# Can Readmission After Stroke Be Prevented?

## Results of a Randomized Clinical Study: A Postdischarge Follow-Up Service for Stroke Survivors

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***Background and Purpose***—About 50% of stroke survivors are discharged to their homes with lasting disability. Knowledge, however, of the importance of follow-up services that targets these patients is sparse. The purpose of the present study was to evaluate 2 models of follow-up intervention after discharge. The study hypothesis was that intervention could reduce readmission rates and institutionalization and prevent functional decline. We report the results regarding readmission.

***Methods***—This randomized study included 155 stroke patients with persistent impairment and disability who, after the completion of inpatient rehabilitation, were discharged to their homes. The patients were randomized to 1 of 2 follow-up interventions provided in addition to standard care or to standard aftercare. Fifty-four received follow-up home visits by a physician (INT1-HVP), 53 were provided instructions by a physiotherapist in their home (INT2-PI), and 48 received standard aftercare only (controls). Baseline characteristics for the 3 groups were comparable. Six months after discharge, data were obtained on readmission and institutionalization.

***Results***—The readmission rates within 6 months after discharge were significantly lower in the intervention groups than in the control group (INT1-HVP 26%, INT2-PI 34%, controls 44%; $P=0.028$). Multivariate analysis of readmission risk showed a significant favorable effect of intervention (INT1-HVP or INT2-PI) in interaction with length of hospital stay ($P=0.0332$), indicating that the effect of intervention was strongest for patients with a prolonged inpatient rehabilitation.

***Conclusions***—Readmission is common among disabled stroke survivors. Follow-up intervention after discharge seems to be a way of preventing readmission, especially for patients with long inpatient rehabilitation. **(*Stroke*. 2000;31:1038-1045.)**

**Key Words:** randomized controlled trial ■ rehabilitation ■ stroke outcome ■ stroke management

Despite modern treatment and multidisciplinary rehabilitation in stroke units, about half of stroke survivors are discharged to their homes with more-or-less severe, persistent neurological symptoms. These neurological impairments have a varying impact on the stroke patient's behavior in terms of functional limitations and disability.[1] Follow-up studies on stroke survivors describe multiple health problems such as falls, depression, deterioration of achieved function, and social inactivity and isolation,[2–4] in addition to age-related symptoms and comorbidity. Furthermore, 10% of stroke survivors have a recurrence of stroke within the first year.[5] Altogether, stroke survivors form a frail and exposed group with a high risk of new illness, aggravation of known diseases, and functional decline and a high death rate. About 25% to 30% die within the first year after their stroke, and 60% to 70% die within 5 years.[6] Other indicators of frailty and disability are rehospitalization and institutionalization; 15% of long-term stroke survivors are institutionalized.[7] Readmission rates of 20% to 27% within 1 year have been reported,[8,9] but none of these studies focused on the subgroup of disabled stroke survivors. Geriatric research documents readmission rates of 25% within 6 months among nonselected elderly patients, 36% among elderly patients with congestive heart failure,[10] and 50% within 1 year among the frail elderly.[11] Readmission of elderly disabled stroke patients, a common occurrence in clinical practice, increases the costs of health care[12] and causes emotional distress for the patient.

Several authors have emphasized the importance of a close liaison between hospital and community at the time of discharge, as well as of professional support and counseling for patients and caregivers after discharge.[13,14] New stroke rehabilitation services, such as stroke units,[15] early supported discharge,[16] and home-based outpatient physiotherapy,[17,18] have been evaluated in clinical trials. However, few studies

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***Stroke* is available at http://www.strokeaha.org**

**TABLE 1. Entry Criteria for the Patients**

| | |
|---|---|
| Inclusion criteria | |
| I.1 | Admitted with acute stroke* |
| I.2 | Discharge to own home |
| I.3 | Impaired motor capacity† |
| Exclusion criteria | |
| E.1 | Communication not possible |
| E.2 | Other disease likely to dramatically shorten life |
| E.3 | Previously included in this study |
| E.4 | Participation in other clinical studies |
| E.5 | Lack of consent to participate in study |

*Defined by the WHO criteria; patients with subarachnoid hemorrhage were not included.

