ORIGINAL INVESTIGATION

Hospital-Acquired Pressure Ulcers

Risk Factors and Use of Preventive Devices

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Background: Pressure ulcers are a frequent complication of bed rest. We examined risk factors for hospital-acquired pressure ulcers, the use of preventive devices, and the impact of case-mix adjustments on between-ward comparisons.

Methods: We conducted 3 cross-sectional surveys in a teaching hospital of 2373 patients who had no pressure ulcer on admission. We assessed the presence of pressure ulcer, dates of admission and ulcer occurrence, hospital ward, patient age and sex, appetite and route of nutrition, surgery during stay, hospitalization for fracture, comorbidities, use of low-pressure devices (special mattresses, cushions, and pressure-reducing beds), and the Norton Pressure Ulcer Prediction score (physical condition, mental condition, activity, mobility, and incontinence).

Results: Two hundred forty-seven new pressure ulcers occurred (5.7 per 1000 person-days). In multivariate analysis, the risk for pressure ulcer increased with age (risk gradient across 5 categories was 1:4.5; $P<.001$) and Norton score (across 5 categories, risk gradient was 30-fold; $P<.001$); other risk factors (all relative risks, 1.5-1.8; $P<.002$) were hospitalization for fracture, surgical intervention, reduced appetite, and nasogastric tube or intravenous nutrition. Adjustment for case mix substantially modified differences between hospital wards. Use of preventive devices was associated with Norton score, but not all high-risk patients benefited.

Conclusions: Pressure ulcers were seen in every 10th hospitalized adult. Patient age and Norton score were the strongest risk factors for pressure ulcers. Use of preventive devices was suboptimal. Adjustment for case mix is essential if pressure ulcer incidence is to be used as an indicator of quality of care.

Arch Intern Med. 1998;158:1940-1945

PRESSURE ULCERS are an uncomfortable, painful, and costly complication of bed rest.[1-4] As most pressure ulcers can be prevented through identification of patients at risk and application of appropriate preventive measures,[5,6] their frequency is a potentially useful indicator of quality of care for inpatient facilities. In contrast to nursing homes,[7-9] general hospitals rarely include pressure ulcer incidence among these indicators. One possible reason is that knowledge about risk factors for pressure ulcers is still fragmentary. Studies of risk factors for pressure ulcers have been more often conducted in nursing homes[7-13] than in general hospitals.[13-16] Because hospitals and nursing homes receive different types of patients, findings from one setting do not necessarily translate to the other. Incomplete knowledge about risk factors for pressure ulcers in acute care hospitals would preclude appropriate adjustments for patient case mix when facilities are compared.[7] We conducted our study to identify risk factors for pressure ulcers in adult patients in a general hospital, to evaluate the impact of case-mix adjustments on comparisons of hospital wards, and to estimate the frequency and correlates of use of preventive devices.

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RESULTS

STUDY SAMPLE

The surveys yielded 907, 844, and 801 patient observations (total, 2552). After exclusion of 10 duplicate records, 112 repeated observations of patients who participated in consecutive surveys, and 57 patients who already had pressure ulcers at admission, 2373 independent patient observations remained. Observations were performed a median of 9 days (mean, 18.0 days; SD, 26.3) after admission. Patient time at risk for ulcer development totaled 42 758 patient-days (about 117 patient-years). Unweighted median length of stay of study pa-

PATIENTS AND METHODS

STUDY DESIGN AND POPULATION

Three cross-sectional surveys of all hospitalized patients were conducted in October and December 1995 and February 1996 at the Geneva University Hospitals, Geneva, Switzerland. This 1100-bed urban teaching hospital is the only public hospital in Geneva. The surveys included all patients 16 years of age or older hospitalized on preselected days. Patients who were free of pressure ulcers on admission were eligible for the study of risk factors.

STUDY VARIABLES AND DATA COLLECTION

The main outcome variable was the presence of a pressure ulcer on any part of the body, of grade 1 (nonblanchable erythema), 2 (partial skin loss), 3 (full-thickness skin loss), or 4 (deep-tissue destruction).[17] The admission date, date of the first appearance of the ulcer, and whether a pressure ulcer was present on admission were noted, so that incidence rates could be computed. The second outcome variable was the use of low-pressure devices (special mattresses, cushions, and pressure-reducing beds) to prevent pressure ulcers.

