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Diagnostic Validity of the Care Dependency Scale as a Screening Tool for Pressure Ulcer and Fall Risks in Dutch and German Hospitals

Research Article

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Abstract: Pressure ulcers and falls are frequent adverse events with negative impacts for hospital patients. Guidelines recommend risk assessment as the first step in prevention. Care dependency correlates with falls and pressure ulcers and the Care Dependency Scale showed a diagnostic validity comparable to that of specific risk assessment tools. The aim of this study was to establish a simple and valid screening index for the risk of falls and pressure ulcers in hospitals by using the Care Dependency Scale and to evaluate this index within two validation samples from different countries. Quantitative, cross-sectional data from two German surveys and one Dutch survey were analysed. A total of 305 Dutch and German hospitals with 21,880 patients took part. The diagnostic validity of the Care Dependency Scale was evaluated by computing receiver operator characteristics curves, the areas under the curves, sensitivity, specificity and positive and negative predictive values.The Scale demonstrated a good diagnostic validity for pressure ulcer risk screening in Dutch and German hospitals. The diagnostic validity regarding the risk for falls was satisfying in Germany and moderate in the Netherlands. Using the Care Dependency Scale for risk screening could reduce the necessity of further assessment by more than a half.

Keywords: *Accidental Falls • Hospitals • Nursing Home • Pressure Ulcer • Risk Assessment*

1. Introduction

Pressure ulcers and falls are frequent adverse events in the care of hospitalized patients; they add to the suffering of affected patients [1-3], are related to higher mortality rates [4,5], and increase health care costs [6,7]. A pressure ulcer survey in five European countries reported a prevalence of 18.1% [8], and in German hospitals it was 11.1% [9]. Fall rates in Europe range from 3.2% to 37% for different hospital units [10,11]. European guidelines and German national expert standards recommend a risk assessment for both problems as the first step in prevention [12,13]. This means that in practice, specific assessments regarding fall and pressure ulcer risks must be conducted for each patient, which puts a burden on nurses as well as patients due to partly redundant assessments. Some risk factors, for example, impaired mobility or incontinence, are contained in most risk scales and are already evaluated during the general nursing assessment. With this in mind, it would be sensible to use an existing nursing assessment tool for initial risk screening prior to any additional specific risk assessment.

1.1. Background

The necessity of risk assessment is contrary to the lack of instruments that ensure absolutely reliable diagnoses. Evaluations of the most common assessment tools for pressure ulcers, like the Braden, Norton, and Waterlow scales, report significantly differing results regarding their predictive or diagnostic validity [14,15]. These tools do not provide a dichotomous decision upon risk/no risk, but produce a range of sumscores that reflect the extent of the risk. Dependent on the selected score as the cut-off point for a risk/no risk decision, different scores are found for sensitivity and specificity, which are

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commonly used to validate a scale. Sensitivity reflects the proportion of individuals correctly assessed as being endangered and specificity stands for the individuals correctly assessed as not being endangered.

A recent systematic review identified the Waterlow scale as the tool with the highest sensitivity (76%-100%) at the expense of a very low specificity (10%-44%), whereas the Braden scale had the best balanced sensitivity (39%-100%) and specificity (34%-100%) values [14]. However, the usefulness of the scales is discussed critically because of their low diagnostic accuracy [15,16].

An extensive systematic review about fall risk assessment [17] revealed eight tools that were sufficiently investigated in acute care settings with sensitivity scores ranging from 66% to 93% and specificity scores from 25% to 88%. Despite Scott and colleagues appreciating the use of a fall risk assessment, they also state that the selection of an appropriate tool is complicated due to varying performances in different settings.

