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Factors Predictive of Stroke Outcome in a Hospital-based Rehabilitation Center

By

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I. Introduction: Stroke Rehabilitation in the Postacute Period

Stroke is the third leading cause of death in the United States. An estimated 700,000 to 750,000 strokes occur each year in the United States, and as the population ages, these numbers may increase. Despite significant advances in acute stroke care, stroke leaves more than half of its survivors with disability, making it the leading cause of chronic disability among adults. Thus, it is essential that stroke patients receive the most appropriate rehabilitation services to maximize recovery and minimize disability.

In 1995, the Agency for Health Care Policy and Research defined its priorities for future stroke rehabilitation research, of which the first two are: (A) To identify the characteristics of patients who are most likely to benefit from rehabilitation; and (B) To determine the optimal program for rehabilitation for different types of patients. Our knowledge about these issues remains unsatisfactory. Since the Balanced Budget Act of 1997, rehabilitation services in the United States have been undergoing dramatic organizational and funding changes. It is more important than ever to establish which rehabilitation services are effective and which patients will benefit in each type of rehabilitation setting. This introduction reviews the evidence concerning these issues.

Stroke rehabilitation during the acute period

Stroke rehabilitation begins during the acute hospitalization as soon as the diagnosis of stroke is made and the patient is medically stabilized. Goals are to prevent complications and recurrence, manage general health functions, mobilize the patient, and facilitate the patient in resuming self-care activities as soon as possible. Involvement, education, and support of the family are also important aims during the acute care period. A number of individual randomized controlled trials and meta-analyses support the
treatment of stroke during the acute period within dedicated stroke units\textsuperscript{6}. Acute stroke units feature organization and coordination of a multidisciplinary team of providers, physicians and nurses with expertise in stroke and rehabilitation, and an ongoing program of education and training for staff\textsuperscript{6}. The Cochrane Collaboration meta-analysis of more than 3500 patients in 20 trials comparing acute stroke units with general medical wards demonstrates that patients who receive care in stroke units had a 17\% reduction in death, 25\% reduction in death or dependency, and 24\% reduction in death or institutionalization. The number needed to treat in the stroke unit compared with a general medical ward is only 18 \textsuperscript{7}. The attributes of stroke unit care responsible for enhanced outcomes are not certain, but may include more efficient and appropriate administration of thrombolytic therapies\textsuperscript{8}, improved prevention of complications due to earlier mobilization, and more coordinated attention to preventive measures\textsuperscript{4}. Despite the evidence in support of acute stroke units, many hospitals do not have them. The low volume of stroke patients admitted to a given hospital may preclude the allocation of financial and human resources to such specialized care. One study notes that the initial costs of developing an acute stroke unit may be mitigated if the stroke unit is part of an existing intensive care unit, using its equipment and staff\textsuperscript{2}.

**Settings of postacute stroke rehabilitation**

While the efficacy of stroke unit care in the acute period is well-established and accepted by the medical community, the same cannot be said of rehabilitation services in the postacute period (i.e., following discharge from acute care). In the United States, postacute rehabilitation services may be delivered in a number of settings: inpatient
rehabilitation hospitals, skilled nursing facilities, the patient's home, or outpatient facilities. The capabilities generally available in each setting are as follows:

**Hospital Inpatient Rehabilitation:** Hospital-based inpatient rehabilitation may occur in a freestanding rehabilitation hospital or a rehabilitation unit within an acute care hospital — both of which I will refer to as inpatient rehabilitation facilities (IRFs) in this discussion. On one end of the spectrum of hospital-based care, rehabilitation may be conducted in a general medical ward, a unit within a hospital that does not specialize in rehabilitation services. The unit lacks therapists and others specifically skilled in rehabilitation procedures. Typically, however, IRFs are marked by organized inpatient multidisciplinary rehabilitation services performed by a broad range of rehabilitation professionals — nurses, physical and occupational therapists, speech-language pathologists, psychologists, social workers, recreational therapists, and physicians. A physician trained in physical medicine and rehabilitation is available around the clock, and physicians are directly involved with patient care every 2-3 days. The multidisciplinary team of specialists meets at least once each week to coordinate patient care. At each meeting, the team develops a rehabilitation plan for each patient, assesses patient progress, identifies difficulties the patient has encountered, and revises rehabilitation goals accordingly. In addition to other services, Medicare requires that IRFs provide at least 3 hours of physical and/or occupational therapy per day, five days per week. Thus, IRFs provide the most intense and comprehensive rehabilitation services among the spectrum of rehabilitation settings. Of note, in some cases hospital-based care is provided in a stroke-dedicated IRF.
**Skilled Nursing Facility (SNF) Rehabilitation:** Unlike for IRFs, Medicare does not require SNFs to provide any specific amount of rehabilitation services each day. Thus, substantial variation exists among SNFs in the intensity and types of rehabilitation services offered. For the purpose of this discussion, I will group SNFs into two categories based on the level of care afforded: traditional SNFs and subacute SNFs. Traditional SNFs provide supportive or maintenance care. They offer limited rehabilitation services, providing physical therapy (PT) and occupational therapy (OT) for less than 1 hour per day, 5 days per week. The nursing staff and the physicians may or may not have special training in rehabilitation. On the other hand, subacute SNFs offer comprehensive rehabilitation services by a multidisciplinary team of rehabilitation professionals, including a physician trained in rehabilitation medicine. The subacute SNF offers a similar breadth of services as an IRF, but of a lesser intensity—between 1 and 3 hours of therapy per day. As Kane put it, the subacute SNF “represents a movement from two directions. In one respect, it is an enriched nursing home. In another, it is a reduced rehabilitative facility.” For all SNFs, Medicare requires a physician to visit the facility only once every 30 days.

**Home Rehabilitation:** Home health agencies (HHA) provide care for stroke patients who are medically stable and require only intermittent access to PT, OT, and nursing services. As with SNFs, there is a lot of variability among HHAs, and some can provide an intense program with a broad range of services including speech therapy, medical social services, personal care services, rehabilitation nursing, mental health nursing, and even an “on-call” physician. Medicare requires that a physician work with a multidisciplinary team to develop a rehabilitation plan and monitor medical stability.
Home rehabilitation allows the patient to learn skills in the environment in which they are to be used, and the familiar surroundings may instill confidence in the patient and facilitate functional improvement. On the other hand, home care programs lack peer support from other stroke survivors, may increase the burden on caregivers, limit access of physicians to the patient, and restrict the use of hospital equipment.

**Outpatient Rehabilitation:** Outpatient facilities may be freestanding or located within hospitals. As with the other rehabilitation programs, they can provide a comprehensive array of services. Depending on need, patients may make up to four appointments per week. A more intense variant of outpatient rehabilitation is the day hospital program, in which the patient may spend several hours in the facility multiple days per week. Unlike home programs, outpatient rehabilitation allows patients access to a network of peer support and rehabilitation equipment. However, the necessity for transportation to and from the outpatient facilities is no trivial matter.

Wide variation pervades rehabilitation practice patterns throughout the country. There exists no standard of care for postacute stroke patients. Thus, from one part of the country to another, rehabilitation programs differ in treatment regimens, and inpatient facilities differ in thresholds for admission. Which rehabilitation programs are most effective, which aspects of those programs confer the added benefit, and which patients are the most likely to benefit are all currently debated.

**Inpatient rehabilitation facility vs. skilled nursing facility**

One important and controversial question is whether the more intensive rehabilitation provided in IRFs is more effective than that delivered in SNFs. The driving concern behind this question is the fact that IRF care is far more expensive than SNF
care. In 1991, the average Medicare-covered SNF reimbursement was $2880, with an average length of stay of 27.8 days, whereas Medicare reimbursement for a stay in IRFs was more than three times as much, $9768, with an average length of stay of 21.3 days. A stroke-specific study in 1995 compared IRFs with subacute SNFs and found that IRF care cost $1,021 per day, with an average length of stay of 28.6 days, whereas subacute SNF care cost $562 per day, with an average length of stay of 24.2 days. So does the greater intensity and cost of IRF services translate to better outcomes for stroke patients? In a 1962 randomized controlled trial comparing IRF care with traditional SNF care, Feldman et al showed that stroke patients treated in an IRF were 10% less likely to be dead or dependent at follow-up, although the results did not achieve statistical significance. The IRF patients were also less physically impaired at follow-up (12% of the IRF group had little or no impairment vs. 27.5% of the SNF group) and were more functional for a given level of physical impairment. This last finding suggests that IRF patients may be better trained in compensating for their disabilities. In a more recent prospective cohort study, Keith et al found that stroke patients treated in IRFs made significantly better improvement in function than patients treated in subacute SNFs, with a slightly better rate (4%) of discharge to the community. In another prospective cohort study, Kramer et al also found that stroke patients treated in IRFs achieved significantly better outcomes than patients treated in either subacute SNFs or traditional SNFs. Elderly stroke patients treated in IRFs were more likely to return to the community and recover activities of daily living. In three more cohort studies, Kane et al also showed that stroke patients who rehabilitate in IRFs achieve significantly better functional outcomes compared to their SNF counterparts.
Does intensity matter?

The most readily apparent attribute of IRF care that may explain its superior outcomes relative to SNF care is its greater intensity. Another finding by Kramer et al suggests a dose-response relationship between intensity of rehabilitation and outcome. The authors compared subacute SNF care for stroke with traditional SNF care and found that subacute SNF patients were more likely than their traditional SNF counterparts to return to the community, despite similar functional outcomes. Thus, IRFs appear to exceed subacute SNFs in both intensity and outcome, and subacute SNFs exceed traditional SNFs. However, there is some conflicting data. Kane et al showed “no substantial benefit” of subacute SNF care over traditional SNF care. Other evidence also suggests that more intense rehabilitation results in more rapid improvement and better long-term outcomes than less intense programs. Two randomized controlled trials of outpatient services demonstrated positive relationships between the intensity of rehabilitation and functional outcomes in patients with mild or moderate levels of impairment. Also, two studies of inpatient care found that more intense rehabilitation on specialized units resulted in better functional outcomes than care on general medical units. An overview of the stroke rehabilitation literature concluded that the intensity of rehabilitation services is weakly associated with improvement in functional outcome.