Independent variables included patient age and sex, type of ward, history of surgery during hospitalization, hospitalization for fracture, presence of diabetes and other comorbidities, quality of patient's appetite and route of nutrition, and the Norton Pressure Ulcer Prediction score (hereafter referred to as the Norton score),[18] which is a sum of 5 variables (physical condition, mental condition, activity, mobility, and incontinence) scored from 1 (worst) to 4 (best).

Data were obtained by trained data collectors from written nursing records, complemented by interviews with nursing staff and patient examinations whenever necessary. Hospital admission and discharge dates were retrieved from computerized hospital records.

STATISTICAL ANALYSIS

We used time-failure methods to account for the duration of the time at risk for development of an ulcer. Ulcer incidence rates were computed per 1000 person-days at risk. The period at risk lasted from admission to ulcer occurrence (in those in whom ulcers developed) or the assessment date (in those in whom they did not). Patients who underwent evaluation on their admission day were assigned a half-day of follow-up. Rates of ulcer incidence in time were examined using the Kaplan-Meier method and log rank tests.[19] Multivariate modeling was performed in proportional hazards models.[20] To extrapolate from the study sample to the general hospital patient population, we weighed observations by the inverse of length of stay, because length of stay is proportional to the probability of being included in a cross-sectional survey (hence patients with long stays are overrepresented in cross-sectional surveys).

tients was 20 days (mean, 34.9 days; SD, 39.9). After weighting for the unequal probability of selection, median length of stay was 7 days (mean, 11.9 days), consistent with hospital statistics for 1995 and 1996.

Males and females were equally represented in the sample (**Table 1**). Ages ranged from 16 to 102 years, with a mean of 63.1 and an SD of 18.9 years. Patients were hospitalized in the following various clinics: internal medicine (606 [25.5%]), abdominal surgery (430 [18.1%]), orthopedic surgery (334 [14.1%]), neurology (163 [6.9%]), ophthalmology (85 [3.6%]), intensive care (79 [3.3%]), ear-nose-throat (58 [2.4%]), gynecology (47 [2.0%]), and dermatology (48 [2.0%]). Rehabilitation and semi–acute care wards contributed 523 patients (22.0%).

ULCER INCIDENCE

Between admission and day of observation, new pressure ulcers occurred in 245 patients (10.3%), 56 patients (22.8%) had multiple ulcers, and 189 patients (77.2%) had single ulcers. Ulcer stage on day of observation (or highest stage when more than 1 ulcer was present) was stage 1 for 171 patients (69.8%), stage 2 for 48 patients (19.6%), stage 3 for 24 patients (9.8%), and stage 4 for 2 patients (0.8%). The most frequent single ulcer locations were the sacrum (83 [33.9%]) and heels (52 [21.2%]). Correction for unequal probability of inclusion brought the risk for pressure ulcer during hospitalization from 10.3% to 4.1%. The incidence rates were 5.7 new ulcers per 1000 person-days (95% confidence interval [CI], 5.3-6.2) and 1.7 per 1000 person-days (95% CI, 1.5-1.9) for ulcers of stage 2 or greater.

RISK FACTORS FOR PRESSURE ULCERS

In univariate analysis, pressure ulcer incidence was higher in females than in males (Table 1). The relationship with patient age was striking; the risk difference between the youngest and the oldest patients was 10-fold. Patients who underwent surgery or who were admitted for fracture were also at moderately increased risk. Other medical conditions, such as diabetes, cardiovascular disease, or cancer, were not associated with the presence of pressure ulcers (data not shown). Patients who had a good appetite (as judged by the nursing team) were 3 to 4 times less prone to ulcers than patients who lacked appetite or were fed by a nasogastric tube or a parenteral line. The Norton score was strongly correlated with the risk for pressure ulcer, even across scores greater than 16 that are usually considered normal (**Figure 1**).

In multivariate models, all variables but sex remained independent risk factors for pressure ulcers (**Table 2**). The relationships of pressure ulcer risk with Norton score and age were particularly strong. There was no interaction between these 2 variables ($P = .97$), suggesting that the effects of the Norton score and age were multiplicative on the relative hazard scale. Patterns of risk differed little according to ulcer stage. Norton scores in the middle range (17-19 and 15-16) were particularly strongly associated with stage 1 ulcers. On the other hand, patient age and having had surgery appeared to be stronger risk factors for stage 2 or greater ulcers.