The main obstacles regarding the assessment of pressure ulcer risks are described by Halfens (2000) and also apply to fall risks: the lack of a solid external criterion for the measurement of risks and the bias caused by prevention. The lack of a solid external criterion is predicated on the fact that "risk" is an abstract construct, and cannot be observed and measured directly. Hence, the occurrence of the adverse event is commonly used as an external criterion to evaluate a test's validity, which is beneficial in two respects: it is clearly measurable and it provides data that are comparable with the results of other studies. On the other hand, the incidence of an adverse event is not identical to being at risk, and not all endangered patients will fall or develop pressure ulcers. Additionally, risk assessment is influenced by prevention. Applying preventive measures to patients at risk decreases the risk, and thereby the incidence and prevalence of the adverse event. This treatment paradox leads to low scores of diagnostic validity parameters like sensitivity and specificity.

The complexity of risk assessment is further increased by the fact that fall and pressure ulcer risks are composed of a wide range of risk factors, which mutually influence each other. Even if it was possible to develop a perfect instrument comprising all the factors, it would be too extensive to apply in practice [18] and its usefulness and necessity would be doubtful. Contrary to the expectation that ever more exact measurements of ever more factors would lead to improved decisions, cognition scientists found that the results of fast and simple decision strategies considering only up to three cues, were as good as, or even better than, complex ones, such as regression models consisting of about 10 cues [19]. For medical emergency diagnostics, it was found that heart attack patients were classified more accurately by using a fast and frugal decision tree (asking simply for systolic blood pressure above 90mm/HG, age above 62 years and presence of a sinus tachycardia) than by using complex statistical classification methods [20].

Apart from the requirement of daily practice to make fast decisions based on as few parameters as possible, those decisions should be valid and reliable. Previous studies investigated whether or not the Care Dependency Scale (CDS), a tool for nursing assessment that is short and easy to administer, provided the chance to meet both necessities in relation to the risk of falls and pressure ulcers.

With regard to the risk of falls in hospital patients, a high correlation was found between the CDS and the Hendrich model, a specific fall risk assessment tool [21]. Patients with falls were distinctly more care dependent than those without [22], and the diagnostic validity of the CDS sumscore was comparable with the results of common fall risk scales [23].

A comparison of three pressure ulcer risk assessment tools and the CDS in hospitals indicated that the CDS has a diagnostic value similar to specific risk tools [24]. In a recent study [25], we detected a high correlation between the Braden scale and the CDS, which indicated a good construct validity of the CDS regarding pressure ulcer risks. Sensitivity and specificity scores were identical to the scores of the Braden scale. Hence, we can assume that the CDS is appropriate to screen pressure ulcer and fall risks.

In order to ensure a valid basis as well as a beneficial use in practice, further investigations were necessary and this paper describes the development and evaluation of a simple risk index using the CDS.

1.2. The Study: Aims and Objectives

The overall aim of this study was to establish a simple, quickly available and valid index for the risk of falls and pressure ulcers in hospital patients by using the CDS.

Objectives:

1. To investigate if former findings that showed that the diagnostic validity of the CDS was similar to that of specific risk assessment tools were reproducible.
2. To develop an index by combining the most appropriate cut-off point and the CDS items with the highest impact on the studied risks.
3. To evaluate the risk index within two validation samples from different countries.

Table 1. CDS items and item descriptions.

Item	Item description
Eating/drinking	The extent to which the patient/resident is able to satisfy his/her need for food and drink
Continence	The extent to which the patient/resident is able to voluntarily control the discharge of urine and faeces
Body posture	The extent to which the patient/resident is able to adopt a position appropriate to a certain activity
Mobility	The extent to which the patient/resident is able to move about unaided
Day/night pattern	The extent to which the patient/resident is able to maintain an appropriate day/night cycle unaided
Getting (un)dressed	The extent to which the patient/resident is able to get dressed and undressed unaided
Body temperature	The extent to which the patient/resident is able to protect his/her body temperature against external influences unaided
Hygiene	The extent to which the patient/resident is able to take care of his/her personal hygiene unaided
Avoidance of danger	The extent to which the patient/resident is able to assure his/her own safety unaided
Communication	The extent to which the patient/resident is able to communicate
Contact with others	The extent to which the patient/resident is able to appropriately make, maintain and end social contacts
Sense of rules/ values	The extent to which the patient/resident is able to observe rules by him/herself
Daily activities	The extent to which the patient/resident is able to structure daily activities within the facility unaided
Recreational activities	The extent to which the patient/resident is able to participate in activities outside the facility unaided
Learning ability	The extent to which the patient/resident is able to acquire knowledge and/or skills and/or to retain anything that was previously learnt unaided

2. Material and Methods

A quantitative, cross-sectional design was used. Data from three surveys were investigated. In these large and extensive data sets, the studied variables had been collected in a standardized way from two different countries.