It is worth noting that of these studies, only Smith et al effectively controlled for other differences in treatment when analyzing the influence of intensity on outcome. Furthermore, these studies do not define the optimal amounts of therapy that should be provided. One might imagine a threshold of intensity would exist beyond which the
various types of therapy no longer improve functional outcome – to borrow an economics term, a law of diminishing returns. In fact, Beatty et al showed that the benefit of PT and recreational therapy on the functional outcome of stroke patients plateaus after 19 hours and 8 hours of treatment, respectively. In September 1982, Medicare instituted a requirement that IRFs provide OT and PT services for at least 3 hours per day, 5 days per week. Because state law and accreditation regulations required that hospitals not discriminate on the basis of payment source, the 3-hour requirement affected all patients. The law resulted in increasing the intensity of these OT and PT services an average of 0.55 hours per day, and as the concept of the threshold suggests, this increase may not have added any benefit. Indeed, Johnston et al demonstrated that the Medicare-mandated increase in intensity did not evoke any improvement in functional outcome. Their data included rehabilitation of various conditions, but it is especially germane to stroke patients, who tend to be elderly and severely impaired and thus may not benefit from 3 hours of rehabilitation per day. This finding is important for many reasons. First, the chief concern regarding IRF care is its high cost. Kramer et al note that the significantly greater cost of IRF care versus SNF care is due, in part, to the differences in the “volume of therapy services.” Part of this difference in volume and, thus, cost may be due to the 3 hour requirement that IRFs must meet, rather than a true need for that much therapy. Second, the regulation makes IRFs less efficient. As Johnston et al explain, the law “places a straitjacket on the physician, who cannot prescribe two hours of therapy for the patient who only needs two hours, and who may not be able to prescribe four hours for the patient who needs more intense treatment because therapists, who are in short supply, are busy trying to meet the three-hour quota for every patient.” Finally, the regulation
may serve to exclude severely disabled patients from IRF care (who are “ineligible” because they cannot tolerate a full 3 hours of therapy each day) when in fact they may greatly benefit from it. More research is needed to establish optimum standards of care and evidence-based practices.

**Characteristics of effective rehabilitation programs**

While the intensity of a rehabilitation program appears to play a role in its potential for success, recent research has identified other, perhaps more important factors that confer successful outcomes. A meta-analysis of randomized controlled trials compared organized inpatient multidisciplinary care with an alternative model of care. More specifically, the authors compared IRFs – both stroke-dedicated IRFs and general IRFs -- with general medical wards, SNFs, and some outpatient and home services. Stroke patients who received organized inpatient multidisciplinary rehabilitation had significantly reduced odds of death, institutionalization, and dependency. Interestingly, with the exception of two trials in the analysis, the authors did not find any significant differences in the staffing levels or intensity between the experimental and control rehabilitation programs. Thus, factors other than intensity must have been responsible for the better outcomes. While the organized multidisciplinary rehabilitation programs in the study varied in a number of ways, they did appear to share certain features: 1) a multidisciplinary team of medical, nursing, and therapy staff with an expertise in stroke or rehabilitation; 2) coordination of care through weekly multidisciplinary meetings, with involvement of the patient and family in the process; and 3) a program of ongoing staff training. These characteristics have been shown to be beneficial in acute stroke care.
but this study demonstrates that organized inpatient multidisciplinary rehabilitation is clinically important in the postacute period, as well.

**Stroke-dedicated rehabilitation units vs. general rehabilitation units**

The authors also performed a subanalysis comparing stroke-dedicated IRFs with general IRFs. They concluded that there was insufficient data to establish whether stroke-dedicated IRF care performed significantly better than general IRF care, “but the trends are in favor of the stroke unit rehabilitation model of care”\(^9\). They cite that one of the studies included in their review has since published a 5-year follow-up that confirms sustained benefits in the stroke-dedicated IRF group. It is important to lay this recent meta-analysis against a backdrop of older literature that shows less impressive outcomes of stroke IRFs relative to general IRFs and general medical wards. In 1994, Alexander described the research available on the issue as being “equivocal” and “uncertain”\(^26\). Among other reviews, he cites a 1993 meta-analysis that “concludes with little conviction that specialized stroke rehabilitation units may have some impact on functional outcome”\(^27\). However, Kalra et al suggests some reasons why the literature had failed to definitively establish the benefit of stroke IRFs. For one, the authors believe that these specialized units have been improving with time, explaining why older studies may show a lack of benefit. The authors cite as evidence their own studies in which a stroke IRF improved its performance relative to general medical wards between 1991 and 1994. Therefore, they propose that stroke IRFs are “dynamic environments” that may grow more effective with experience\(^28\). Kalra offers another explanation for the conflicting results of previous studies. The author suggests that studies weighted with large proportions of patients at either end of the disability spectrum -- either severely disabled

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or minimally disabled – would underestimate the real differences in outcome between stroke IRFs and less specialized facilities.\textsuperscript{29}

**Home rehabilitation vs. inpatient settings**

In 1991, more than a third of Medicare stroke patients received some postacute rehabilitation services at home.\textsuperscript{30} A number of studies have demonstrated the effectiveness of home programs. In a randomized controlled trial comparing stroke patients receiving conventional inpatient hospital care with those receiving early discharge to a specialist home care program, Rudd et al found that home care was as clinically effective as hospital care.\textsuperscript{31} Studies by Wade et al, Neu et al,\textsuperscript{32,33} Widen Holmqvist et al,\textsuperscript{34} and Mayo et al\textsuperscript{35} also support the effectiveness of home health programs. However, these studies did not clearly define which stroke patients are most likely to benefit from home rehabilitation. In an editorial, Zorowitz and Stineman point out that the stroke patients in the Mayo et al study had very mild disabilities. They suggest that “a coordinated home care program might be more appropriate than more intensive settings for stroke survivors with mild disabilities whose goals focus more on community reintegration and instrumental rather than basic activities of daily living.”\textsuperscript{36} They also note that home care assumes that the stroke survivor either is physically self-sufficient or has enough family support. Anderson et al also recommended that home care should be limited to stroke patients with mild disability. In addition, their trial provided evidence that the stress home care places on caregivers within the home may be detrimental to their mental health.\textsuperscript{37,38}
Medicare’s influence on the landscape of postacute stroke care

With the introduction of Medicare, the proportion of spending for hospital inpatient services for the elderly declined from 70% in 1967 to 49% in 1998. On the other hand, the proportion spent on home health and SNF services increased markedly. In an effort to curb rising health care costs, in 1983 Medicare placed acute hospital care under a Diagnostic Related Group (DRG) Prospective Payment System (PPS), in which Medicare would reimburse hospitals on a per-episode basis, with the diagnosis driving the level of compensation. Previously, hospitals received payment on a fee-for-service (FFS) system, in which Medicare would reimburse all costs that were deemed “reasonable” including therapy services and the direct and indirect costs necessary to provide those services. Postacute care providers, such as IRFs, SNFs, and HHAs, were not included under the new PPS and continued to receive reimbursement under the FFS system.

The PPS provided financial incentive for a “quicker and sicker” discharge of stroke patients from the acute care hospital into postacute settings of care. The percentage of Medicare Part A expenditures going to postacute care – provided by IRFs, SNFs, HHAs, and outpatient facilities – jumped from 7% in 1986 to 25% in 1994. The number of Medicare-certified PPS-exempt IRFs more than doubled from 1984 to 1993. In many ways, the PPS spawned a new industry of postacute care. For example, the “quicker and sicker” discharges from acute care hospitals under the DRG PPS increased the volume and acuity of the case mix of SNFs. Many SNFs responded to the demand for more sophisticated and intense rehabilitation services than what they traditionally provided, creating medical institutions now known as “subacute” SNFs. Similarly,
home care providers grew rapidly, and many began to offer intense, comprehensive rehabilitation services including 24-hour coverage by physicians. Between 1988 and 1996, Medicare spending on HHA care increased an astounding 31% per year. Thus, the DRG PPS of 1983 actually served to expand Medicare spending on rehabilitation services.

The success of the PPS in decreasing the growth rate of Medicare spending on acute hospital care has motivated the federal government to apply the same tactic to postacute settings of care. In 1997, Congress passed the Balanced Budget Act (BBA). The BBA has reduced Medicare payments to virtually all providers of health care, and it has had a profound effect on rehabilitation providers. Among other changes, the 1997 BBA places the once PPS-exempt IRFs, SNFs, and HHAs under a new PPS. Beginning in July 1998, a stroke patient receiving care in a SNF was categorized in a rehabilitation group defined by the new PPS. The group and its associated Medicare reimbursement rate depend on the patient’s functional status and the amount of therapy service required (often called a Function Related Group, or FRG) at the time of initial assessment. The rehabilitation payment unit is a per diem that may be adjusted with changes in the patient’s therapy needs and functional status. Notably, subacute SNFs are not recognized by the Medicare program as distinct from traditional SNFs and are subject to the same per diem limits. The change in reimbursement from a FFS system to a PPS may cost these subacute SNFs hundreds of dollars per patient per day. As a result of these changes, Rao observes that “the subacute industry has evaporated virtually overnight, resulting in an urgent and daunting challenge to many rehabilitation providers and limited choices for many persons with stroke.” The author notes that under the
new PPS many subacute SNFs cannot afford to treat stroke patients, who often have considerable medical and rehabilitative needs.

The BBA resulted in a similar fate for home care programs. Before the BBA, HHAs received Medicare reimbursement for the actual costs of their services up to an annual limit. Thus, HHAs could maximize Medicare net income simply by increasing the patient visits while keeping their costs below this limit. To combat the continuous rise of Medicare spending on home care, the 1997 BBA dictated that the Health Care Financing Administration (HCFA) develop a home health PPS. While that process was underway, HCFA established an interim payment system (IPS) to ease the transition from FFS to the new home care PPS. In October 1997, HCFA implemented the IPS, which decreased per visit limitations and added a per-patient limit. The BBA also tightened eligibility requirements for Medicare reimbursement, reducing payments for aide visits and other personal care services (as opposed to skilled nursing and therapy services). As a result of the IPS, the proportion of patients using home care services fell by more than one-fifth, reducing total home care spending per quarter from $4.0 billion in 1997 to $1.8 billion in 1999. Use of home care by stroke patients declined even more than average due to their higher incidence of chronic disabilities and consequent higher use of long-term personal care services.