Table 1. Incidence Rates of and Relative Risks for Pressure Ulcers Among Subgroups*

Risk Factor	No. (%) of Patients	No. (%) of Pressure Ulcers	Incidence Rate per 1000 Patient-Days (95% CI)	Relative Hazard† (95% CI)
Sex				
Male	1210 (50.9)	98 (40.0)	4.3 (3.9-4.7)	1.0 (Reference)
Female	1163 (49.0)	147 (60.0)	7.3 (6.4-8.1)	1.6 (1.2-2.1)
Age group, y				
16-39	324 (13.6)	10 (4.1)	1.7 (0.9-2.5)	1.0 (Reference)
40-69	1002 (42.2)	69 (28.1)	3.9 (3.4-4.4)	2.2 (1.1-4.2)
70-79	526 (22.2)	59 (24.1)	6.0 (5.2-6.9)	3.3 (1.7-6.4)
80-89	421 (17.7)	73 (29.8)	9.5 (8.1-11.0)	5.1 (2.7-9.9)
90-102	100 (4.2)	34 (13.9)	18.0 (13.2-22.8)	9.7 (4.8-19.6)
Surgery during stay				
Yes	886 (37.3)	127 (51.8)	7.0 (6.3-7.7)	1.6 (1.2-2.0)
No	1487 (62.7)	118 (48.2)	4.8 (4.2-5.4)	1.0 (Reference)
Hospitalized for fracture				
Yes	294 (12.4)	67 (27.3)	9.8 (8.2-11.5)	2.2 (1.7-2.9)
No	2079 (87.6)	178 (72.6)	5.0 (4.5-5.4)	1.0 (Reference)
Nutrition				
Good appetite	1712 (72.1)	103 (42.0)	3.3 (2.9-3.6)	1.0 (Reference)
Reduced appetite	498 (21.0)	101 (41.2)	11.8 (10.2-13.4)	3.5 (2.6-4.6)
Nasogastric tube or intravenous line	163 (6.9)	41 (16.7)	15.3 (12.3-18.4)	4.6 (3.2-6.6)
Norton Pressure Ulcer Prediction score‡				
20	627 (26.4)	4 (1.6)	0.5 (0.3-0.7)	1.0 (Reference)
17-19	966 (40.7)	39 (15.9)	1.9 (1.5-2.3)	4.6 (1.6-12.8)
15-16	363 (15.3)	46 (18.8)	7.0 (5.8-8.1)	16.3 (5.9-45.3)
12-14	269 (11.3)	76 (31.0)	14.0 (11.8-16.1)	33.6 (12.3-91.9)
5-11	148 (6.2)	80 (32.6)	27.6 (24.1-31.1)	61.3 (22.4-167.4)

*CI indicates confidence interval. Percentages have been rounded and may not total 100.
†From proportional hazards model.
‡Sum of 5 item scores (physical condition, mental condition, activity, mobility, and incontinence), each from 1 (worst) to 4 (best).

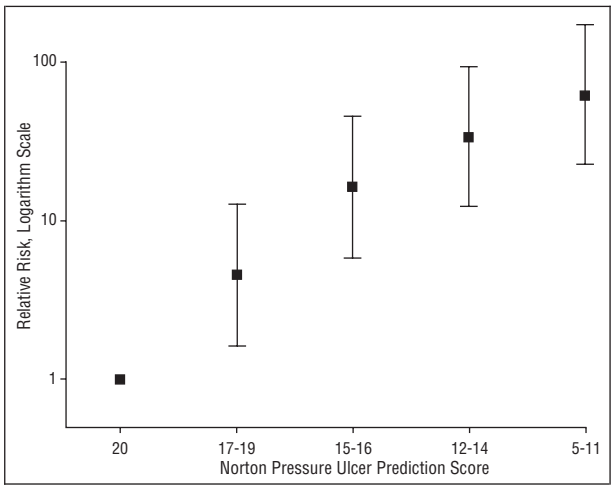

Figure 1. *Relative risk for having a pressure ulcer, with 95% confidence intervals, by Norton Pressure Ulcer Prediction score, in 2373 patients admitted to Geneva University Hospitals, Geneva, Switzerland, during 3 months in 1995 and 1996.*