†SSS score at discharge of <58 (subscore for arm, hand, leg reduced a minimum of 1 point or subscore for gait reduced a minimum of 3 points) or MRC score of ≤4+.

have evaluated follow-up interventions after completed inpatient rehabilitation that focused on social and psychological adjustment,[19–21] and none of these studies addressed the prevention of readmission. In geriatric and cardiological[22,23] research, the use of follow-up home visits by health professionals has been able to reduce the readmission rate, reduce the mortality rate, and postpone institutionalization. We conducted a randomized trial to evaluate the hypotheses that (1) functional decline, institutionalization, and readmission after stroke are common among community-dwelling stroke survivors with persistent disability, (2) readmissions are frequently caused by stroke complications, and (3) follow-up intervention can reduce readmission and institutionalization and prevent functional decline. We report the methodological aspects and results of readmission within a 6-month period after discharge.

## Subjects and Methods

### Recruitment

Patients were recruited from wards at 3 hospitals (Bispebjerg Hospital neurological ward, Kommunehospitalet geriatric and rheumatology ward, and Amager Hospital geriatric ward) within The Copenhagen Hospital Corporation from February 1, 1996, through June 15, 1998. All wards had well-coordinated and integrated multidisciplinary rehabilitation teams. Stroke patients were consecutively screened for eligibility at the end of inpatient rehabilitation.

Patients were eligible if they had a diagnosis of acute stroke, defined with World Health Organization criteria,[24] and were to be discharged to their own home with stroke-related impairment and functional limitations (for details, see Table 1).

### Baseline Assessment

Baseline data, including demographics, data on initial stroke severity, CT scans, and assessment of functional capacity at discharge, were collected during the last 2 weeks of hospitalization. Neurological impairments at discharge (measured by the Scandinavia Stroke Scale [SSS],[25] the British Medical Research Council Muscle Strength Assessment [MRC],[26] and visual field) were assessed by the project physician. Mobility was tested by the project physiotherapists using a newly developed measurement instrument: the Functional Quality of Movement Scale (FQM). FQM measures, quantitatively as well as qualitatively, aspects of movement that include unwanted motor reactions, control of movement, and degree of involvement of the affected parts of the body. Assessments of cognitive functions

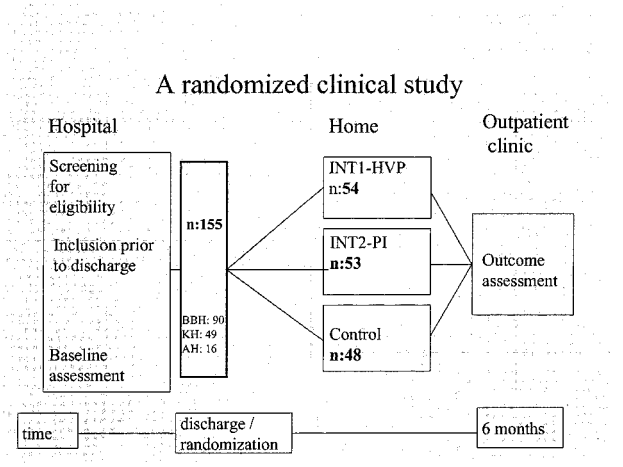


**Figure 1.** Method: a randomized clinical study.

were carried out by research neuropsychologists who tested 9 cognitive domains (anosognosia, general cognitive function, memory, language function, visual and visuoconstructive function, neglect, executive function, speed, and apraxia) using a detailed test battery.[27–29] Functional limitations were measured with the Barthel Index (BI).[30]

Immediately before discharge patients were randomized to receive 1 of 3 different types of aftercare: (1) follow-up home visits by a physician (INT1-HVP), (2) physiotherapist instruction in the patient's home (INT2-PI), or (3) standard aftercare (control). For details of the study design, see Figure 1. The local ethical committee approved the study.

### Randomization

Before initiation of the study, each participant number was assigned to 1 of the 3 care groups: INT1-HVP, INT2-PI, or control. Two secretaries, who were not involved in recruitment or patient selection, made the assignments by randomly drawing lots. The assignments were then stored in a central secretariat and were not accessible to anyone on the research team until after the last 6-month assessment was done. After informed consent was given, participants were registered in the secretariat and provided consecutive participant numbers according to time of inclusion. At discharge, allocation group assignment was derived from the central secretary. Once randomized, the patients were followed for the 6-month period. The research team had no authority to withdraw patients from the study after randomization.

### Interventions

Three types of aftercare were tested: standard aftercare (control) and 2 new types of organized aftercare (INT1-HVP and INT1-PI). INT1-HVP and INT2-PI were provided as a supplement to standard aftercare.