In October 2000, HCFA phased in the new home care PPS, which provides a different set of financial incentives than the IPS. The home health care PPS “will no longer restrict visit payments or yearly costs per beneficiary and thus could result both in a lengthening of episodes (that is, beyond the first sixty days) and a reduction in the number of visits provided within each sixty-day payment period...The PPS provides a
case-mix adjusted capitated payment for a sixty-day episode of care. An unlimited number of episodes authorized by a supervising physician are permitted. Thus, agencies will no longer have incentives to avoid long-stay patients, although incentives will continue to avoid high-cost short-stay patients receiving care for fewer than sixty days” 43. Whether these changes will adversely affect the quality of home care remains unknown and will require future research.

HCFA began implementing the new PPS for IRFs in October 2000, slowly phasing it in over the course of three years 5. Like the new PPS for SNFs and HHAs, the new PPS for IRFs is a case-mix based reimbursement system, with the functional acuity and therapy requirements of each patient driving the level of reimbursement. So early on, it is difficult to assess the effect that the BBS has had and will have on the quality of IRF care. The length of stay (LOS) of Medicare patients in IRFs has steadily declined from 1988 to 1997 due to the general cost-conscious practices of the managed care era. While the FIM functional levels of these discharged patients have not changed over this period, the proportion of these patients using home health services doubled between 1990 and 1996. Thus, the quicker discharge from IRFs may decrease the time the patient’s family and community have to prepare for the patient’s residual disability, resulting in a more profound burden on the caregivers and a greater need for home health services 5. Whether the new BBA will further shorten stroke patients’ LOS in IRFs is yet to be determined. The one certainty is that Medicare reimbursements for IRF care have decreased. Early observations of IRF care under the new PPS reveal some cost-cutting changes. For example, IRFs have begun to reorganize administrative responsibilities in order to decrease reliance on senior clinical staff 5. Also, IRFs have reduced staff time
allotted to meetings, research projects, program development, and other endeavors not
directly focused on patient care. Now clinical staff members must meet more demanding
productivity standards that permit little time for professional development. Recall that
one of the key characteristics of effective inpatient rehabilitation is a program of ongoing
staff training. Availability of social services, recreational therapy, leisure counseling, and
other activities that do not directly contribute to improvement in patient function have
noticeably fallen. Patients have begun to use more outpatient and home services after
discharge from the IRF to complete rehabilitation objectives that were once met within
the IRF. As Melvin concludes, "The general result has been the routinizing of stroke care
with a reduction in innovation within the rehabilitation facility" 5. Again, how these
changes will affect patient outcomes is not yet known.

Cost-effectiveness

As reimbursement for postacute stroke care has dropped under the BBA, the issue
of whether the outcomes of the various rehabilitation programs are worth their costs has
come under increased scrutiny. As discussed above, a growing body of evidence shows
that stroke patients who receive postacute care in IRFs achieve significantly better
functional outcomes than their SNF counterparts. However, even under the new PPS,
reimbursement for IRF care is significantly higher than for SNF care. In turn,
reimbursement for SNF care is significantly higher than home health care. Chen et al set
out to examine the cost-effectiveness of postacute care in different settings, and their
analysis revealed four key findings 41. First, the authors noted that rehabilitation of stroke
patients by HHAs was more cost-effective than rehabilitation in IRFs and SNFs. Second,
rehabilitation at home was also more cost-effective than being sent home without formal
home health care services. Third, when comparing IRF to SNF care of stroke patients, the authors found that “the extra costs (Medicare and total costs) for each additional 1% of ADL score improvement were not substantial” 41. However, when comparing IRF care to home without formal home health care services, each additional 1% of ADL score improvement cost in excess of $11,000 for stroke patients one year post-discharge. Finally, the analysis revealed that postacute care of stroke patients in SNFs was not cost-effective relative to being home without formal care. In fact, SNF care resulted in significantly lower functional improvement despite costing more than being home without formal care. The authors did not distinguish between subacute and traditional SNFs in their analysis.

While the study strongly supported the superior cost-effectiveness of home health programs for stroke patients, it had a number of important weaknesses. First, the investigators recruited stroke patients from only three urban areas and collected their data a decade ago. The generalizability of their findings to today’s rehabilitation programs, which operate under different financial incentives since the 1997 BBA, must be called into question. Further still, the study was not a randomized controlled trial. Also, analysis did not take into consideration the long-term benefits of care. As Keith et al put it, “the functional status gains of acute rehabilitation, for example, might translate into greater long-term benefit in terms of personal competence and less health care utilization” 13. Rehabilitation, in general, has been shown to reduce the long-term financial cost of stroke 3. Finally, the authors did not define for which stroke patients home rehabilitation would prove cost-effective. Anderson et al found that home services for the mildly impaired are most likely to be cost-effective 37. Thus, the claim that home
health care would be the most cost-effective setting for stroke patients may not apply to those with moderate to severe disabilities.

Keith et al performed their own cost-effectiveness analysis comparing IRF with subacute SNF care of stroke patients \(^{13}\). For each one point of functional gain (on the Functional Independence Measure, or FIM scale), IRF care cost 1.5 times more than the subacute SNF care. However, this analysis shared many of the same limitations as the Chen et al study; the data was a decade old, and only treatment costs, not long-term savings, were included in the analysis. This last point is especially important considering both the Chen and Keith studies found that IRF patients enjoyed significantly better functional improvements, which may lead to significantly better long-term benefits. A randomized controlled study of several years duration under the new PPS will be needed to provide a definitive answer.

**Factors predictive of rehabilitation outcome**

Just as there is more than one kind of rehabilitation program for stroke patients, there is more than one kind of stroke patient. As previously discussed, wide variation exists in rehabilitation practice patterns across the country. Ideally, one would expect patient characteristics to determine the type and intensity of rehabilitation program provided. However, Lee et al analyzed 1991 data and discovered that one-half to two-thirds of the practice variation in stroke rehabilitation is not due to patient characteristics \(^{45}\). The number and severity of disabilities, the ability to endure intensive rehabilitation, comorbidities, and the availability of home support explained hardly a third of practice variation and often less than that. The authors believe that much of the variation is due to differences in physician choices, as physicians differ in their opinions on which
rehabilitation program is optimal for a given patient. This difference in opinion may be due to the dearth of literature establishing optimum levels of care based on patient characteristics.

Age and Severity

Several studies have identified age and the initial severity of deficit as the two most powerful predictors of stroke outcome, most often measured by functional improvement and ultimate discharge disposition (home or long-term care facility)\(^\text{26}\). Not surprisingly, a number of authors have heavily weighted these criteria in establishing levels of care of postacute stroke patients. Alexander proposed the following algorithm for managing stroke patients. Patients with high functional scores measured within 1-2 days of admission (AFIM >80) should be discharged from the acute care hospital to home or outpatient services. The rehabilitation setting for patients with poor function at admission (AFIM <40) depends on age. Young patients (<55 years) should receive IRF care, whereas older patients should receive traditional SNF care. Finally, patients in the middle group of functional deficit (AFIM between 40 and 80) are suitable for IRF care. The author bases this algorithm on his outcome study, which demonstrated an inverse relationship between both severity and age and functional improvement. Other authors have proposed similar stratifications\(^\text{46,47}\).

In 1995, the Agency for Health Care Policy and Research (AHCPR) published its clinical practice guideline for stroke rehabilitation\(^4\). Its recommendations for choosing a rehabilitation setting are driven mostly by the severity of the patient’s functional deficits:

*Recommendation: Patients who are medically unstable are generally not suitable for any type of rehabilitation program. Patients who are moderately stable but have complex medical problems that require continuous monitoring are usually better treated in*
inpatient rehabilitation facilities that not only have 24-hour coverage by physicians and nurses skilled in rehabilitation, but also immediately available consultation services from other medical specialties. (Research evidence=NA; expert opinion=strong consensus.)

Recommendation: Patients who meet threshold criteria and need moderate to total assistance in mobility or performing basic activities of daily living are candidates for an intense rehabilitation program, if they are able to tolerate 3 or more hours of physical activity each day, or less intense programs if they are not. (Research evidence=C; expert opinion=consensus.)

Recommendation: Patients who meet threshold criteria and require only supervision or minimal assistance in mobility or ADL are usually candidates for home or outpatient rehabilitation if the home environment and support are adequate, or for a nursing facility if they are not. (Research evidence=NA; expert opinion=consensus.)

Recommendation: Patients who have a mild functional deficit but are able to live independently and manage both basic and more complex activities of daily living may benefit from selected rehabilitation services, but do not require an interdisciplinary rehabilitation program. (Research evidence=NA; expert opinion=consensus.)

The recommendations are based almost entirely on the “expert opinion” of the panel assembled to write the guideline. The panel consisted of 19 medical and rehabilitation professionals involved in stroke rehabilitation. Note that of the four recommendations above, three were classified as “Research evidence=not available,” meaning that the recommendation was not addressed by experimental studies. Only the second recommendation above was supported by any sort of experimental evidence, and even it was given the lowest classification: “Research evidence=C,” meaning it was supported by a single, non-randomized controlled trial (not given). Given the lack of evidence-based recommendations, further research is needed to identify the optimum levels of care for patients of varying stroke severity.

As the recommendations of Alexander and the AHCPR suggest, the general belief is that IRF care should be reserved for patients with moderately severe deficits. However, a meta-analysis of stroke trials showed that organized inpatient
multidisciplinary rehabilitation in a stroke-dedicated IRF showed significantly better outcomes compared to conventional care, independent of age and stroke severity. In other words, the beneficial effect held true for patients of all ages and levels of disability. Another study demonstrated that even severely disabled patients had a better outcome when treated in a stroke IRF than in a general medical ward. The author does note, however, that while stroke IRF care is beneficial even for patients with severe deficits, it provides the greatest benefit to patients with moderate deficit. Thus, one must decide at what point the added benefit of organized inpatient multidisciplinary rehabilitation is so minimal that it no longer justifies its steep cost. Patients, providers, and insurance companies do not always see eye to eye when drawing these lines. Despite not being able to walk or communicate, much less think coherently or even cry in the hospital following a stroke, John Phillips, then 57 years old, describes his struggle to qualify for the IRF care his family and doctors so earnestly wanted for him:

My insurance policy provided “unlimited benefits for all covered expenses” in a rehabilitation hospital, but there was a cap of 120 days each calendar year for rehabilitation through a skilled nursing facility. Representatives of my insurance carrier at first told my family and hospital care providers (e.g., social workers) to limit our research to local skilled nursing facilities with a less aggressive (and less costly) rehabilitation program. But my family and doctors relentlessly documented why aggressive rehabilitation was appropriate for me...The next thing I knew, every time I would settle into what I felt was badly needed sleep, it seemed that another member (or two) of the family committee was there to awaken me, struggle to get my limp body out of bed and into a wheelchair, and run me around the hospital while talking up a blue streak to keep me awake. Well, it worked! We demonstrated to the visiting NRH committee that I could stay awake for at least three one-hour periods, and one day later, I was on my way [to the National Rehabilitation Hospital in Washington].

