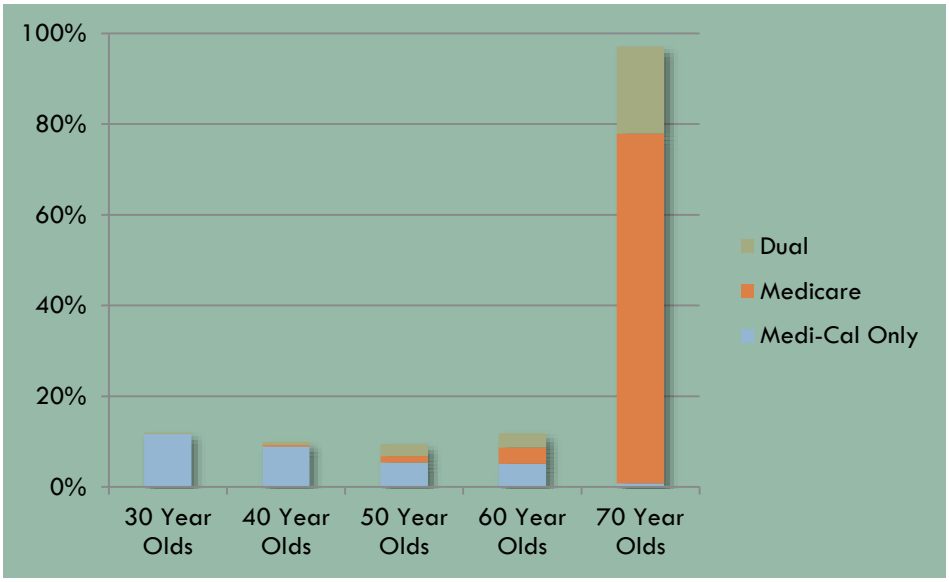
Similarly, we estimate that Medicare could experience savings of $85,000 for each additional 100 California residents that receive telestroke care. Per telestroke patient, this equals about $850. These

[47] Once again, this figure would be reduced by telestroke fees for Medi-Cal beneficiaries at Critical Access Hospitals for a maximum reduction of $69 from the savings.

total savings would be reduced by the telehealth facility fee for each of the Medicare patients, such that the total net savings for each 100 patients is $83,000.

In comparison to the Medicare per patient savings in the narrower per enrollee model, Medicare saves $9,000 more for a cohort of 100 patients than it would if only the benefits of the current enrollees were calculated. In other words, multiplying the estimated per enrollee benefits for Medicare patients times the number of current enrollees in the cohort, we would expect $76,000 in savings. However, Medicare experiences $85,000 in savings. The estimate of overall savings is not significantly more because Medicare already covers more than two-thirds of patients at the time of stroke since 71 percent of all ischemic stroke patients are over 65. Moreover, Medicare would expect to cover virtually all of the patients in the 100 patient cohort in the long run anyway (see Figure 9). As a result, costs from the per enrollee and per telestroke cohort perspectives are similar.