#### *Control Group*

The patients in the control group received standard aftercare, including outpatient rehabilitation on ordination by a hospital physician or the general practitioner, and home care to compensate for disability. Standard aftercare did not include follow-up home visits. The patients were free to contact their general practitioner and the social service center.

#### *INT1-HVP*

The physician intervention consisted of three 1-hour home visits (at 2, 6, and 12 weeks after discharge). These visits focused on early detection and treatment of complications, maintenance of functional capacity, and psychological and social adjustment to a new life with stroke-related disability. Each visit consisted of a discussion concerning actual health conditions, stroke-related symptoms, functional

capacity that included social activity and family function, and use of social services. A medical examination was performed if needed. On this basis, problems were identified, and the physician intervened to solve the problems. Intervention included medication, reference to other services, liaison between the patient and stroke services, and counseling. In addition, patients and caregivers were provided information on stroke, stroke rehabilitation, social services, benefits, and stroke clubs. Patients were provided the opportunity to contact the project physician by telephone whenever they wished. The project physician was trained in geriatric rehabilitation, including stroke rehabilitation.

### *INT2-PI*

Patients in this group received instruction and reeducation by the hospital physiotherapist during a 6-week period immediately after discharge. The visits took place in the patient's home; frequency was determined by the physiotherapist and was adjusted to the patient's needs. Each visit lasted ≈1 hour. The average number of visits per patient was 2.9 (range 1 to 8). The physiotherapist evaluated a range of functions related to indoor and outdoor mobility and some activities of daily living. Problems were identified, and the physiotherapist intervened to try to solve the problems. Relatives and professional caregivers were instructed how to assist the patient in a way that allowed the patient use his or her functional skills as best as possible. Instruction and education, not training, characterized the intervention.

## Outcome Assessment

Six months after discharge, patients reported to the outpatient clinic, where we assessed neurological impairment, mobility, and cognitive function with the same test instruments used at discharge. Disability was measured with the Index of Extended Activities of Daily Living that included personal, instrumental, and social activities of daily living and was administered by the research neuropsychologist, who had no information about group allocation. BI and the Frenchay Activity Index (FAI)[31] were administered by the project physician. Data on mortality, institutionalization, and readmission rates came from the Danish Central Person Register, the City of Copenhagen Health Administration, and the Copenhagen Hospital Corporation. Further details on readmission were obtained from discharge records. Two independent physicians, 1 of whom was unaware of which group the patient had been assigned, classified readmissions as stroke related or non–stroke related. Stroke-related readmissions were further divided into 2 categories: new cerebrovascular attack (transient ischemic attack, stroke) and stroke complications (poststroke epilepsy, fall, stroke-related decline in functional capacity, neurological bladder or constipation problems, and others). In case of disagreement, the physicians met and discussed their differing assessments. In all cases, a consensus was reached.

## Statistical Analysis

Group differences at baseline were tested with $\chi^2$ for categorical variables and ANOVA and the $F$ test for continuous, normally distributed variables. Level of significance was set to 0.1. We analyzed the correlation between readmission and types of intervention with the Goodman and Kruskall $\gamma$-coefficient, testing the hypotheses that INT1-HVP was more successful than INT2-PI, which in turn was better than standard care (control) in preventing readmission. The level of significance was set to 0.05, and we used a 1-sided $P$ value. Differences in time to first readmission, presented graphically with Kaplan-Meier curves, were tested with the log-rank test.

For multivariate analysis of effect of intervention on readmission, we used a Cox regression model with intervention as the primary variable. We included the following possible confounding factors: gender, age, living alone, education, occupational skills, length of inpatient rehabilitation, diabetes, heart disease, atrial fibrillation, alcohol abuse, depression (diagnosed and treated during inpatient rehabilitation), poststroke epilepsy (diagnosed and treated during inpatient rehabilitation), BI at discharge, SSS at discharge, and FQM at discharge. A backward selection procedure was performed, followed by stepwise selection, including interaction between variables. For all tests, the level of significance was set to 0.05. All analyses were performed based on the intention-to-treat principle.

# Results

## Patients

A total of 866 patients were screened for eligibility: 88 (10%) had had no recent stroke, 209 (24%) were discharged to an institution, 354 (41%) had no motor impairment at discharge, and 14 were excluded according to the exclusion criteria E.1 to E.4. Two hundred one (25%) patients fulfilled the entry criteria. Of these, 46 were excluded because of lack of consent to participate. The remaining 155 patients (77% of the eligible) (Bispebjerg Hospital 90, Kommunehospitalet 49, Amager Hospital 16) were randomized: 54 to INT1-HVP, 53 to INT2-PI, and 48 to standard aftercare. Four patients dropped out within the first 6 months after discharge. Three patients died, and 1 patient withdrew her consent. For these patients, data on readmission and institutionalization from discharge until dropout are included. For the remaining 151 patients, data on readmission and institutionalization were obtained for the full 6-month period. A total of 133 patients (86%) completed all assessments of functional outcome at 6 months.