As is suggested by the fact that he was able to articulate his own ordeal, Phillips went on to become a walking, talking rehabilitation success story. At first glance, Phillips would fit in the low functioning category and be placed in a SNF under Alexander’s algorithm. Yet he is confidant that the intensive multidisciplinary rehabilitation he received at the
IRF is responsible for his remarkable turnaround. This vignette is not only an example of the conflict between patient and payer\textsuperscript{40}, but also an example of the difficulty in defining who should rehabilitate in which setting, an issue deserving of further investigation.

\textit{Other factors}

While age and severity of deficit are accepted to be the most reliable factors, they only serve as crude predictors of outcome and are most helpful at the extremes of the disability spectrum\textsuperscript{47}. Investigators have studied other variables to help refine their ability to predict stroke outcomes. Ween et al found that large-vessel strokes had significantly worse outcomes than small-vessel strokes and hemorrhages, and bilateral and right-sided lesions did significantly worse than left-sided lesions\textsuperscript{47}. They hypothesize that the poorer outcomes of right hemisphere lesions may be due to cognitive impairments specific to damage on that side, such as visuospatial deficits and agnosias. Thus, lesion type and location correlate with outcome. Multiple imaging studies using CT and MRI technologies have found both lesion size and location to be predictors of motor and functional outcome. Chen et al found that brain lesion profiles, which combine size and location, are more powerful predictors than either by itself\textsuperscript{50}.

Dysphagia and bowel and bladder incontinence strongly correlated with poor outcomes\textsuperscript{47,51}. The Framingham and Rochester studies found the presence of symptomatic comorbidities to correlate with poor outcome\textsuperscript{52,53}. Ween et al found a similar association, but discovered no single comorbidity to have an isolated effect on outcome, including prior strokes\textsuperscript{47}. Three studies found the absence of a committed caregiver to decrease the likelihood of home discharges, especially for men\textsuperscript{47,52,54}. Yet another found that living alone before stroke was associated with better functional recovery\textsuperscript{55}. 
The authors of the latter study hypothesized that patients used to living alone would display more independent behavior, driving them to higher rehabilitation achievements.

One of the difficulties in assessing the predictive potential of various factors is the wide variation of rehabilitation settings and interventions. These observational studies do not leave a clear picture of which factors are most predictive in a given setting. Nor do they delineate the benefits of rehabilitation from spontaneous recovery. Controlled clinical trials are needed to establish which patients are most likely to benefit from each type of rehabilitation program ⁴.

Summary

The chief goals of stroke rehabilitation are to restore function to previous levels, to maximize quality of life within the context of the patient’s disability, and, whenever possible, to reintegrate the patient into the community ³. The stroke patient, in partnership with his or her family and physician, must choose the rehabilitation setting that provides the greatest potential for reaching these goals. A growing body of evidence indicates that well-organized inpatient multidisciplinary rehabilitation in the postacute period improves outcomes for stroke patients relative to alternative forms of care. Less understood is which stroke patients are most likely to benefit and whether these improved outcomes justify the higher cost of treatment in this setting.

The literature repeatedly and unanimously emphasizes the predictive power of age and stroke severity on outcome. Across the board, worse functional outcome is seen in older patients with more severe levels of initial disability. While age and severity of deficit are accepted to be the most reliable factors, they only serve as crude predictors of outcome and are most helpful at the extremes of the disability spectrum⁴⁷. The power of
other variables to refine our ability to predict stroke rehabilitation outcome is more controversial. This study analyzes the power of routine clinical variables in predicting the outcome of stroke patients at a hospital-based rehabilitation center. Ultimately, such data can be used to develop a clinically principled prognostic model that may increase the efficiency of our rehabilitation system.

II. SUBJECTS AND METHODS

The rehabilitation center under study was Herrick Hospital in Berkeley, California. Data were culled retrospectively from the electronic patient database at Herrick. The hospital collects data on each patient’s primary diagnosis, comorbidities, functional status at admission, discharge, and 3 months following discharge, sex, ethnicity, living situation before hospitalization and at discharge, time since onset of disability, marital status, and previous life role. Additional data on each patient include date of birth, admission, discharge, and any transfers from rehabilitation to another hospital service.

Functional status is assessed using the Functional Independence Measure (FIM), a tool which attempts to objectively measure the severity of disability and the amount of assistance required to perform everyday activities. Developed by the University of New York at Buffalo as part of the Uniform Data System for Medical Rehabilitation (UDSMR) standardized assessment program, the FIM is used by over 400 rehabilitation facilities across the country. The FIM consists of 18 items, each scored on a scale of 1 to 7, with 7 indicating complete independence and 1 total dependence. Conceptually, the 18 items can be divided into 3 subscales: Activities of Daily Living (ADL), Mobility, and

24
Cognition. The ADL subscale contains 8 items (eating, grooming, bathing, dressing the upper body, dressing the lower body, toileting, bladder management, and bowel management), ranges in score from 8 to 56, and measures functions that depend primarily on the use of the upper extremities. The Mobility subscale contains 5 items (bed/chair/wheelchair transfer, toilet transfer, tub or shower transfer, walking or wheelchair, and stairs), ranges in score from 5 to 35, and measures functions that depend primarily on the use of the lower extremities. The Cognition subscale also contains 5 items (comprehension, expression, social interaction, problem solving, and memory) and ranges in score from 5 to 35. The total FIM score is the sum of these subscale scores and can range from 18 to 126. Patient performance on the FIM is assessed by rehabilitation nurses and therapists, each of whom must pass a written examination certifying his or her aptitude in coding it.

All patients admitted to Herrick Hospital from November 1995 through June 2001 with primary diagnosis of ischemic stroke, intraparenchymal hemorrhage, or subarachnoid hemorrhage were reviewed (n=1619). Five hundred ninety-nine cases were excluded because a complete set of FIM scores (at admission, discharge, and 3 months following discharge) was not available. A post hoc review of this group found no systematic differences from the study group. There were 1020 admissions included in the outcome analysis.

Outcome was analyzed in terms of disposition and functional improvement. Disposition was categorized into either home discharge or discharge to an institutional care setting. Institutional care settings included skilled nursing facilities, board & care facilities, acute care hospitals, and other rehabilitation facilities. Functional improvement
was defined as the change in total FIM score between admission to Herrick and 3 months following discharge. When useful in post hoc testing, FIM change at discharge was also calculated.

A large number of independent variables were analyzed for their ability to predict the above outcomes. Demographic variables under analysis included:

1) Age at admission (<55, 55-64, 64-74, 75-85, >85).
2) Sex.
3) Ethnicity (White, Black, Hispanic, Asian, Other).
4) Previous social role (employed, homemaker, or not working/retired).
5) Marital status (married, not married).
6) English skill (yes, no, partial).
7) Insurance status was designated MediCal, Medicare, Medi-Medi (dual coverage under both Medicare and MediCal), and Private. No patients admitted to Herrick were uninsured.
8) Medical variables under analysis included:
9) Lesion type was classified as ischemic stroke, intraparenchymal hemorrhage (IPH), or subarachnoid hemorrhage (SAH).
10) Lesion location for ischemic strokes were classified as right cerebrum, left cerebrum, bilateral cerebrum, cerebellum, or brainstem. Lesion location for IPH was classified as cerebrum, cerebellum, basal ganglia/thalamus/internal capsule, or brainstem. Due to the diffuse nature of SAH, lesion location was not distinguished for this lesion type.
11) Stroke severity was defined by the severity of functional disability at admission to Herrick as measured by the FIM (Admission-FIM, or A-FIM). A low score indicates a more severe disability. Total A-FIM scores were grouped as follows: <40, 40-60, 61-80, >80. Severity was also assessed in terms of each of the FIM subscales: ADL (8-18, 19-27, 26-36, 37-56), Mobility (5-8, 9-12, 13-16, 17-35), and Cognition (5-13, 14-21, 22-28, 29-35).

12) Comorbidities suspected of influencing outcome included prior stroke, cardiovascular disease, hypertension, diabetes, and major neurodegenerative diseases. Cardiovascular disease included ischemic heart disease (International Classification of Diseases, 9th Revision, Clinical Modification codes ranging from 410-414), hypertensive heart disease (ICD-9 code 402), congestive heart failure (ICD-9 code 428), and cardiac dysrhythmias (ICD-9 code 427). Major neurodegenerative diseases included Alzheimer’s and Parkinson’s.

13) Rehabilitative variables under analysis included:

14) Interval from stroke onset to rehabilitation admission, grouped as follows: ≤ 8 days, 9-12 days, 13-20 days, and ≥ 21 days.

15) Length of rehabilitation stay, grouped in a similar fashion: ≤ 9 days, 10-20 days, ≥ 21 days.

Data analysis was performed using the statistics package SPSS Version 10.0. The relationship between each independent variable and disposition (home vs. institutional care, a dichotomous outcome) was evaluated using a univariate logistic regression, producing an unadjusted odds ratio for home discharge for each variable. To determine the effect of each predictor variable on disposition independent of the other variables,
(adjusted odds ratios), I performed a multivariate logistic regression in which most of the
dependent variables were included in the model. Some variables were
excluded from the multivariate model due to effects of collinearity. For example,
subscales measures of stroke severity (ADL, Mobility, and Cognition) were not included
because they are inherently correlated to the aggregate measure of stroke severity (total
A-FIM score), which was included in the model. Similarly, the presence of individual
comorbidities (prior stroke, diabetes, etc.) and the number of comorbidities were not
considered as independent variables in the same multivariate model. The model was first run
with the presence of individual comorbidities, then again with the number of
comorbidities. Location of ischemic strokes was also not included in the multivariate
model because these data would apply only to ischemic stroke admissions, and likewise
for location of intraparenchymal hemorrhages.