The development of the risk screening index was applied to data from the German prevalence survey of 2006. In order to evaluate if the results were stable in Germany and transferable to the Netherlands, the index was tested with data from the German and the Dutch prevalence surveys of 2007.

2.1. Sampling and Procedure

The surveys are conducted annually and nationwide in Germany and the Netherlands following similar study protocols. All health care institutions are invited to participate in the survey by written invitation, study presentations, and announcements in nursing and health care management journals. The sole inclusion criterion is the patients' informed consent. For the presented analyses, all hospital patients ages 18 and older are selected out of the data sets.

The main focus of the surveys is to describe preventive measures and the prevalence of pressure ulcers, falls, incontinence, care dependency, and malnutrition in different health care settings. The study protocol and questionnaire were predicated on the development of the Dutch National Registration Project of Pressure Ulcers [26].

This paper focuses on care dependency, falls, and pressure ulcers. Staff nurses of the participating institutions collected the respective data from the patients. Prior to this, the nurses had been trained with regard to the study and the applied instruments, and were given a research manual containing detailed explanations of the questionnaire and definitions of the studied concepts. During the data collection, the researchers were available by telephone and instant email.

2.2. Variable Definitions and Instruments

2.2.1. Care Dependency and CDS

Care dependency is a complex construct and was defined as "a subjective, secondary need for support in the domain of care to compensate a self-care deficit" [27].

The CDS assesses an individual's care dependency with 15 items (Table 1) on a five-point Likert scale for each item, ranging from completely dependent to completely independent. Sumscores range from 15 to 75 with a low score indicating a high care dependency. The scale was developed by Dijkstra and colleagues in the Netherlands based on Virginia Henderson's theoretical framework [28,29]. The Dutch scale has been translated into German and back-translated independently by different persons, followed by a discussion of the differences with the scale developer [30]. Originally focusing on demented and mentally handicapped patients, the CDS was utilised and evaluated in various settings and showed good to moderate validity and reliability in the assessment of the care dependency of

hospital patients [31-33]. The CDS should be filled in by registered nurses who actually care for the patient to be assessed. Newly admitted patients can be assessed by the admitting nurse.

2.2.2. Pressure Ulcers

A pressure ulcer was defined as "[...] an area of localised damage to the skin and underlying tissue caused by pressure, shear, friction, and/or a combination of these" [34]. For the detection, every patient was examined by the staff nurses who documented the location, grade and duration of the ulcers.

2.2.3. Falls

A fall was characterised as a "[...] descent of the body from a higher to a lower level due to disturbed balance of the body or reduced capacity to bear weight or body in different positions" [35].

Data about falls were collected by consulting the documentation, the patients and their relatives. The assessment of falls varied slightly in both countries. The German questionnaires of 2006 and 2007 contained the question: "Did the patient suffer a fall inside the institution within the last 14 days?" The Dutch questionnaire of 2007 asked: "Did the client suffer a fall within the last 14 days?" The implications of this difference are addressed in the discussion.

2.2.4. Covariables

Based on the aim of the paper to establish a brief risk screening index, the CDS sumscore and the 15 CDS items were analysed as potential predictor variables. As there was evidence that an increasing age had a significant correlation with both falls and pressure ulcers [23,36], it was selected as a covariable. Since there were contradictory findings concerning the influence of sex on the occurrence of falls and pressure ulcers [23,36,37], it was also selected as a covariable.

The primary outcomes were the existence of a pressure ulcer at the time of data collection and the incident of a fall within the last 14 days prior to data collection.