IMPACT OF RISK ADJUSTMENT

Crude differences in ulcer prevalence between hospital clinics were large; the difference between clinics at lowest and highest risk (specialized clinics and intensive care wards, respectively) was 8-fold (**Table 3**). Compared with the internal medicine clinic (the largest sample), 4 of 6 differences were statistically significant. After adjustment for previously identified predictors, the ratio of extremes was less than 3-fold, clinics at lowest and highest risk changed (rehabilitation clinics and abdominal surgery, respectively), and only 1 of 6 comparisons with the internal medicine clinic remained significant (Table 3).

USE OF PRESSURE-REDUCING DEVICES

On the day of the survey, 443 patients (18.7%) were treated with the following preventive devices: pressure-alternating mattresses (274 [11.5%]), protective cushions (205 [8.6%]), and pressure-reducing beds (18 [0.8%]). (Some patients were treated with more than 1 device.) The use of any device was related with the Norton score, particularly in patients who did not have ulcers, but not all patients who had pressure ulcers on the assessment day benefited from protective treatment (**Figure 2**). In a multivariate logistic regression model, independent risk factors for preventive device use were presence of a pressure ulcer, Norton score, surgery during hospital stay, presence of orthopedic fixation devices, neurologic impairment, and hospital clinic (**Table 4**). In particular, intensive care wards and rehabilitation and chronic care clinics used preventive devices much more often than other acute care clinics.

COMMENT

INCIDENCE AND RISK FACTORS FOR PRESSURE ULCERS

This study suggests that pressure ulcers of stage 1 or greater will develop in about 4% of patients admitted to

Table 2. Independent Predictors of Pressure Ulcer Incidence During Hospitalization*

	All Pressure Ulcers, RH (95% CI)†	Stage 1 Ulcers Only, RH (95% CI)‡	Stage 2-4 Ulcers Only, RH (95% CI)§
Age group, y			
16-39	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
40-69	1.9 (1.0-3.6)	1.3 (0.6-2.5)	8.2 (1.1-60.9)
70-79	2.4 (1.2-4.7)	1.9 (0.9-3.8)	7.5 (1.0-57.3)
80-89	3.9 (2.0-7.6)	2.7 (1.3-5.4)	18.5 (2.5-138.5)
90-102	4.7 (2.3-9.7)	4.1 (1.9-8.7)	12.0 (1.4-99.5)
Hospitalized for fracture	1.6 (1.1-2.2)	1.5 (1.0-2.2)	1.5 (0.9-2.7)
Surgery during hospitalization	1.5 (1.2-2.0)	1.5 (1.1-2.1)	2.5 (1.5-4.2)
Nutrition			
Good appetite	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Reduced appetite	1.6 (1.1-2.1)	1.8 (1.2-2.6)	1.4 (0.8-2.4)
Nasogastric tube or intravenous line	1.8 (1.2-2.8)	1.8 (1.1-3.0)	1.7 (0.8-3.6)
Norton Pressure Ulcer Prediction score‖			
20	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
17-19	3.6 (1.3-10.2)	5.1 (1.2-21.4)	2.3 (0.5-10.3)
15-16	11.1 (4.0-31.1)	16.6 (4.0-69.9)	6.8 (1.5-30.6)
12-14	20.6 (7.4-57.4)	32.0 (7.7-133.2)	12.6 (2.8-56.4)
5-11	33.5 (11.9-94.5)	50.0 (11.8-212.0)	41.2 (9.1-185.8)

**Determined using multivariate proportional hazards model. RH indicates relative hazard; CI, confidence interval.*
†*Includes 247 events.*
‡*Includes 172 events.*
§*Includes 75 events.*
‖*Described in the third footnote to Table 1.*

Table 3. Effect of Adjustment for Known Risk Factors on Comparisons of Pressure Ulcer Incidence Between Hospital Clinics*