A separate analysis was performed using functional improvement as the outcome
measure. First, mean improvement in FIM score was calculated for each subject group.

To determine the effect of each predictor variable on functional improvement
independent of other variables, a multivariate linear regression was run. The same set of
independent variables that were included in the logistic regression model was included in
this linear regression model.
III. RESULTS

Table 1 gives a summary description of my study population.

<table>
<thead>
<tr>
<th>Table 1. Population description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic characteristics</td>
</tr>
<tr>
<td>Mean age</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Ethnicity</td>
</tr>
<tr>
<td>Previous social role</td>
</tr>
<tr>
<td>Marital status</td>
</tr>
<tr>
<td>English skill</td>
</tr>
<tr>
<td>Insurance</td>
</tr>
<tr>
<td>Medical characteristics</td>
</tr>
<tr>
<td>Lesion type</td>
</tr>
<tr>
<td>Left 52%, Right 42%, Bilateral 1%, Brainstem 3%, Cerebellum 1%</td>
</tr>
<tr>
<td>Hemorrhagic lesion location</td>
</tr>
<tr>
<td>Stroke severity</td>
</tr>
<tr>
<td>Mild-to-moderate (total A-FIM 61-80) 36%</td>
</tr>
<tr>
<td>Moderate-to-severe (total A-FIM 40-60) 37%</td>
</tr>
<tr>
<td>Severe (total A-FIM &lt;40) 18%</td>
</tr>
<tr>
<td>Comorbidities</td>
</tr>
<tr>
<td>Number: any of the above 91%, exactly 4 of the above 2%, exactly 3 of the above 16%, exactly 2 of the above 35%, exactly 1 of the above 37%, none of the above 9%</td>
</tr>
<tr>
<td>Rehabilitative characteristics</td>
</tr>
<tr>
<td>Length of stay</td>
</tr>
</tbody>
</table>

The Big Players: Age & Severity

The unadjusted and adjusted odds of home discharge for different age and stroke severity classes are shown in Table 2.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total</th>
<th>Discharged home (%)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age at admission, years</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;55</td>
<td>106</td>
<td>92 (86.8)</td>
<td>4.5 (2.3-8.9)</td>
<td>10.7 (2.6-44.2)</td>
</tr>
<tr>
<td>55-64</td>
<td>135</td>
<td>116 (85.9)</td>
<td>4.2 (2.3-7.7)</td>
<td>6.5 (1.8-22.9)</td>
</tr>
<tr>
<td>65-74</td>
<td>273</td>
<td>196 (71.8)</td>
<td>1.7 (1.1-2.8)</td>
<td>1.9 (0.9-3.9)</td>
</tr>
<tr>
<td>75-85</td>
<td>393</td>
<td>252 (64.1)</td>
<td>1.2 (0.8-1.9)</td>
<td>1.4 (0.7-2.6)</td>
</tr>
<tr>
<td>&gt;85</td>
<td>113</td>
<td>67 (59.3)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Total FIM score at admission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;80 (mild)</td>
<td>97</td>
<td>91 (93.8)</td>
<td>20.8 (8.7-49.9)</td>
<td>25.2 (7.8-80.7)</td>
</tr>
<tr>
<td>61-80 (mild-to-moderate)</td>
<td>363</td>
<td>304 (83.7)</td>
<td>7.1 (4.7-10.6)</td>
<td>7.4 (4.9-14.1)</td>
</tr>
<tr>
<td>40-60 (moderate-to-severe)</td>
<td>375</td>
<td>250 (66.7)</td>
<td>2.7 (1.9-3.9)</td>
<td>2.6 (1.5-4.5)</td>
</tr>
<tr>
<td>&lt;40 (severe)</td>
<td>185</td>
<td>78 (42.2)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>ADL FIM score at admission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37-56 (mild)</td>
<td>133</td>
<td>122 (91.7)</td>
<td>12.5 (6.4-24.2)</td>
<td></td>
</tr>
<tr>
<td>26-36 (mild-to-moderate)</td>
<td>354</td>
<td>284 (85.0)</td>
<td>6.4 (4.3-9.4)</td>
<td></td>
</tr>
<tr>
<td>19-27 (moderate-to-severe)</td>
<td>298</td>
<td>197 (66.1)</td>
<td>2.2 (1.6-3.1)</td>
<td></td>
</tr>
<tr>
<td>8-18 (severe)</td>
<td>255</td>
<td>120 (47.1)</td>
<td>Reference 1.0</td>
<td></td>
</tr>
<tr>
<td><strong>Mobility FIM score at admission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-35 (mild)</td>
<td>272</td>
<td>240 (91.7)</td>
<td>12.5 (6.4-24.2)</td>
<td></td>
</tr>
<tr>
<td>13-16 (mild-to-moderate)</td>
<td>240</td>
<td>188 (78.3)</td>
<td>4.0 (2.7-6.0)</td>
<td></td>
</tr>
<tr>
<td>9-12 (moderate-to-severe)</td>
<td>270</td>
<td>182 (67.4)</td>
<td>2.3 (1.6-3.3)</td>
<td></td>
</tr>
<tr>
<td>5-8 (severe)</td>
<td>238</td>
<td>113 (47.5)</td>
<td>Reference 1.0</td>
<td></td>
</tr>
<tr>
<td><strong>Cognitive FIM score at admission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-35 (mild)</td>
<td>41</td>
<td>36 (87.8)</td>
<td>6.9 (2.3-15.7)</td>
<td></td>
</tr>
<tr>
<td>22-28 (mild-to-moderate)</td>
<td>265</td>
<td>208 (78.5)</td>
<td>3.0 (2.0-4.5)</td>
<td></td>
</tr>
<tr>
<td>14-21 (moderate-to-severe)</td>
<td>482</td>
<td>352 (73)</td>
<td>2.2 (1.6-3.1)</td>
<td></td>
</tr>
<tr>
<td>5-13 (severe)</td>
<td>232</td>
<td>127 (54.7)</td>
<td>Reference 1.0</td>
<td></td>
</tr>
</tbody>
</table>

**Age:** The younger the patient, the greater the likelihood of returning home, with significantly higher likelihood for patients younger than 65 than those older than 85.

After multivariate adjustment, the effect size grew, such that patients younger than 55 were more than 10 times as likely to go home as the oldest group, and patients 55-64 were more than 6 times as likely to go home. When using functional improvement as the outcome measure, there existed a clear trend, such that younger patients achieved larger improvements in FIM score. Even after controlling for all measured demographic, medical, and rehabilitative variables in the multivariate linear regression model, age was a significant predictor of functional improvement. For each year older in age, patients would gain 0.7 fewer FIM points by 3 months.
Severity: As the severity of deficit at admission increased, the likelihood of home discharge decreased dramatically. After multivariate adjustment, the effect remained. Relative to severe strokes, patients with mild strokes were 25 times as likely to go home, patients with mild-to-moderate strokes were more than 7 times as likely, and patients with moderate-to-severe strokes were more than twice as likely. The same effect was seen, although to a lesser magnitude, when the severity scale was analyzed in terms of its three individual components: ADL, Mobility, and Cognition. Thus, the comprehensive FIM score was a stronger predictor of disposition than any of the subscales in isolation. When using functional improvement as the outcome measure, patients with the most severe strokes appeared to achieve larger improvements in FIM score. This trend is likely due to a ceiling effect, as the patients with the most severe initial deficits have the greatest room for improvement. In the multivariate linear regression model, severity was a significant independent predictor of functional improvement. For each point lower on the FIM scale at admission (recall: the lower the score, the more severe the disability), patients would gain 0.6 more FIM points by 3 months.

Age x Severity: The effects of age and severity on outcome appeared to interact, both when disposition and functional improvement were used as outcome measures. Figure 1 of the Appendix shows the percent of subjects discharged to home stratified by both age and severity classes. The consequences of severity are dramatically greater in older patients than in younger ones. In general, patients younger than 55 had a high likelihood of home discharge almost regardless of the severity of their stroke. But the impact of severity on disposition grew progressively stronger with increasing age; the
more severe the stroke, the lower the likelihood of going home. Despite this graphically apparent interaction, the “age x severity” interaction term was not included in the multivariate logistic regression model because I did not have the power for the interaction term to have significant effect on the model, as determined by post hoc testing. In the multivariate logistic regression, in which FIM change is the outcome, the “age x severity” interaction term did prove statistically significant in the model. That is, severity affects functional outcome differently at different age groups. At age 40, a 20-point improvement in severity (moving from one severity class to the next, more mild class) reduces functional gain at 3 months by 14 points. At age 60, a 20-point improvement in severity reduces functional gain by 7 points, and at age 80, a 20-point improvement in severity reduces functional gain by only 0.4 points. Figure 2 of the Appendix more clearly illustrates the complexity of this interaction. In the youngest age groups (<55 and 55-64), there is an apparent trend such that the more severe the stroke, the more function is gained. Again, this trend is likely due to a ceiling effect. However, in the three oldest age groups, an inverted-U relation of severity to functional improvement appears. Thus, among the elderly, having a severe stroke appears to limit the potential for functional gain, whereas among the young, a severe stroke poses no such limit. This interaction between age and severity is consistent with that seen in other studies\textsuperscript{26,55}.