2.2.5. Ethical Considerations

Ethical approval was given for the Dutch study and both German studies. In all three studies, patient data were gathered with anonymised questionnaires, and the patients' informed consent or proxies had to be obtained.

2.3. Statistical Methods and Procedures

All calculations were carried out with SPSS (versions 12.0 and 14.0) and Excel 2003.

Age and CDS sumscores were described in means, and sex distribution was displayed in number and percentage proportions of female participants. The numbers and percentages of affected individuals were given for falls and pressure ulcers. Percentages and associations were analysed using the appropriate statistical tests (unpaired t test, chi-squared test).

Two steps were taken for the development of the risk indexes:

1. For estimating the most appropriate cut-off point, we analysed the sensitivity and specificity of all CDS sumscores in relation to falls or pressure ulcers respectively. Sensitivity (specificity) reflects the probability of a positive (negative) test result when the adverse event is present (absent). Additionally, we calculated the area under the receiver operating characteristics curve (AUC), which provided information about the quality of a test with values between 0 and 1. The closer an AUC is to 1, the better the hit ratio.

With continuous variables, there is no clean cut-off for a normal range and each defined cut-off point implies a certain degree of false estimates [38]. The determination of the most appropriate cut-off point is a clinical decision and depends on the objective, as well as the benefit or harm a false positive or negative result would cause [38,39]. For screening purposes, it is important to identify as many individuals at risk as possible, because the benefit is that endangered patients would receive appropriate preventive measures after further individual evaluation, whereas no harm will arise for patients wrongly screened as at risk because they would not receive preventative measures after further individual evaluation. Considering that sensitivity and specificity would not be high with the adverse event as the external criterion, we fixed a sensitivity of 70% and a specificity of 60% as the clinical minimum requirement. For the determination of the most appropriate cut-off, we put our main emphasis on a high sensitivity and accepted a lower specificity, aiming at maximizing the true positive and minimizing the false negative rate.

2. In order to identify if special CDS items had a distinct correlation with the occurrence of the adverse events and in order to find an improved predictor, discriminatory analysis [40] was employed. The components of this linear function were chosen by a stepwise selection algorithm on a 5% significance level from the following items: CDS sumscore, each CDS item and the patients' age and sex. ROC

Table 2. Characteristics of the samples from Germany 2006 (G 2006) and 2007 (G 2007) and the Netherlands 2007 (NL 2007).

	G 2006 N=5035	G 2007 N=4067	NL 2007 N=12778
Age: Mean (SD)[1]	65.3 (17.0)	64.7 (17.0)	66.5 (16.7)
CDS: Mean (SD)[2]	64.5 (15.5)	64.2 (15.6)	63.2 (17.6)
Women: N (%)[3]	2728 (55.3%)	2172 (55.2%)	6698 (52.4%)
Falls: N (%)[3]	205 (4.1%)	157 (3.9%)	240 (1.9%)
Pressure ulcers: N (%)[3]	338 (6.7%)	290 (7.1%)	1517 (11.9%)

[1] *t-test was significant between G 2007 and NL 2007 ($p < 0.05$), and not significant between G 2006 and G 2007 and between G 2006 and NL 2007*
[2] *t-test was significant between G 2006 and NL 2007 and between G 2007 and NL 2007 ($p < 0.05$), and not significant between G 2006 and G 2007*
[3] *chi-squared test was significant between G 2006 and NL 2007 and between G 2007 and NL 2007 ($p < 0.05$), and not significant between G 2006 and G 2007*

curves, AUCs, and sensitivity and specificity were computed to evaluate the diagnostic validity of the model.

For the purpose of evaluating the risk index, sensitivity and specificity were analysed in two new data sets. When a risk is diagnosed, the safety of this diagnosis is important to the patients and carers. Therefore, we also calculated the positive and negative predictive values (PPV and NPV). PPVs demonstrated the probability of an adverse event being present given a positive test result, while NPVs demonstrated the probability of an adverse event not being present given a negative test result [38].

Finally, the percentage proportion of individuals at risk in relation to the whole sample was calculated for assessing the clinical usefulness of the index.