Baseline characteristics for the randomized patients are shown in Table 2. No significant differences in baseline characteristics were found among the groups.

## Readmissions

Readmission rate within 6 months after discharge appears in Table 3. A total of 53 (34%) patients were readmitted to hospital during the period. Thirteen (8%) patients were readmitted more than once. Thirty-three (21%) patients were readmitted due to a stroke-related condition. Readmission rate was significantly lower in the intervention groups compared with the control group (INT1-HVP 26%, INT2-PI 34%, control 44%, $\gamma$-coefficient 0.258, $P=0.028$). During the 6 months after discharge, 3 patients died and 5 were institutionalized.

The causes of the 66 readmissions are shown in Table 4. Thirty-nine (59%) readmissions were due to a stroke-related condition, of which stroke complications were the most common, causing 32 readmissions. No differences in the distribution of readmission subtypes (stroke related/non–stroke related) within the 3 groups could be documented.

Total number of readmission days was 1344; 1053 days (79%) were stroke related. Stroke complications accounted for 59% of all readmission days, and the subcategory "stroke-related disability" was especially important, accounting for 50% of all readmission days. The total number of readmission days was greater in the control group than in each of the intervention groups. However, we found no statistically significant difference in length of readmission. An analysis of the distribution of readmission days according to readmission subtypes within each group showed no difference among groups.

The effect of intervention on readmission rate was further analyzed by including in the analysis the time to first readmission. The Kaplan-Meier curves presented in Figure 2

**TABLE 2. Baseline Characteristics of Patients in Randomization Groups**

| Characteristic | INT1-HVP (n=54) | INT2-PI (n=53) | Control (n=48) |
|---|---|---|---|
| Gender, % F/M | 56/44 | 62/38 | 44/56 |
| Age, y (mean±SD) | 69.8±9.9 | 74.1±11.4 | 68.3±12.3* |
| Living alone, % | 56 | 62 | 58 |
| Medical history, % | | | |
| Previous stroke | 20 | 15 | 19 |
| Ischemic heart disease | 14 | 15 | 33* |
| Hypertension | 24 | 42 | 29 |
| Diabetes mellitus | 20 | 11 | 19 |
| Atrial fibrillation | 13 | 8 | 17 |
| Respiratory disorder | 13 | 6 | 10 |
| Rheumatic disorder | 19 | 21 | 23 |
| Alcohol abuse | 11 | 8 | 21 |
| Stroke severity | | | |
| Bamford classification, % | | | |
| Total anterior circulation syndrome | 20 | 13 | 13 |
| Partial anterior circulation syndrome | 35 | 45 | 37 |
| Lacunar syndrome | 39 | 34 | 42 |
| Posterior circulation syndrome | 4 | 8 | 6 |
| Lesion side, % | | | |
| Left hemisphere | 52 | 38 | 40 |
| Right hemisphere | 39 | 49 | 46 |
| Brain stem | 6 | 11 | 8 |
| Cerebellar, bilateral, and others | 3 | 2 | 6 |
| Stroke subtype, % | | | |
| Hemorrhage/infarction | 11/89 | 11/89 | 15/85 |
| SSS at onset† | 33.4±11.7 | 35.6±9.7 | 31.9±13.3 |
| BI at onset‡ | 37.4±26.6 | 36.7±29.9 | 29.8±22.8 |
| Complications in hospital, % | | | |
| Reinfarction | 5 | 2 | 4 |
| Stroke in progress | 31 | 21 | 27 |
| Depression | 19 | 26 | 15 |
| Functional state at discharge | | | |
| SSS | 47.7±6.9 | 48.7±6.1 | 46.9±9.1 |
| FQM, function score | 21.7±12.0 | 18.9±12.2 | 18.0±15.5 |
| FQM, quality score | 57.9±31.6 | 57.4±38.8 | 47.0±39.3 |
| BI | 81.5±19.0 | 80.6±17.4 | 76.8±23.7 |
| Cognitive function, % | | | |
| General reduction | 21 | 20 | 28 |
| Aphasia | 23 | 24 | 22 |
| Impaired visuospatial function | 21 | 37 | 36 |
| Neglect | 6 | 20 | 10 |
| No cognitive impairment | 9 | 6 | 10 |
| Hemianopia, % | 17 | 13 | 17 |
| Length of stay, d (mean/median) | 87.6/76 | 83.0/74 | 98.3/88.5 |
| Planned help/support at discharge, % | | | |
| Home care service | 74 | 75 | 83 |
| Nursing at home | 41 | 47 | 50 |
| Meals on Wheel | 31 | 38 | 38 |
| Daycare | 11 | 9 | 17 |
| Planned hospital-based follow-up§ | 80 | 72 | 71 |
| Planned day hospital rehabilitation | 78 | 58 | 67 |