	Unadjusted Comparisons		Adjusted Comparisons†	
Hospital Clinic	RH (95% C)	Rank‡	RH (95% CI)	Rank‡
Internal medicine	1.0 (Reference)	4	1.0 (Reference)	4
Abdominal surgery	1.0 (0.7-1.5)	3	1.2 (0.8-2.0)	7
Orthopedic surgery	1.8 (1.2-2.7)	6	1.1 (0.7-1.8)	5
Intensive care	3.0 (1.8-5.1)	7	1.2 (0.7-2.1)	6
Dermatology	1.7 (0.8-3.4)	5	0.9 (0.4-1.9)	3
Other specialties§	0.4 (0.2-0.8)	1	0.5 (0.3-1.1)	2
Rehabilitation and subacute care	0.6 (0.4-0.8)	2	0.4 (0.3-0.7)	1

**RH indicates relative hazard; CI, confidence interval.*
†*Adjusted for risk factors identified in Table 2.*
‡*Indicates rank according to presssure ulcer incidence from 1 (lowest) to 7 (highest).*
§*Includes ear, nose, and throat; neurology; ophthalmology; and gynecology.*

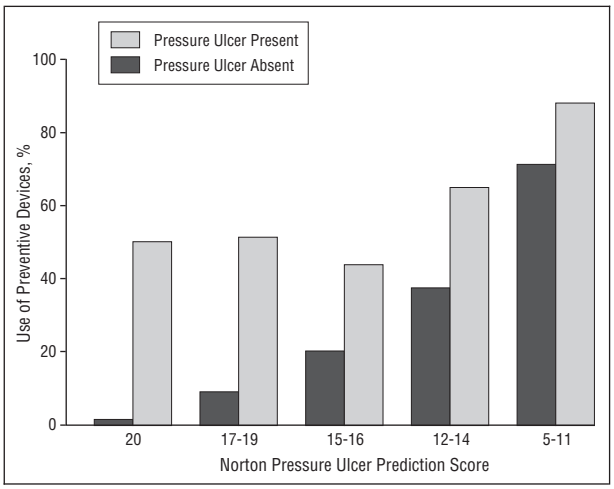

Figure 2. *Proportion of patients treated with a pressure-reducing device (alternating-pressure mattress, pillows, or pressure-reducing bed), by Norton Pressure Ulcer Prediction score (20 indicates best and 5, worst) and current presence or absence of a pressure ulcer, in 2373 patients admitted to Geneva University Hospitals, Geneva, Switzerland, during 3 months in 1995 and 1996.*

a general hospital, and that on any given day, about every 10th hospitalized patient has a pressure ulcer (the difference between these numbers stems from the fact that patients who have long hospital stays are overrepresented in cross-sectional surveys and are at increased risk for a pressure ulcer). These figures are consistent with published data.[4]

We also identified strong risk factors for hospital-acquired pressure ulcers. The strongest risk factor was the Norton score, which confirms the validity of this widely used tool. The relationship between Norton score and ulcer risk was gradual (Figure 1), without evidence of a threshold. Thus, dichotomization of Norton scores into normal and abnormal values may cause loss of information about a given patient's level of risk. In particular, among patients whose Norton score was normal (>16), those who had scores of 17 to 19 were at 3 to 4 times greater risk for pressure ulcer than those with scores of 20. The multiplicative contributions of patient age and Norton score to pressure ulcer risk estimation suggest that different cutoff values should be used in young, middle-aged, and elderly adults; a Norton score of 16 implies a much higher absolute risk for pressure ulcer in an 80-year-old than in a 50-year-old patient.

The second strongest risk factor was patient age. After adjustment for other predictors, patients who were 90 years of age or older still had a 5-fold increase

Table 4. Risk Factors for Use of an Ulcer Prevention Device During Hospitalization*

	Odds Ratio	95% CI
Presence of pressure ulcer	5.0	3.2-7.9
Norton Pressure Ulcer Prediction score†		
20	1.0	Reference
17-19	3.0	1.5-5.7
15-16	6.1	3.0-12.2
12-14	16.8	8.3-34.0
5-11	69.2	28.5-168.5
Surgery during stay	2.1	1.4-3.1
Orthopedic immobilization device	2.1	1.3-3.4
Neurologic deficit	2.3	1.5-3.6
Hospital clinic		
Internal medicine	1.0	Reference
Abdominal surgery	2.0	1.0-4.0
Orthopedic surgery	1.8	0.9-3.7
Intensive care	42.7	16.5-110.6
Dermatology	0.5	0.1-2.9
Other specialties‡	1.0	0.5-2.2
Rehabilitation and subacute care	7.1	4.1-12.4