3. Results

3.1. Sample Characteristics

In 2006, 5035 patients took part in the survey in Germany and in 2007, there were 4067 patients. The Dutch sample of 2007 consisted of 12,778 patients.

The sample characteristics are presented in Table 2. The German samples of 2006 and 2007 were similar regarding the mean age, mean CDS score, sex distribution, and fall and pressure ulcer rates. The differences were minor and not statistically significant. The Dutch sample consisted of considerably more participants and showed small differences in the mean age, mean CDS score, and sex distribution, all of which were statistically significant in comparison to the German data of 2006 and 2007, except when compared to the mean age in the Germany data of 2006. The Dutch patients had more pressure ulcers and less falls than the Germans, and both differences were statistically significant in comparison to the German data of 2006 and 2007.

3.2. Covariables

In the total sample, we found a pressure ulcer rate of 6.7%; subgroup analyses resulted in a rate of 6.0% in male participants and 7.1% in females. The difference was not statistically significant in the chi-squared test. This also applied to the small difference between fall rates of men (4.1%) and women (3.9%).

On average, patients with pressure ulcers were 11 years older and distinctly more care dependent than participants without pressure ulcers (mean age 75.5 (SD 12.6) versus 64.6 (SD 17.1); mean CDS score 44.2 (SD 20.3) versus 65.8 (SD 14.1)). Both differences were statically significant in t-test analyses ($p<0.001$).

Participants who had experienced a fall were 12 years older on average and far more care dependent than patients who had not fallen (mean age 73.2 (SD 14.9) versus 65.0 (SD 17.0); mean CDS score 54.8 (SD 18.1) versus 64.8 (SD 15.3)). T-test analyses showed statistically significant results ($p<0.001$) for both age and CDS sumscore in relation to falls.

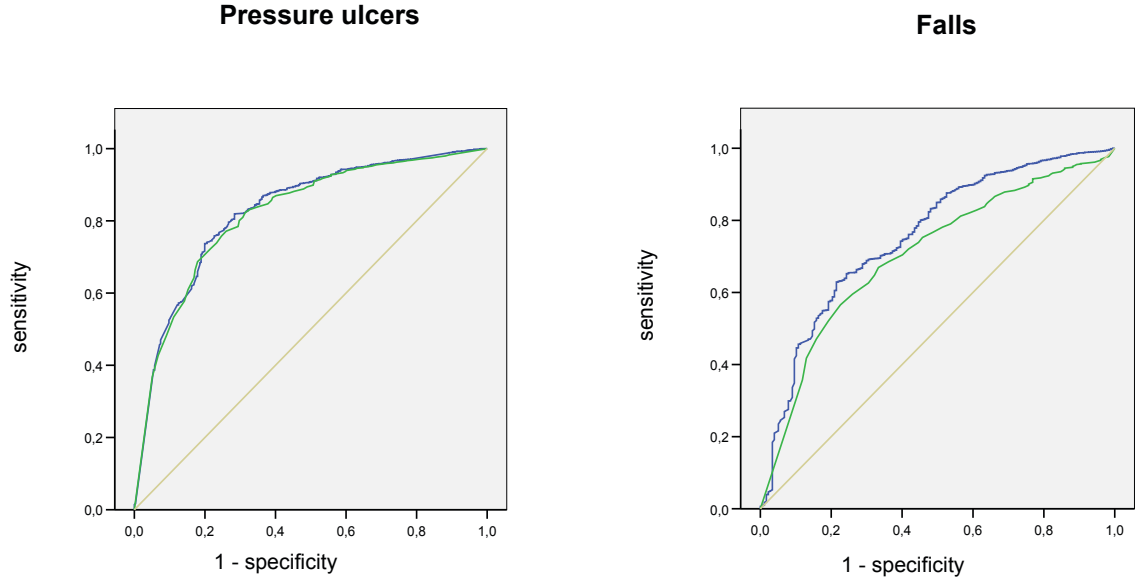
3.3. Reproducibility

The ROC curves of the CDS sumscores are displayed in Figure 1. For pressure ulcers, the AUC was 0.82 and for falls, it was 0.70, which were similar to the results of previous studies that found an AUC of 0.80 for pressure ulcers [25] and 0.71 for falls [23].