Functional state values are given as mean±SD unless stated otherwise.
*$P<0.1$ (age $P=0.026$, ischemic heart disease $P=0.009$).
†SSS score on admission available for 71 of 155 patients.
‡BI on admission available for 81 of 155 patients.
§Planned day hospital or outpatient follow-up.

indicate a difference that favors intervention, but this was not statistically significant (log rank 3.57, *df* 2, $P=0.17$).

Using a Cox regression model, we analyzed the effect of intervention on the readmission risk. No difference was found between INT1-HVP and INT2-PI with respect to the effect of intervention on readmission risk (log rank 0.94, *df* 2, $P=0.63$). Therefore, in the final analysis we combined the 2 intervention groups into 1 (INT1-HVP or INT2-PI) and compared that group with the control group. Results are presented in Table 5. A statistically significant effect of intervention in interaction with length of hospital stay (LOHS) was demonstrated ($P=0.0332$). The interaction between intervention and LOHS implies that (1) in the intervention group, readmission risk was not influenced by the LOHS; (2) in the control group, the greater the LOHS, the greater the readmission risk; (3) after a short hospital stay, there was no difference in readmission risk between the intervention and control group; and (4) after a long hospital stay, there was a great difference in readmission risk between the 2 groups that favors the intervention group. For statistical details, see Appendix 1.

Curves that show the estimated probability of staying free of rehospitalization as a function of days since discharge for patients discharged after 30 and 180 days, respectively, illustrate the interaction between the effect of intervention and the effect of LOHS: the effect of intervention is strongest for patients discharged after a long hospital stay (Figure 3).

In addition to intervention and LOHS, vocational training status, age, and depression significantly and independently influenced readmission risk (unskilled status, high age, and depression increased risk). Other tested variables had no independent effect on the risk of readmission.

The practical implication of the model is illustrated by the following example. The probability was calculated of not being rehospitalized within 6 months after discharge for unskilled, nondepressive 70-year-old patients who are discharged after 90 days of inpatient rehabilitation. Without intervention (standard aftercare), the probability of not being rehospitalized was 0.40. Intervention increased the probability of not being rehospitalized to 0.62.

## Discussion

The results of the present study confirmed the hypotheses put forward that (1) readmission is common among community-

**TABLE 3. Data on Readmission, Death, and Institutionalization Within 6 Months After Discharge for Intervention Groups Compared With Control Group**

| | INT1-HVP (n=54) | INT2-PI (n=53) | Control (n=48) | *P* |
|---|---|---|---|---|
| Readmitted | 14 (26) | 18 (34) | 21 (44) | 0.028* |
| Readmitted more than once | 4 (7) | 2 (4) | 7 (15) | 0.140 |
| Readmitted due to stroke-related condition | 7 (13) | 11 (21) | 15 (31) | 0.079 |
| Died | 1 | 2 | 0 | ... |
| In institution | | | | ... |
| Nursing home | 0 | 1 | 1 | ... |
| Sheltered housing | 0 | 1 | 2 | ... |

Values are given as numbers (percentages) of patients unless stated otherwise.
*$P<0.05$ (Goodman's and Kruskall's $\gamma$ coefficient=0.258).

dwelling stroke survivors with persistent disability, (2) readmissions are frequently caused by stroke complications, and (3) readmission can be prevented to some extent with follow-up intervention after discharge for specific subgroups of patients.

The results substantiate the effect of follow-up intervention for disabled elderly patients discharged to independent living in the community found by other researchers in the rehabilitation field.[22,23] To our knowledge, only 1 stroke study[21] has evaluated follow-up with home visits after completed inpatient rehabilitation. This study found no significant intervention effect on functional capacity; however, it did not include an evaluation of the effect on readmission. The present study is the first stroke study to suggest that follow-up home visits prevent readmission.