FIGURE 9: MEDICARE ENROLLMENT DIFFERENCES BY AGE GROUP



SENSITIVITY ANALYSIS

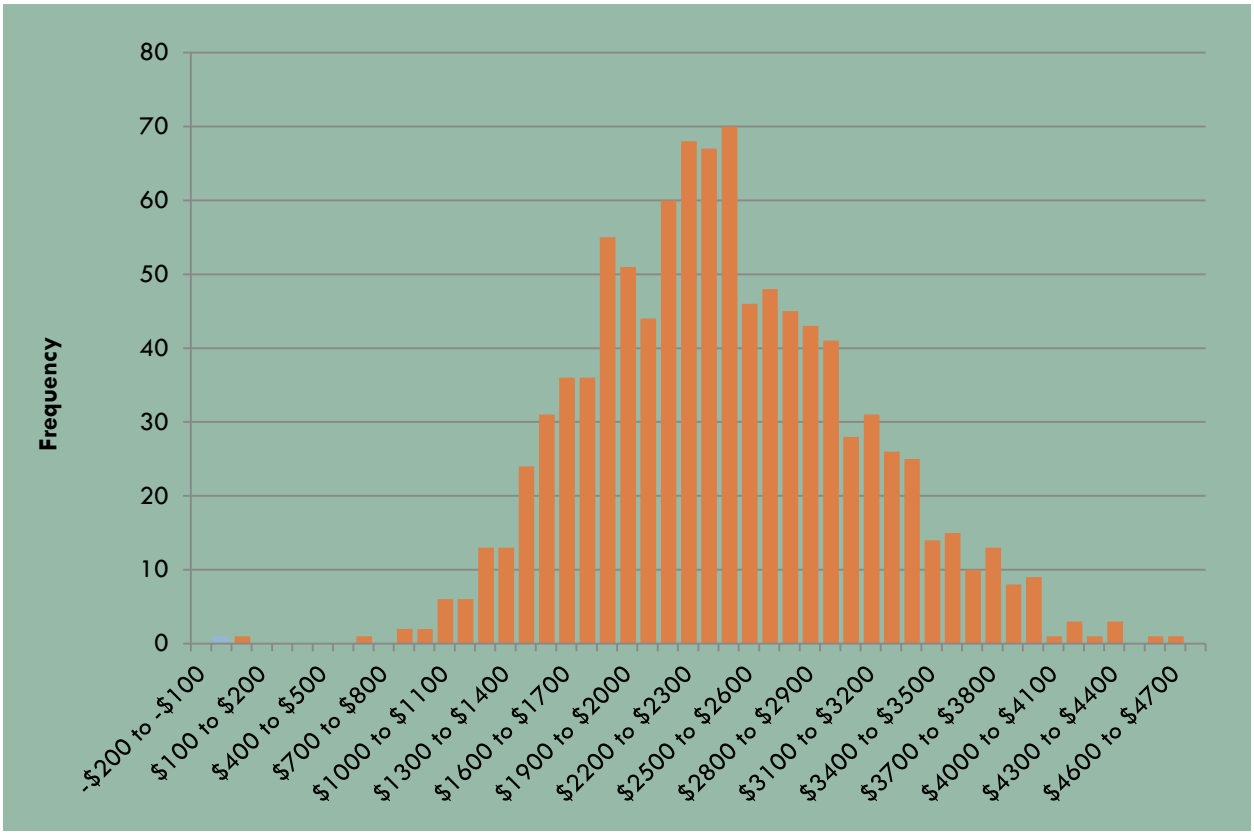
Our results are based on a series of assumptions, derived from our research on health care costs incurred by Medicare and Medi-Cal as well as results reported in the published research literature. Although these estimates are based on the best available data and research, they are nevertheless subject to uncertainty. In order to test the dependence of our results on individual input parameters, we conducted a sensitivity analysis, in which we varied the key input parameters across a likely range.

Specifically, we varied each key parameter by 20 percent, with a maximum value 20 greater than that used in the base case and a minimum value 20 percent lower than that from the base case. We then

conducted a series of 1,000 Monte Carlo simulations, in which a random value was selected for each key parameter from within the likely range we established.

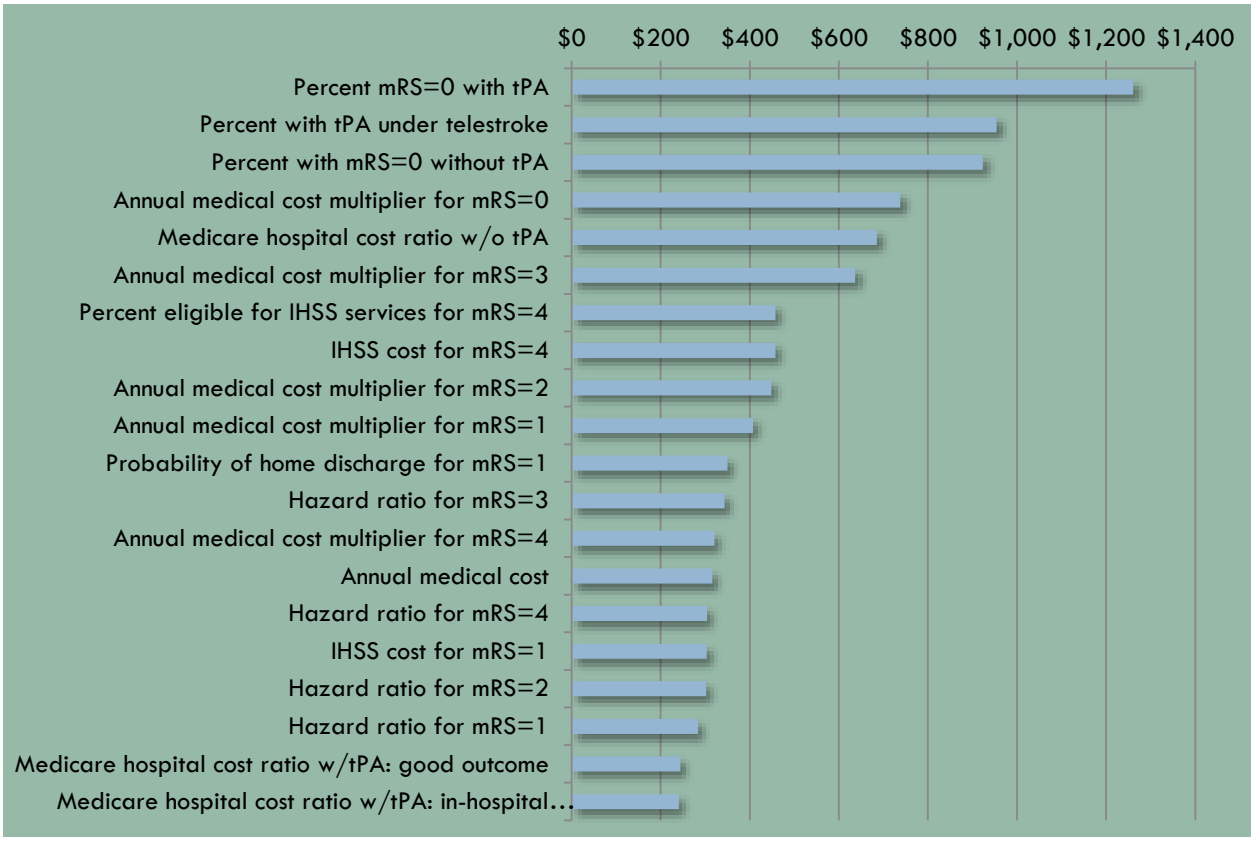
This sensitivity analysis suggests that, while telestroke is likely to produce cost savings to public payers under a majority of the potential outcomes, the results are sensitive to the input assumptions. Our analysis suggests that net cost savings result in approximately 99 percent of the simulations. Figure 10 presents the results of our sensitivity analysis.