3.4. Development of the Risk Index, Data from Germany 2006

Table 3 gives the sensitivity and specificity values of all CDS sumscores in relation to pressure ulcers and falls, and illustrates that a high sensitivity goes along with a low specificity and vice versa. CDS sumscores of 59 and higher for pressure ulcers and 69 and higher for falls were potential cut-off points with a sensitivity of 70% and more.

Figure 1. ROC curves for pressure ulcers and falls for CDS sumscore (green) and discriminatory function (blue).



The discriminatory analysis regarding pressure ulcers resulted in the inclusion of the variables CDS sumscore, eating/drinking, body temperature and communication into the model. The respective ROC curve (Figure 1) was similar to the curve of the sole CDS sumscores and the AUC was 0.83. With regard to falls, the discriminatory analysis detected the variables age, eating/drinking, body posture, mobility, day/night pattern, body temperature, avoidance of danger, contact with others, and learning ability as being of continued importance. The respective AUC was 0.76 and this ROC curve (Figure 1) was slightly higher than the curve of the CDS sumscores.

Basing the risk index on the discriminatory analysis would require a weighting of the items and its calculation would be too complex for simple bedside documentation. Since the aim of the study was to develop a simple risk index, this investment would only be justified by a far better differentiation. As the discriminatory analyses did not give rise to any AUCs being distinctly better than the AUCs of the sole CDS sumscores, we decided to base the risk index on the latter.

According to the weighting of sensitivity and specificity highlighted in the analysis section, we established a CDS score of 69 as the cut-off point for the risk of falls, as well as pressure ulcers, for further analyses. Concerning pressure ulcers, 85% of all patients with ulcers were identified as being at risk (sensitivity), and 61% of all participants without ulcers were identified as not being at risk (specificity). Regarding falls, sensitivity was 73% and specificity was 59% (Table 3).

3.5. Evaluation of the Risk Index, Data from Germany 2007 and the Netherlands 2007

In Germany during 2007, the CDS was completed for 3735 patients, and 1581 (42.3%) patients were assigned to the risk groups with a cut-off point of 69. In the Dutch sample, the CDS was completed for 9819 patients, and 4110 (41.9%) of them were assigned to the risk groups with the same cut-off point.

The ROC curves of the CDS regarding pressure ulcers resulted in an AUC of 0.81 in Germany and 0.77 in the Netherlands. For falls, the AUC was 0.74 in the German and 0.66 in the Dutch sample.

The findings regarding the diagnostic accuracy of the established cut-off point in the German and Dutch samples of 2007 are presented in Table 4. Sensitivity was above 80% for pressure ulcers in both countries and for falls in Germany and 70% for falls in the Dutch sample. Specificity was about 60% for both pressure ulcers and falls in both samples. Positive predictive values were low and lay between 4% and 24%, and negative predictive values scored high between 96% and 99%.

4. Discussion

Men and women did not differ regarding pressure ulcer and fall rates and therefore, sex differences were not considered in the index development. Age showed statistically significant differences regarding both adverse events. However, age also correlated strongly and was statistically significant with care dependency

Table 3. Sensitivity and specificity values (%) of all CDS sumscores for pressure ulcers and falls.