Other Factors Suspected of Predicting Outcome

Table 3 shows the odds of home discharge for each of the patient characteristics before and after multivariate adjustment. Table 4 shows the results of the multivariate linear regression in which functional improvement was the outcome measure.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total</th>
<th>Discharged home (%)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>404</td>
<td>302 (74.8)</td>
<td>1.4 (1.0-1.8)</td>
<td>0.6 (0.3-1.3)</td>
</tr>
<tr>
<td>Female</td>
<td>615</td>
<td>421 (68.5)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>419</td>
<td>315 (75.2)</td>
<td>1.6 (0.2-2.1)</td>
<td>1.7 (1.0-2.8)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>32</td>
<td>27 (84.4)</td>
<td>2.8 (1.1-7.4)</td>
<td>3.4 (0.6-17.8)</td>
</tr>
<tr>
<td>Asian</td>
<td>96</td>
<td>65 (67.7)</td>
<td>1.1 (0.7-1.7)</td>
<td>1.0 (0.4-2.4)</td>
</tr>
<tr>
<td>Other</td>
<td>33</td>
<td>25 (75.8)</td>
<td>1.6 (0.7-3.7)</td>
<td>1.8 (0.5-6.3)</td>
</tr>
<tr>
<td>White</td>
<td>423</td>
<td>279 (66.0)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Previous social role</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>135</td>
<td>105 (77.8)</td>
<td>1.5 (1.0-2.3)</td>
<td>0.6 (0.3-1.3)</td>
</tr>
<tr>
<td>Homemaker</td>
<td>29</td>
<td>20 (69.0)</td>
<td>1.0 (0.4-2.2)</td>
<td>1.2 (0.4-3.7)</td>
</tr>
<tr>
<td>Not working, retired</td>
<td>806</td>
<td>559 (69.4)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>383</td>
<td>308 (80.4)</td>
<td>2.5 (1.7-3.1)</td>
<td>3.0 (1.8-5.1)</td>
</tr>
<tr>
<td>Not married</td>
<td>491</td>
<td>316 (64.4)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>English skill</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>73</td>
<td>49 (67.1)</td>
<td>0.8 (0.5-1.4)</td>
<td>0.8 (0.3-2.5)</td>
</tr>
<tr>
<td>Partial</td>
<td>13</td>
<td>9 (69.2)</td>
<td>0.9 (0.3-3.0)</td>
<td>0.5 (0.1-3.7)</td>
</tr>
<tr>
<td>Yes</td>
<td>901</td>
<td>640 (71.0)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>MediCal</td>
<td>105</td>
<td>79 (75.2)</td>
<td>0.6 (0.3-1.0)</td>
<td>0.6 (0.2-2.2)</td>
</tr>
<tr>
<td>Medicare</td>
<td>572</td>
<td>380 (66.4)</td>
<td>0.4 (0.2-0.6)</td>
<td>0.9 (0.3-2.2)</td>
</tr>
<tr>
<td>Medi-Medi</td>
<td>195</td>
<td>139 (71.3)</td>
<td>0.5 (0.3-0.8)</td>
<td>1.3 (0.5-3.6)</td>
</tr>
<tr>
<td>Private</td>
<td>148</td>
<td>125 (84.5)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Lesion type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intraparenchymal hemorrhage</td>
<td>114</td>
<td>80 (70.2)</td>
<td>0.9 (0.6-1.4)</td>
<td>0.4 (0.2-0.9)</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>21</td>
<td>11 (52.4)</td>
<td>0.4 (0.2-1.1)</td>
<td>0.1 (0.0-0.4)</td>
</tr>
<tr>
<td>Ischemic</td>
<td>885</td>
<td>632 (71.4)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td><strong>Ischemic stroke location</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brainstem</td>
<td>26</td>
<td>20 (76.9)</td>
<td>1.3 (0.5-3.4)</td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>12</td>
<td>11 (91.7)</td>
<td>4.4 (0.6-34.1)</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>11</td>
<td>11 (100)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>445</td>
<td>313 (70.3)</td>
<td>1.0 (0.7-1.3)</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>358</td>
<td>255 (71.2)</td>
<td>Reference 1.0</td>
<td></td>
</tr>
<tr>
<td><strong>Intraparenchymal hemorrhage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brainstem</td>
<td>4</td>
<td>4 (100)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>BG/thalamus/internal capsule</td>
<td>29</td>
<td>20 (69.0)</td>
<td>1.7 (0.5-5.3)</td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>58</td>
<td>43 (74.1)</td>
<td>2.2 (0.8-6.1)</td>
<td></td>
</tr>
<tr>
<td>Cerebrum</td>
<td>23</td>
<td>13 (56.5)</td>
<td>Reference 1.0</td>
<td></td>
</tr>
<tr>
<td><strong>Comorbidities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior stroke</td>
<td>293</td>
<td>200 (68.3)</td>
<td>0.8 (0.6-1.1)</td>
<td>0.6 (0.4-1.1)</td>
</tr>
<tr>
<td>No prior stroke</td>
<td>727</td>
<td>523 (71.9)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>367</td>
<td>232 (63.2)</td>
<td>0.6 (0.4-0.7)</td>
<td>0.7 (0.4-1.0)</td>
</tr>
<tr>
<td>No cardiovascular disease</td>
<td>653</td>
<td>491 (75.2)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td>Hypertension</td>
<td>693</td>
<td>496 (71.6)</td>
<td>1.1 (0.8-1.5)</td>
<td>1.3 (0.8-2.0)</td>
</tr>
<tr>
<td>No hypertension</td>
<td>327</td>
<td>227 (69.4)</td>
<td>Reference 1.0</td>
<td>Reference 1.0</td>
</tr>
<tr>
<td>Variable</td>
<td>Unstandardized Coefficients</td>
<td>p-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>β</td>
<td>Std. Error</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Severity (A:FIM)</strong></td>
<td>-1.241</td>
<td>0.229</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td><strong>Age x Severity (interaction term)</strong></td>
<td>-1.381</td>
<td>0.284</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Male (Reference: Female)</td>
<td>0.017</td>
<td>0.004</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>African American (Reference: White)</td>
<td>-1.863</td>
<td>1.875</td>
<td>0.321</td>
<td></td>
</tr>
<tr>
<td>Hispanic (Reference: White)</td>
<td>-0.144</td>
<td>4.842</td>
<td>0.976</td>
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</tr>
<tr>
<td>Asian (Reference: White)</td>
<td>0.907</td>
<td>3.483</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>Other (Reference: White)</td>
<td>0.660</td>
<td>4.594</td>
<td>0.886</td>
<td></td>
</tr>
<tr>
<td>Employed (Reference: Not employed, retired)</td>
<td>0.247</td>
<td>3.003</td>
<td>0.935</td>
<td></td>
</tr>
<tr>
<td>Homemaker (Reference: Not employed, retired)</td>
<td>6.357</td>
<td>4.168</td>
<td>0.128</td>
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</tr>
<tr>
<td>Married (Reference: Not married)</td>
<td>2.611</td>
<td>1.804</td>
<td>0.148</td>
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</tr>
<tr>
<td>No English (Reference: Yes English)</td>
<td>1.341</td>
<td>4.037</td>
<td>0.740</td>
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</tr>
<tr>
<td>Partial English (Reference: Yes English)</td>
<td>7.248</td>
<td>7.812</td>
<td>0.354</td>
<td></td>
</tr>
<tr>
<td>MediCal (Reference: Private)</td>
<td>-7.429</td>
<td>4.207</td>
<td>0.078</td>
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<tr>
<td>Medicare (Reference: Private)</td>
<td>-2.316</td>
<td>3.189</td>
<td>0.468</td>
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</tr>
<tr>
<td>Medi-Medi (Reference: Private)</td>
<td>-3.972</td>
<td>3.508</td>
<td>0.258</td>
<td></td>
</tr>
<tr>
<td>Intraparenchymal hemorrhage (Reference: Ischemic)</td>
<td>2.775</td>
<td>2.808</td>
<td>0.323</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid Hemorrhage (Reference: Ischemic)</td>
<td>3.947</td>
<td>6.349</td>
<td>0.534</td>
<td></td>
</tr>
<tr>
<td>Prior Stroke (Reference: no prior stroke)</td>
<td>-7.802</td>
<td>1.834</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular Disease (Reference: No CVD)</td>
<td>0.396</td>
<td>1.698</td>
<td>0.816</td>
<td></td>
</tr>
<tr>
<td>Hypertension (Reference: No hypertension)</td>
<td>3.238</td>
<td>1.695</td>
<td>0.057</td>
<td></td>
</tr>
<tr>
<td>Diabetes (Reference: No diabetes)</td>
<td>0.308</td>
<td>1.821</td>
<td>0.866</td>
<td></td>
</tr>
<tr>
<td>Neurodegenerative disease (Reference: No neuro.dis.)</td>
<td>8.973</td>
<td>6.318</td>
<td>0.156</td>
<td></td>
</tr>
<tr>
<td>Number of comorbidities (included in separate model)</td>
<td>-0.725</td>
<td>0.917</td>
<td>0.429</td>
<td></td>
</tr>
<tr>
<td>Onset-to-admission-interval</td>
<td>-0.211</td>
<td>0.052</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Length of rehabilitation stay</td>
<td>0.124</td>
<td>0.093</td>
<td>0.183</td>
<td></td>
</tr>
</tbody>
</table>

* indicates group for which odds ratio was not calculable (100% of patients were discharged home)
In the univariate analysis, the likelihood of home discharge was significantly higher for patients who were male, married, employed, privately insured, not comorbid with cardiovascular disease, admitted to Herrick sooner rather than later after stroke onset, and admitted for longer stays at the facility. Surprisingly, African Americans and Hispanics were more likely to go home than their white counterparts. Factors having no effect on disposition in the univariate analysis included lesion type, lesion location, English skill, and comorbid hypertension, diabetes, Parkinson’s, Alzheimer’s, or prior stroke. The number of comorbidities also had no significant effect on disposition.

How did these findings in the univariate analysis hold up after adjusting for all the demographic, medical, and rehabilitative variables measured?

**Lesion type:** In the multivariate model, lesion type proved a significant predictor of disposition, as patients with ischemic strokes were twice as likely to go home as those with IPH, and ten times as likely to go home as those who suffered SAH. In the univariate analysis, this effect was probably masked by the fact that patients with IPH and SAH are much younger than patients who suffer ischemic strokes. Twenty-seven percent of IPH and SAH patients are younger than 55, compared to only 8 percent of ischemic stroke patients, and as we have seen, younger patients are more likely to go home. After adjusting for age (among other variables) in the multivariate logistic regression, the disadvantage of IPH and SAH lesions emerged. However, lesion type was not a significant predictor of functional improvement at 3 months in the multivariate linear regression model.

**Lesion location:** The lack of a statistically significant effect of lesion location on disposition persisted in the multivariate model. However, when stratifying ischemic
stroke side by severity class, patients with left-hemispheric lesions were slightly more likely to go home than those with right-hemispheric lesions, although this discrepancy did not achieve significance in any of the severity classes (see Figure 3 in Appendix). A similar effect was seen when functional improvement was used as the outcome measure (see Figure 4 in Appendix). There was less improvement after right hemispheric strokes than after left hemispheric strokes in the most severe groups, but again significance was not reached. The potentially poorer outcomes in right-sided lesions may be due to visuospatial deficits associated with damage to the right hemisphere, such as neglect and agnosia, which could impede rehabilitation therapies.