FIGURE 10: FREQUENCY OF PER PATIENT MEDI-CAL OUTCOMES



We also conducted a one-way sensitivity analysis, in which a single input parameter was varied. These results suggest that our results are most sensitive to the mRS outcomes of care with and without tPA, the fraction of telestroke patients that get tPA, hospital costs with and without tPA, most of the annual medical cost multipliers, the life expectancy (i.e., hazard ratios) for most mRS outcomes, and the IHSS cost for the relatively severely disabled (mRS = 4). Figure 11 presents the results of our one-way sensitivity analysis.

FIGURE 11: FACTORS WITH THE LARGEST INFLUENCE ON PER PATIENT MEDI-CAL OUTCOMES



PROVIDER PERSPECTIVE AND TECHNOLOGY COSTS

Since our analysis focused on the potential for public payer savings from telestroke, it does not factor in the cost of telestroke technology, training, and ongoing maintenance that will be borne by telestroke network hospitals. Yet these costs – and provider-based profits more generally – impact the decision to create and/or join a telestroke network. The University of Utah researchers estimated that technology costs in an 8 spoke telestroke network with 12 patients per year per spoke equaled almost $1000 per patient. Nevertheless, hospitals could experience benefits that make telestroke a good investment. For example, the decrease in patient transfers means that hospitals can retain and bill for a larger number of patients. Moreover, participation in a telestroke network can bring in additional patients from the surrounding community in search of specialist stroke care.

Finally, health care payers could pay a higher network and/or a facility fee that would allow participating hospitals to recoup (some portion of) the technology and training costs. Since per patient savings for Medi-Cal and Medicare in both of our models were more than the $1000 technology cost per patient, it may be in the interest of Medi-Cal and Medicare to further invest in the creation of telestroke networks. For example, Medi-Cal could pay the facility fee to all hospitals instead of just Critical Access Hospitals; and, both Medicare and Medi-Cal could pay a facility fee to both the consulting hospital in addition to the originating hospital. Additional investment could also come from an increase in the facility fee itself.

The exact amount of any increase, however, should take into account the decreasing cost of telestroke network technology and incent the creation of networks with enough scale to minimize the per patient cost of the technology and training investment. In other words, networks should be encouraged to spread the costs over a large enough number of spoke hospitals.

CONCLUSION

Telestroke has demonstrated its ability to improve outcomes for patients without access to specialty stroke care. Recently, the cost-effectiveness of telestroke has been demonstrated; however, public payers are often more concerned with overall cost, especially in tough budget times. Thus, this analysis has sought to demonstrate that telestroke can provide better care for essentially the same cost by modeling the effect of telestroke on a cohort of California patients. In fact, our model demonstrates that Medi-Cal could save $2,400 per Medi-Cal only patient and $600 per dual eligible, while Medicare would save $1,100 per patient. In addition, both programs could experience additional savings from privately insured or uninsured stroke victims that enroll in these programs after the initial stroke. These results are sensitive to our underlying assumptions about treatment effects and costs, but show that improved outcomes do not necessarily mean increased expense for public payers. Because these savings accrue to payers, rather than providers, policies that incent the adoption of this mode of care should be considered.

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