Pressure ulcers			Falls		
CDS sumscore	Sensitivity	Specificity	CDS sumscore	Sensitivity	Specificity
15	11	98	15	2	98
16	12	98	16	3	97
17	15	98	17	4	97
18	16	97	18	4	97
19	18	97	19	5	96
20	20	97	20	5	96
21	21	97	21	8	96
22	23	97	22	9	96
23	23	97	23	9	96
24	24	96	24	10	95
25	26	96	25	11	95
26	27	96	26	11	95
27	28	96	27	11	95
28	30	96	28	14	94
29	31	96	29	14	94
30	33	95	30	15	94
31	35	95	31	15	93
32	35	95	32	16	93
33	37	95	33	17	93
34	38	94	34	18	93
35	40	94	35	19	92
36	40	94	36	20	92
37	41	93	37	21	92
38	43	93	38	23	91
39	44	93	39	23	91
40	44	92	40	23	91
41	45	92	41	23	90
42	47	92	42	24	90
43	47	91	43	24	90
44	49	91	44	25	89
45	49	90	45	28	88
46	51	89	46	31	88
47	52	89	47	32	87
48	54	88	48	33	87
49	55	88	49	34	86
50	56	88	50	34	86
51	60	87	51	36	85
52	61	86	52	36	84
53	61	86	53	37	83
54	62	85	54	39	83
55	65	84	55	41	82
56	67	83	56	43	81
57	69	82	57	44	80
58	69	81	58	46	79
59	70	80	59	48	78

continued **Table 3.** Sensitivity and specificity values (%) of all CDS sumscores for pressure ulcers and falls.

60	71	78	60	51	76
61	74	77	61	54	75
62	75	76	62	55	74
63	77	74	63	58	72
64	78	72	64	60	70
65	80	70	65	63	68
66	82	69	66	66	67
67	83	66	67	67	65
68	83	64	68	69	62
69	85	61	69	73	59
70	86	58	70	77	56
71	89	53	71	80	52
72	91	48	72	83	47
73	93	43	73	86	42
74	95	37	74	87	36
75	100	0	75	100	0

Table 4. Diagnostic accuracy of the CDS cut-off point 69 for pressure ulcers and falls.

Outcome	Data set	AUC	Sensitivity	Specificity	PPV[3]	NPV[4]
Pressure ulcers	G 2007[1]	0.81	84	61	13	98
	NL 2007[2]	0.77	81	64	24	96
Falls	G 2007[1]	0.74	81	59	07	99
	NL 2007[2]	0.66	70	59	04	99

[1] Germany 2007; [2] the Netherlands 2007; [3] positive predictive value; [4] negative predictive value

(Mertens *et al.*, 2008), and therefore, it can be deemed as sufficient for screening purposes to concentrate on the latter.

Dutch patients only fell half as often as the German patients did. This is surprising considering the slightly different question used to assess falls in both countries, where the more general Dutch question would imply a higher fall rate than the more restrictive German question. Further investigations are needed to explain this difference.

Pressure ulcers occurred one and a half times more often in Dutch patients than they did in German ones, confirming the findings of previous studies [41]. The varying frequencies of adverse events sub-served the research objectives because we were able to evaluate the established risk index in two different samples.

The first objective was to verify the screening abilities of the CDS. We could reproduce the findings of the CDS, which showed a diagnostic validity comparable to, or better than, specific risk assessment tools for falls and pressure ulcers in hospital patients. The ROC curves of the CDS sumscores identified an AUC of 0.82 for pressure ulcers and an AUC of 0.70 for falls. This is similar to previous findings in other hospitals and indicates that these results are stable in hospital settings. Compared to results of biomedical tests, scores for diagnostic accuracy of risk tests are low because risks cannot be observed directly and solid external criteria are not available. The use of adverse events as the external criterion provides the advantage that these are clearly measurable and the study results can be compared to other studies.

The second objective in this study was to develop a simple risk index. Due to the fact that discriminatory analyses did not produce distinctly better sensitivity and specificity values than the CDS score alone, we employed the latter for constituting the index. Sensitivity was favoured over specificity, and a CDS sumscore of 69 was established as the cut-off point for the risk of pressure ulcers as well as falls.

As there is no perfect threshold in a continuous scale for a dichotomous decision, this cut-off comprises misjudgements. In practical use, it must be considered that the risk increases with a higher care dependency and patients may fall or develop pressure ulcers, although the CDS score did not indicate a risk.

Nevertheless, the 69 cut-off identified 85% true positives and 61% true negatives regarding pressure

ulcers, which can be estimated as reasonable. We found lower scores for falls (73% sensitivity and 59% specificity), which indicates a weaker differentiation but seems to be sufficient enough for a first screening.