**Comorbidities:** In the univariate analysis, only cardiovascular disease had a significant negative impact on likelihood of home discharge. However, in the multivariate model, even this association disappeared. The presence of cardiovascular disease may have simply been a proxy for older age, as only 16 percent of patients with documented cardiovascular disease were younger than 65, compared to 28 percent of patients without documented cardiovascular disease. When functional improvement was used as the outcome measure, only prior stroke had a significant impact on FIM change in the multivariate model. A history of prior stroke decreased functional improvement by 7.3 FIM points at 3 months ($p = 0.000$). None of the other comorbidities were significant predictors of functional outcome in the multivariate model. The number of comorbidities had no effect on disposition or functional improvement in the multivariate models.

**Marital Status:** Married patients were three times more likely to return home than those who were not currently married, even after adjustment. The presence of a caregiver in the home would be expected to improve the odds of a stroke patient
returning home, but not necessarily to improve functional gain. Indeed, marital status was not a significant predictor of functional improvement in the multivariate linear regression.

**Sex:** While the advantage of marriage persisted in the multivariate model, the advantage men appeared to have over women disappeared. This finding can be explained by the fact that men in the study population were far more likely to be married than women (67% vs. 28%). It is well known that women live an average of 8 to 9 years longer than men, so it is likely that many women in this elderly population outlived their husbands and have no caregiver available at home. Thus, controlling for marital status in the multivariate model made insignificant the association between sex and disposition. However, sex did prove a significant predictor of functional improvement in the multivariate linear regression, with male sex conferring a 1.9-point advantage in FIM improvement at discharge ($p = 0.039$) and 3.8-point advantage in FIM improvement at 3 months post discharge, relative to women ($p = 0.027$).

**Ethnicity:** In the multivariate model, the higher likelihood of home discharge among Hispanics relative to whites disappeared, but the advantage seen among African Americans persisted. Fifty percent of the Hispanics in this population suffered their stroke before the age of 65, compared to only 16% of white patients. Thus, Hispanics were more likely to go home in the univariate analysis because they were suffering strokes at younger ages than whites, and as we have seen, younger patients are far more likely to go home than older ones. Thus, controlling for age in the multivariate model made insignificant the association between being Hispanic and going home.
African American patients also suffered strokes at younger ages than whites (30% of African Americans in the study population were younger than 65), yet their higher likelihood of home discharge remained after adjustment. One could postulate that African Americans are more likely to go home than whites because they recover more function than whites by the time they are discharged. However, the mean discharge FIM score for African American patients (82.4 ± 21.6) was not significantly different than that of white patients (84.0 ± 21.0). Thus, despite being no better off functionally at discharge, African Americans were more likely to be sent home than whites, even after controlling for factors such as age and stroke severity. Logic follows that African American patients were discharged home at more severe levels of disability than their white counterparts. In fact, the mean discharge FIM score for African American patients who went home was modestly but significantly lower than that of white patients (88.3 ± 17.5 vs. 90.9 ± 18.2 for whites, t = 1.776, p < 0.05). Similarly, the mean discharge FIM score for African American patients sent to an institutional care setting was significantly lower than that of white patients (64.6 ± 23.1 vs. 70.4 ± 19.6 for whites, t = 2.055, p < 0.025). Also of note, being African American predicted a significantly poorer gain in function at discharge in the multivariate linear regression model. African American ethnicity predicted 2.2 points less improvement in FIM change at discharge relative to white patients, controlling for all demographic, medical, and rehabilitative variables that were assessed in this study (p = 0.019). However, this disadvantage in functional improvement for African Americans disappeared at 3 months. Curiously, at 3 months a 9.7-point disadvantage in FIM improvement appeared for Asians in the multivariate
linear regression ($p = 0.006$). Yet Asian ethnicity did not show any disadvantage in functional gain at discharge.

**Previous social role:** The advantage of being previously employed disappeared after multivariate adjustment. Once again, age was probably the confounder in the univariate analysis. Sixty-one percent of patients who were employed were younger than 65, compared to only 14 percent of patients who were not working or were retired. Thus, employed patients were more likely to go home because they were younger, not because they were employed. Consistent with these findings, previous social role was not a significant predictor of functional improvement in the multivariate linear regression model.

**Insurance:** In the univariate analysis, patients who were privately insured were more than twice as likely to go home than patients who were either insured by Medicare or dually insured under both Medicare and MediCal. However, this association lost significance in the multivariate model. Once again, the univariate association was most likely confounded by age, as patients on Medicare are generally older than patients with private insurance. In fact, only 6 percent of patients on Medicare (with or without MediCal) were under the age of 65, compared to 75 percent of patients with private insurance. Patients on MediCal (without Medicare) had virtually the same age profile as those with private insurance, and they were not significantly less likely to return home than patients with private insurance. Similarly, patients dually covered by both MediCal and Medicare (the poor elderly) were not less likely to return home than patients on Medicare alone (the non-poor elderly). Thus, insurance status did not significantly affect
disposition. Similarly, in the multivariate linear regression, insurance status was not a significant predictor of functional improvement.

**Onset to admission interval:** In the univariate analysis, patients whose intervals between stroke onset and admission to Herrick was shorter than 13 days were more than twice as likely to go home than those whose intervals were longer than 20 days. One may interpret this analysis as meaning that there exists a critical post-stroke window of neural plasticity during which rehabilitation must be initiated for maximal benefit. But in the multivariate model, the significantly higher likelihood of home discharge for shorter intervals did not persist. Post hoc review revealed that 77 percent of the patients whose interval was longer than 20 days had severe or moderate-to-severe strokes, compared to 47 percent of patients whose interval was shorter than 13 days. Thus it is possible that the greater severity of strokes in the longer interval group was the reason this group was less likely to return home, not because these patients had missed some critical window period. However, in support of the critical window hypothesis, onset to admission interval was a statistically significant predictor of functional improvement in the multivariate linear regression model, which controlled for severity. For each day that passes between onset and admission, FIM improvement at 3 months decreases by 0.2 points ($p = 0.000$).

**Length of stay:** In the univariate analysis, a direct and significant association appeared between length of rehabilitation stay and likelihood of home discharge. In general, the longer a patient stayed at Herrick, the more likely that patient went home. One may interpret this finding in different ways. The longer one stays, the more hours of therapy he/she will receive, which may result in greater functional gain and higher
likelihood of home discharge. However, patients with severe strokes who prove unable to participate meaningfully in their therapy may be discharged sooner than originally planned. In such cases, the patient is often sent to an institutional care setting, such as a skilled nursing facility, until the patient recovers enough function to benefit from the intensive services offered at Herrick. In this way, shorter lengths of stay may be artificially associated with institutional disposition and, conversely, longer lengths of stay may be associated with home discharge. But the significant effect remained even after controlling for severity in the multivariate model. This finding may lend credence to the first interpretation, that longer stays independently produce greater functional independence and therefore greater odds of home discharge. However, the multivariate model using FIM change as the outcome measure countered this notion, as length of stay was not a significant predictor of functional improvement.

IV. DISCUSSION

The results of this study reconfirm the effects that age and stroke severity have on rehabilitation outcome. Many variables that appeared to influence outcome in the univariate analysis (e.g., sex, previous social role, insurance, Hispanic ethnicity, cardiovascular disease) lost significance after adjusting for age. The effect of another variable (lesion type) was unmasked by adjusting for age. The major contribution of age to so many other variables underscores the fact that age encompasses a wide variety of difficult-to-assess clinical characteristics, such as senescent brain changes, diminished physical endurance, and many other medical and psychosocial factors whose effects are not powerful enough to stand out individually.
The majority of stroke patients are 65 years old or older (76 percent in this study). From Figure 2, we can see that in this age group, patients with mild and severe strokes gain the least function in the hospital-based rehabilitation facility. It is the middle group, the moderately severe patients that gain the most function. It is a widely held assumption that patients most appropriate for hospital-based rehabilitation in the postacute period are those with moderately severe disability, and this study supports this notion. However, these data do not justify the exclusion of more severe patients from admission to a facility such as Herrick. Medicare requires that inpatient rehabilitation facilities provide at least 3 hours of therapy per day, 5 days per week. Patients who cannot tolerate 3 hours of therapy are ineligible, and are likely sent to a SNF to rehabilitate. If the patient can recover enough function and stamina in the SNF to endure more intensive therapy, he or she may then be transferred to a hospital-based facility. Such a system works well in areas where there exists high quality SNFs that provide meaningful physical and occupational therapy. But nursing homes have been much maligned in the media for neglecting their residents and providing marginal levels of exercise, intellectual stimulation, and social opportunity.

These stereotypes may not be fair to a large number of well-run nursing homes, but the new Medicare prospective payment system under the 1997 Balanced Budget Act provides incentives for SNFs to offer fewer services, not more. Under the old reimbursement system established in 1983, SNFs thrived and many began to offer more sophisticated and intense rehabilitation services than what they traditionally provided, creating medical institutions now known as “subacute” SNFs. As a result of the new prospective payment system, Rao observes “the subacute industry has evaporated
virtually overnight. Thus, fewer areas have available SNFs that offer rigorous therapies, and many stroke patients whose severity prohibits their admission to a hospital-based facility have no choice but to receive care in a traditional nursing home that offers minimal rehabilitation services. In this way, severe stroke patients may be at risk of “falling through the cracks” of our rehabilitation system.

There exists no obvious solution to this dilemma. The new prospective payment system was put in place to uphold a Medicare system at risk of going bankrupt; reverting back to the old, financially-hemorrhaging system is not possible. Reduction of the 3-hour therapy requirement may compromise the quality of hospital-based rehabilitation. Perhaps if Medicare would recognize these more intensive “subacute SNFs” as separate entities from “traditional SNFs,” and reimburse them accordingly under the new prospective payment system, severe stroke patients would have as an option a level of care in between that of the traditional nursing home and the hospital-based facility.