Intervention reduced the number of readmissions. The length of readmission also tended to be lower in the intervention groups compared with the control group, but this difference was not statistically significant. The effect of intervention (INT1-HVP or INT2-PI) was strongest for patients with prolonged inpatient rehabilitation courses, presumably representing the patients with the most severe and most complicated strokes.

Data on initial stroke severity were collected retrospectively at discharge, causing problems with incompleteness and lack of details, which made it impossible to directly

**TABLE 4. Data on Readmissions Within 6 Months After Discharge Showing Distribution Within Groups**

| Total No. of Readmissions | Total (n=66) | INT1-HVP (n=18) | INT2-PI (n=20) | Control (n=28) | *P* |
|---|---|---|---|---|---|
| Readmission causes, n of readmissions (% of all) | | | | | |
| Stroke related | 39 (59) | 9 (50) | 13 (65) | 17 (61) | 0.627 |
| Recurrent stroke, TIA | 7 (11) | 3 (17) | 1 (5) | 3 (11) | ... |
| Stroke complications | 32 (48) | 6 (33) | 12 (60) | 14 (50) | ... |
| Epilepsy | 7 | 1 | 4 | 2 | ... |
| Disability (including fall) | 16 | 3 | 7 | 6 | ... |
| Bladder/constipation | 5 | 0 | 0 | 5 | ... |
| Others | 5 | 2 | 1 | 1 | ... |
| Total number of readmission days | 1340 | 336 | 270 | 734 | ... |
| Length of readmission, d (mean±SD) | ... | 19±31 | 14±14 | 26±38 | 0.355 |
| Readmission causes, n of readmission days: | | | | | |
| Stroke related, d (% of all) | 1053 (79) | 247 (74) | 184 (68) | 622 (85) | ... |
| Recurrent stroke, TIA, d | 268 | 181 | 17 | 70 | ... |
| Stroke complications, d | 785 | 66 | 167 | 552 | ... |
| Epilepsy | 14 | 1 | 4 | 9 | ... |
| Disability (including fall) | 667 | 3 | 162 | 502 | ... |
| Bladder/constipation | 31 | 0 | 0 | 31 | ... |
| Others | 73 | 62 | 1 | 10 | ... |

Values are given as number of readmissions (percentage of total number of readmissions in each group) unless stated otherwise.

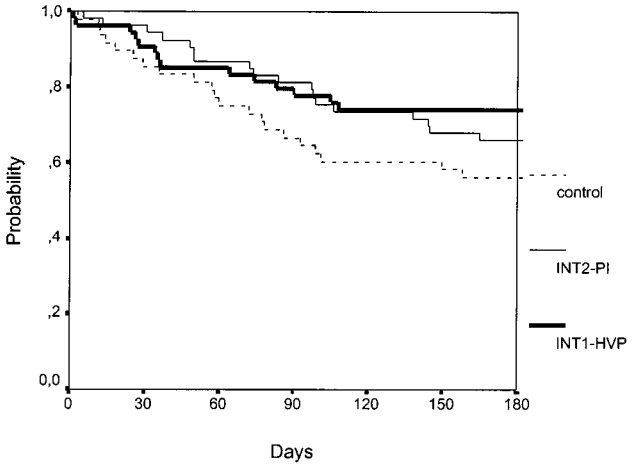


**Figure 2.** Kaplan-Meier curve showing the probability that a stroke patient discharged after completed inpatient rehabilitation will remain free of rehospitalization as a function of days since discharge. Intervention groups in comparison with controls (log rank 3.57, *df* 2, $P=0.17$).

include stroke severity in the multivariate analysis. However, according to a study of the costs of stroke rehabilitation and its clinical and social determinants, the most important factor that affects length of stay is stroke severity.[32] This suggests that the effect of this type of follow-up intervention is strongest for the subgroup of stroke survivors with the most severe strokes.

Our expectation that intervention prevented mainly stroke-related readmissions was not confirmed. A distinction between stroke-related and non–stroke-related readmission might have been artificial and without correspondence to reality. Although a further breakdown of readmission causes was possible, the groups were too small for statistical analysis.