**Devices include special mattresses, cushions, and pressure-reducing beds. CI indicates confidence interval.*
†Described in Table 1.
‡Includes ear, nose, and throat; neurology; ophthalmology; and gynecology.

in the risk for development of a pressure ulcer, compared with young adults. Age is probably a proxy variable for tissue resistance to pressure, shear, and friction, the latter external stressors being measured by the Norton score. The age gradient we observed was much stronger than age gradients reported in all[11-15,20] but 1 previous study,[16] perhaps because many previous studies were restricted to elderly patients. In general hospitals, where patient ages vary widely, patient age should be explicitly included among variables used for pressure ulcer risk calculation.

Less impressive independent risk factors included having been hospitalized for fracture, surgery during hospital stay, and suboptimal nutrition (poor appetite, nasogastric tube, and intravenous nutrition). A high risk for pressure ulcer in patients with fractures has been reported previously.[14,21,22] The role of nutritional factors is still a matter of debate.[23,24]

LIMITATIONS OF RELATIVE RISK ESTIMATES

The risk models we developed have several limitations. First, we did not include laboratory tests that may have predictive usefulness, such as serum albumin level[14,21] or lymphopenia,[15] because this information was not available for all patients. The second limitation stems from the cross-sectional design of this study. The temporal sequence and hence the direction of causality of some associations remain a concern. For instance, we cannot be certain that a low Norton score actually preceded the occurrence of a pressure ulcer and helped to cause it, and not the opposite. Similarly, the prescription of nasogastric or intravenous nutrition may have been a consequence of a pressure ulcer, and not a risk factor for its development. This issue can only be addressed in prospective studies. However, this problem does not affect variables that could not have changed as a result of a pressure ulcer, such as age, sex, admission for fracture, and surgery during stay. Another limitation is that assessments of pressure ulcers and risk factors were performed with the investigators aware of patient status, which may have affected the quality of the data. This is particularly true for Norton scores. Research assistants may have been more likely to assign less favorable scores to patients who already had pressure ulcers. Finally, our models were developed with most ulcers in stage 1, which would limit the generalizability of our results if risk factors were stage specific. Our analyses suggest that this is partially true (Table 2); for instance, age was a stronger risk factor for more advanced ulcers than for stage 1 ulcers.

IMPLICATIONS FOR CASE-MIX ADJUSTMENT

Although the exact specification of a pressure ulcer prediction model for use in acute care hospitals may require further refinements, our results suggest that case-mix adjustments are indispensable for comparisons of hospital wards and likely comparisons of hospitals. For instance, the 3-fold higher risk for pressure ulcers in intensive care wards was fully explained by the higher risk profile of patients who require such care. The importance of case-mix adjustments for comparisons of pressure ulcer incidence has been already noted in nursing homes.[7]

PREVENTIVE DEVICES

Finally, use of preventive devices was not optimal in our hospital. Many patients who already had a pressure ulcer or who were at high risk for development of one received no protective treatment. Interestingly, however, the frequency of preventive device use increased gradually with the Norton score among patients who were free of pressure ulcers, suggesting that hospital staff were able to identify informally high-risk patients, since none of the clinics used the Norton score (or any other ulcer prediction tool) routinely. Similar patterns of use have been observed by others.[13,25] Nevertheless, differences between clinics in the frequency of use of preventive devices were important. Such variations argue that practices are suboptimal in at least some of the clinics. For instance, previous studies have related greater incidence of pressure ulcers in nursing homes with low staffing patterns[8,9]; this makes sense, as systematic detection and prevention of pressure ulcers is labor intensive. Better identification of patients at risk and more systematic implementation of preventive measures are clearly warranted at our hospital.

Accepted for publication January 27, 1998.

Supported by the Medical Director's Office, Geneva University Hospitals, Geneva, Switzerland, and grant 3233-32609.91 from the Swiss National Science Foundation, Berne, Switzerland (Dr Perneger).

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