The third objective of the study was to evaluate the index in additional, different samples, and this was investigated using data from the Dutch and German surveys of 2007. When using the CDS sumscore of 69 as the risk index, about 42% of the patients were assigned to the risk groups in both countries. If the index is used for risk screening, this means that further assessments for pressure ulcer and fall risks have to be accomplished for this group only and the remaining 58% of the patients can be spared further assessment.

Regarding pressure ulcers, the AUC in the German sample of 2007 was similar to the AUC in 2006 (0.81 vs. 0.82), indicating a good differentiation ability. In the Dutch sample, the AUC (0.77) represented a slightly weaker differentiation. More than 80% true positives and more than 60% true negatives were identified in both samples, which can be deemed satisfactory for screening purposes.

Negative predictive values (NPV) were very high: 96% (Germany) and 98 % (Netherlands) of all patients who were not assigned to the risk group had not developed a pressure ulcer indicating a sound assessment of no risk. Positive predictive values (PPV) seem to be insufficiently low at first glance, but this is due to the chosen external criterion. In Germany, 13% of the patients who were assessed as being at risk did actually have a pressure ulcer. This applied to 24% of the patients in the Netherlands. As the PPV calculation includes the prevalence, it yields higher scores with a higher prevalence rate. Given the aim of developing a simple screening index and the lack of a solid external criterion, and considering that little harm arises for patients that are wrongly assessed as being at risk, these results can be regarded as satisfactory.

The AUC regarding falls in Germany in 2007 was higher than in 2006 (0.74 vs. 0.70), and indicates that the index performs better in the new sample. In the Dutch sample, the AUC was 0.66, representing a lower differentiation. This may be due to the different kinds of questions in both countries, or may be a result of the very low fall rate in the Netherlands. The index resulted in good sensitivity and specificity scores in Germany and moderate ones in the Netherlands. Positive predictive values were lower compared to those regarding pressure ulcers due to lower fall rates. Negative predictive values were 99% in both samples, indicating that an assignment to the no-risk group is very reliable. These findings can be deemed as good for Germany and as moderate for the Netherlands. In the latter, the diagnostic validity should be additionally evaluated with appropriate data collection methods to investigate if the results could be enhanced.

When applying assessment instruments, it generally must be considered that although a simplification of assessment procedures is worthwhile, the application of assessment and screening instruments can only supplement, and never replace, the personal professional estimation of advanced nurses. In this context, the CDS can be used in the first step of the nursing process to assess the patients' situation in general, as well as to screen for pressure ulcer and fall risks. If the screening indicates a potential risk, nurses should assess the individual risk factors of the affected patient and/or apply specific risk assessment tools in order to plan appropriate preventive measures.

A limitation of the study is the cross-sectional design, which does not permit conclusions about causal relationships and results should be evaluated in longitudinal research designs. The strengths of the study are the large sample sizes and the fact that data, gathered with similar study protocols, were available from two different countries, which enabled the evaluation of the transferability of the index.

5. Conclusion

The aim of this study to identify a simple and quickly available risk index can be achieved. The findings provide definite indications that the CDS encompasses a sufficient diagnostic validity for pressure ulcer and fall risk screening in Dutch and German hospitals.

Using the CDS sumscore of 69 as risk index for pressure ulcers resulted in satisfactory sensitivity scores of more than 80%, and acceptable specificity scores of more than 60% in both Germany and the Netherlands. Using the same score as risk index for falls, we found analogous scores in Germany. In the Dutch sample, the sensitivity was lower (70%).

Although these findings are supported by different studies that measured similar results, they should be confirmed in a prospective study design.

The paper showed that using the index for pressure ulcer and fall risk screening reduced further risk assessment by more than one half, which means the burden on patients and nurses can also be distinctively decreased. However, as each cut-off score contains misjudgements, specific risk assessments should always be accomplished where clinical signs indicate a potential risk.

The presented study focused on hospital patients. As nursing home residents are affected by the same risks, future enquiries will focus on developing an index for application in nursing homes.

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