A crude analysis of our data showed that physician intervention was more effective in the prevention of readmissions than was physiotherapist intervention. This, however, was not confirmed in the multivariate analysis, nor could any difference in the type of prevented readmissions be documented. The explanation could be that both professions were able to detect and handle the specific health problems associated with the aftermath of a stroke. Alternatively, the effect was mediated through an nonspecific health-maintaining effect of knowing where to seek help and

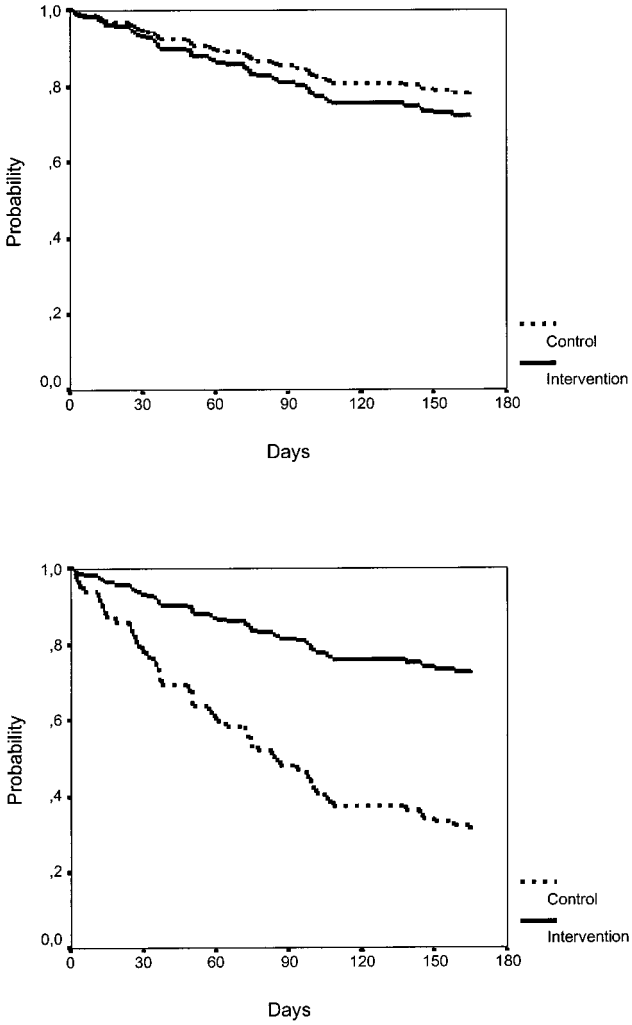


**Figure 3.** Interaction between intervention and LOHS. Estimated curve of the probability that a stroke patient discharged after 30 days (top) or 180 days (bottom) in hospital will remain free of rehospitalization. Intervention group is compared with controls.

support, which was provided equally well by the 2 types of intervention.

We have no reason to believe that bias caused serious problems of internal validity for the following reasons: (1) the study was a randomized clinical trial in which the 3 groups were comparable at baseline; (2) baseline data were collected

**TABLE 5. Results of the Cox Regression Analysis of Readmission Risk: Estimates and Test Results (Likelihood Ratio Test) for the Variables Included in the Model**

| Variable | $\beta$ | SEM | LR | *df* | *P* |
|---|---|---|---|---|---|
| Unskilled (occupational) | −0.8252 | 0.2934 | 7.86 | 1 | 0.0051 |
| Age | 0.0317 | 0.0137 | 5.66 | 1 | 0.0174 |
| Depression | −0.9437 | 0.3741 | 5.82 | 1 | 0.0158 |
| Intervention · LOHS | 0.0117 | 0.0055 | 4.54 | 1 | 0.0332 |
| Intervention | −0.5983 | 0.6611 | ... | ... | ... |
| LOHS | −0.0012 | 0.0036 | 0.1060 | 1 | 0.7447 |

LOHS indicates length of hospital stay.
Intervention (INT1-HVP or INT2-PI) is set as the reference category.

before randomization and data on readmission came from an official health register; (3) the method of a "blinded assessor" without knowledge of group allocation was used to avoid subjectivity; (4) possible confounding factors were controlled for in the multivariate analysis[33,34]; and (5) intention-to-treat analyses were performed.

If a contagious effect from the intervention groups to the control group had occurred, it would have been in the direction of reducing the effect of the interventions in comparison with controls.

Although it can be argued that institutionalization tends to lower the risk of readmission, only 5 patients were institutionalized, and 4 of them were readmitted before institutionalization. Moreover, there was no difference between the intervention groups and the control group regarding institutionalization. We are also aware that readmission may be influenced by local factors, such as differences in hospital bed availability[35] and possible differences in readmission rate among stroke-treating wards. However, each of the participating hospitals contributed with the same percentage of patients to the 3 groups, and patients were discharged to the same local area, with the same readmission policy and professional support system. This ensured that local factors did not limit the internal validity of the study.