Length of rehabilitation stay produced somewhat inconsistent results in the multivariate logistic and linear regression models. While length of stay was a positive predictor of home discharge, it had no significant effect on functional improvement. Thus, either length of stay is an independent predictor of disposition, or it is associated with another, unmeasured factor that does influence disposition without affecting functional status. The finding that length of stay does not affect FIM change indicates that the shorter stays allowed in this era of cost-containment may not be detrimental to functional outcomes of stroke rehabilitation. Of note in this study, the mean length of rehabilitation stay decreased from 23.8 days in 1995-96 to 18.4 days in 2000-01, yet the mean FIM improvement at follow-up did not decline over this period. In fact, one study
argued that it was not the intensity (number of hours of therapy provided) of hospital-based inpatient rehabilitation that accounted for its superior outcomes relative to SNF and home health services. Rather, other characteristics set it apart from alternative settings of care. Specifically, patients at facilities such as Herrick received organized inpatient multidisciplinary rehabilitation services, which is defined in the literature as care involving three principal features: 1) a multidisciplinary team of medical, nursing, and therapy staff with an expertise in stroke or rehabilitation; 2) coordination of care through weekly multidisciplinary meetings, with involvement of the patient and family in the process; and 3) a program of ongoing staff training.

Recent observations suggest that Medicare changes under the 1997 Balanced Budget Act may be affecting care in rehabilitation facilities in ways beyond shorter stays. For example, rehabilitation facilities have begun to reorganize administrative responsibilities in order to decrease reliance on senior clinical staff. Also, rehabilitation facilities have reduced staff time allotted to meetings, research projects, program development, and other endeavors not directly focused on patient care. Now clinical staff members must meet more demanding productivity standards that permit little time for professional development. Recall that one of the key characteristics of effective inpatient rehabilitation is a program of ongoing staff training. Availability of social services, recreational therapy, leisure counseling, and other activities that do not directly contribute to improvement in patient function have noticeably fallen. Patients have begun to use more outpatient and home services after discharge from the rehabilitation facility to complete rehabilitation objectives that were once met within the facility. As Melvin concludes, "The general result has been the routinizing of stroke care with a reduction in
innovation within the rehabilitation facility\textsuperscript{35}. How these changes will affect patient outcomes is not yet known.

Stroke onset to admission interval also produced somewhat puzzling results in the two multivariate models. Longer periods between onset and rehabilitation admission were not associated with lower odds of home discharge, yet were associated with smaller functional improvement. My analysis was not able to distinguish whether there existed a threshold onset to admission interval beyond which functional improvement would dramatically fall off. One may hypothesize that there exists a time period after neural injury associated with the greatest neuroplasticity, during which rehabilitation therapies are most effective, and beyond which they are progressively less effective. The Copenhagen Stroke Study found that stroke patients plateau for improvement (activities of daily living and neurologic outcome) by 12 weeks, regardless of initial severity, and the most rapid rate of recovery occurred between 3 and 6 weeks\textsuperscript{56}. The authors argue that this window may be a critical time to receive intensive rehabilitation services and a vulnerable time to receive therapy of poor quality. Interestingly, one study using primate models demonstrated that rehabilitation initiated too early could also be damaging. When physical rehabilitation was initiated within 24-36 hours post cerebral infarction, the animals showed an early transient loss of motor skills with more extensive structural damage around the lesion\textsuperscript{57}. The mechanism of functional decline may involve glutaminergic excitotoxicity\textsuperscript{58}.

Unlike length of stay, onset to admission interval did not fall over the period 1995-2001 in this study. If the interval between onset and admission to rehabilitation is reflective of the length of acute hospitalization prior to rehabilitation, the data suggests
that stays at the acute care hospital have not been affected by cost-cutting strategies as dramatically as rehabilitation stays (a direct measure of length of acute hospitalization was not available in this dataset).

The analysis of ethnicity produced three key findings. First, African American and Hispanic patients in this study suffered strokes at much younger ages than white patients. This finding may result from higher rates of stroke risk factors — such as hypertension and diabetes — among African Americans and Hispanics, and poorer control of those conditions. In this study, 43 percent of African Americans had diabetes and 76 percent had hypertension, compared to 17 percent and 58 percent for whites, respectively. Similarly, 41 percent of Hispanics had diabetes and 63 percent had hypertension.

Second, even after adjusting for age and stroke severity, African Americans were more likely to be discharged home than whites. Possible explanations of this finding are many. Perhaps African Americans are less able to afford nursing home care. Thus, an African American patient at the same level of disability as a white patient who was transferred to a SNF may have no option but to go home. African Americans were more likely to be on MediCal than white patients (43 percent of African Americans vs. 10% of whites), but even after adjusting for insurance status, African Americans were still more likely to be sent home. Another explanation involves the availability of community resources. Perhaps African Americans have a stronger network of family and friends available in the home, or the church may offer more supportive services in the African American community. Whatever the explanation, this finding is in line with other recent literature that suggests that African American patients are commonly not receiving the same standard of care as their white counterparts in the United States. The ethnic
discrepancy in disposition does bring into question the use of home discharge as a “good” outcome in the literature. As we have seen in this study, home discharge is not always tightly correlated with functional level.

The third significant finding was that Asian ethnicity predicted poorer functional gain than whites at 3 months post discharge, despite not predicting poorer functional gain at discharge. This would suggest that Asians do not continue to recover function after discharge from rehabilitation (whether at home or in an institutional care setting) at the same rate as whites. Perhaps Asians have a greater dependence for recovery on the intensive services available in the hospital, or perhaps their window period for greatest rate of recovery ends earlier than that for white patients. However, I have not observed this effect in the literature.

Another interesting discrepancy was uncovered between men and women. While men were no more likely to go home after controlling for marital status, male sex did confer a small but significant advantage in functional improvement at discharge and at 3 months post discharge. Perhaps the greater physical strength and endurance that men possess relative to women imparts an advantage in participating in and benefiting from physical and occupational therapies. However, similar discrepancies have not been reported in the literature.

With regard to lesion type, IPH was related to more severe initial deficits than ischemic strokes, but there was no difference in deficit at discharge or 3 months post discharge, consistent with findings in another study by Jorgensen et al.56 The same was true for SAH relative to ischemic lesions. When controlling for severity, there was no difference in functional recovery between IPH, SAH, and ischemic lesions. Thus, lesion
type does not seem to affect functional prognosis. Oddly, however, both IPH and SAH conferred lower odds of returning home relative to ischemic strokes in the multivariate model.

Prior stroke was the only comorbidity to predict poorer functional improvement, although even it had no effect on disposition. One can imagine that the effects of successive strokes may be additive. Even when the brain tissue adjacent a lesion has compensated for the initial injury, additional insults would eventually overwhelm the limited functional reserve of the brain. It seems reasonable that comorbidities of less direct neural involvement would have negligible effects on stroke recovery. Neurodegenerative diseases such as Alzheimer's and Parkinson's did not appear to have a significant effect on recovery, although the sample of subjects (n = 17) with these diseases was quite small. With the exception of prior stroke, the comorbidities under investigation — even in aggregate — did not significantly prevent good rehabilitation outcome.

This study demonstrates that factors beyond age and stroke severity may prove useful in the triage of stroke patients in the postacute period. Clinical practice guidelines for stroke rehabilitation that are driven almost purely by the severity of the patient's functional deficits — such as those put forth by the Agency for Health Care Policy and Research in 1995 — may be neglecting other, easily assessed clinical variables with significant predictive power. Data similar to the kind gathered here have been used to develop prognostic models with a respectable level of accuracy. However, one must be very cautious before advocating the use of such a model in clinical practice. Before these tools can influence the management of individual patients, they must be shown in clinical
trials to exceed the accuracy of physician’s informal predictions and to improve patient
care and outcomes\textsuperscript{63}. Even still, these predictive models may have many potential uses in
the immediate future. Like diagnostic tests, they can add to the pool of information upon
which the physician relies to decide which patients are appropriate for hospital-based
inpatient rehabilitation\textsuperscript{55}. They may also provide patients and their families with more
reliable information to help better plan for the future\textsuperscript{63}. The prognostic models can be
used by policy analysts to monitor the effect of the new Medicare prospective payment
system on the quality of rehabilitation services\textsuperscript{55}. Finally, they can be used by
researchers to correct for case mix when different groups of patients are compared\textsuperscript{63}.

It is important to recognize the limitations of this study and to recommend
directions for future research. First, this study was based on a secondary data analysis.
As such, the types of variables that could be examined were limited to the data routinely
collected by the hospital. Second, the results of this single-center study are not
generalizable to other settings of postacute stroke care. The predictive power of the
variables studied here cannot be directly applied to rehabilitation services that take place
in the home or a SNF. Few studies have compared the effectiveness and predictive
variables in different settings, so more multi-center studies are in order. A randomized
controlled trial may be ethically problematic. But there is likely enough overlap in case
mix between settings (due to practice variation and affordability of services – patients
who are eligible for hospital-based care but cannot afford it may end up in a SNF) to
match cases in a prospective multi-center cohort study.

Whether the results in this study are even applicable to other hospital-based
facilities is uncertain, as variation in rehabilitation practices exist between rehabilitation
centers across the country. Furthermore, the new Medicare prospective payment system may alter rehabilitation practices within individual centers, so the reproducibility of these results should be evaluated after the prospective payment system dust settles.

Also, the predictive power of radiological variables (e.g., size of lesion, precise location of lesion) was not assessed in this report. Further research is needed to test whether information from CT and MRI brain scans would improve the accuracy of a prognostic model. Finally, few studies have attempted to correlate common stroke outcome variables (e.g., disposition, FIM scores) with quality of life. Does home discharge equate to more fulfilling lives than residence in a nursing home? Does functional independence correlate strongly with happiness? What is the subjective experience of a stroke patient participating in rehabilitative therapies? Few of these questions have been addressed in the literature. With the availability of multiple quality of life scales, this would seem a first step toward understanding outcomes from a more patient-oriented perspective.
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APPENDIX
Figure 1. Age & Severity vs. Home Discharge
Figure 3. Ischemic Stroke Side & Severity vs. Home Discharge

% Home Discharge

A-FIM Class

<40  40-60  61-80  >80

38.5  66.6  85.6  94.1
38.4  64.1  84.2  92.3

- Left hemisphere
- Right hemisphere
Figure 4. Ischemic Stroke Side & Severity vs. Functional Improvement