The researchers were not involved in admission visitation. All readmissions were arranged according to local clinical practice: patients were readmitted by their family physician, by the emergency medical services, or from an emergency department.

Because follow-up intervention was provided in addition to standard care after discharge, we carefully studied the standard care applied at discharge for the different groups. No difference in home care service, nursing at home, Meals on Wheel, daycare, day hospital rehabilitation, or hospital-based follow-up was found among the groups (Table 2).

In our selection of this frail and exposed subgroup of stroke survivors, who in line with previous studies and clinical experience were expected to be in need of intervention after discharge, we followed the principle of targeting recommended in geriatric research and practice.[36] We estimated the target population in our Copenhagen setting to be 25% of the survivors from an nonselected stroke population. Because the patients in this study were described with the use of internationally acknowledged measurements, it should also be possible to define the study population in other settings.

Inherent in a focus on functional outcome at the time of discharge and follow-up intervention after discharge is the inevitable problem of different discharge policies in different settings, which may limit the generalizability of our results.

In Denmark, the Nordic countries, and most of Europe, stroke rehabilitation is managed mainly as inpatient rehabilitation, whereas other countries (including the United States) have a policy of earlier discharge followed by community rehabilitation. Stroke units in our system discharge patients when no further neurological improvement or increase in basal activities of daily living activities can be achieved, usually after a relative long inpatient rehabilitation (mean length of stay ≈40 days[37,38] which is in accordance with other nonselected stroke populations in similar settings).[39,40] This discharge policy explains the long inpatient rehabilitation period (mean length of stay 90 days) in our study population, which consisted of patients with severe and disabling strokes. In systems with a tradition of earlier discharge, patients with even more severe impairment and disability are sent back to their homes for further outpatient rehabilitation. There is no reason to believe that these more disabled patients would be in less need of follow-up services.

In conclusion, our results can be applied to the subgroup of stroke survivors, discharged to their own homes, who after the completion of inpatient rehabilitation still have persistent stroke-related impairment and disability. This corresponds to approximately one fourth of survivors in an nonselected stroke population. Generalizability is restricted to stroke settings comparable to ours with stroke rehabilitation being provided mainly on an inpatient basis.

National and international guidelines for stroke rehabilitation emphasize support during the transition from hospital to community and the importance of follow-up services after discharge.[41,42]

Our results shows that subgroups of stroke survivors with moderate to severe functional problems need follow-up services that continue even after no further neurological improvement or betterment of basal activities of daily living seems probable. The provision of support during this transition is suggested as a useful and effective prevention strategy. The present study did not provide information about the specific services that are most relevant.

In light of the current interest in the development of early discharge stroke rehabilitation programs in Western societies, future research should focus on follow-up services: what types are most relevant and effective, and how long should they continue? Our detailed description of the subgroup of disabled stroke survivors discharged to their own homes offers information useful in the planning of future follow-up services for this patient group.

## Appendix 1

### Analysis of the Effect of Intervention on the Readmission Risk

#### *Cox Regression Model*

The model shows a significant effect of intervention in interaction with LOHS on readmission risk ($P=0.0332$) (Table 5).

The combined effect on readmission risk, $z$, of intervention and LOHS can be calculated as the following:

$$z=\beta_i\cdot\text{Intervention}+\beta_L\cdot\text{LOHS}+\beta_{i,L}\cdot\text{Intervention}\cdot\text{LOHS}$$

where intervention is coded 0 for intervention and 1 for no intervention, $\beta_i$ and $\beta_L$ are the main effects of Intervention and LOHS, and $\beta_{i,L}$ is the interaction between intervention and LOHS.

Based on the results in Table 5, the combined effect ($z$) of intervention and LOHS on readmission risk can be estimated for the 2 groups:

Intervention group: $z=-0.0012\cdot\text{LOHS}$

Control group: $z=-0.5983+(0.0117-0.0012)\cdot\text{LOHS}$

For the control group, an increasing risk of readmission is seen with increasing LOHS.

In the intervention group, the effect of LOHS seems to have disappeared in that the estimated effect, 0.0012, of LOHS is insignificant ($P=0.74$). This implies that the effect of intervention is mediated through elimination of the effect of LOHS.

It is seen that the longer the LOHS, the greater the difference in readmission risk between intervention and control groups.

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