

Research Article

Prevalence and Associated Factors of Pressure Ulcer among Hospitalized Patients at Felegehiwot Referral Hospital, Bahir Dar, Ethiopia

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Introduction. Pressure ulcers, also known as decubitus ulcers (bed sores), are localized skin injuries that remain a major health problem affecting approximately 3 million adults. **Objective.** The aim of this study was to assess the prevalence and associated factors of pressure ulcer among hospitalized patients in Felegehiwot referral hospital. **Methods.** This cross-sectional study used systematic sampling on a sample of 422 patients. The data was collected by trained data collectors through pretested checklist. Bivariate analysis was used principally and variables were then entered into multiple logistic regressions model for controlling the possible effect of confounders and the variables which have significant association were identified on the basis of OR with 95% CI and *P* value. **Results.** The finding of this study revealed that 71 (16.8%) of them had pressure ulcer. Prolonged length of stay in hospital, slight limit of sensory perception, and friction and shearing forces were significantly associated with the presence of pressure ulcer. **Conclusions and Recommendations.** The prevalence of pressure ulcer was high among hospitalized patients. Researches of prospective (follow-up) study required investigating the incidence and associated factors of pressure ulcer for hospitalized patients.

1. Background

Pressure ulcers also known as decubitus ulcers (bed sores) are localized skin injuries that develop when soft tissue is compressed between a bony prominence and an external surface for a prolonged period of time. It leads to ischemia, cell death, and tissue necrosis, as capillaries are compressed and the blood flow is restricted [1, 2]. The cutaneous tissues become broken or destroyed, leading to progressive destruction and necrosis of underlying soft tissues. This process results in a painful and slow healing of pressure ulcer. Pressure ulcers are usually occurring over bony prominences such as sacrum, shoulders, occiput, ear lobes, elbows, and trochanters depending on patients' position [3, 4].

The most important cause of pressure ulcers is pressure exerted for an excessive period of time. Other physical influences that can damage the skin include friction at the

skin surface, shearing forces (lateral displacement of the skin, whose layers are of differing firmness), and moisture. Moisture is also associated with the development of pressure ulcer. Loss of sensory perception (impaired level of consciousness) and immobility are the main risk factors for decubitus ulcers because patients may not be aware of the discomfort and do not change their position to relieve the pressure [5–7].

Development of pressure ulcers is complex and multifactorial. Despite advances in medical technology and the use of formalized prevention programs based on clinical practice guidelines, the prevalence of pressure ulcers during hospitalization continues to increase (80%). Among all hospitalized patients, prevalence rates of acquired pressure ulcers are the highest in patients in the intensive care unit (ICU), from 14% to 42%. Mortality is also associated with pressure ulcers. Several studies noted mortality rates as high as 60 percent for

older persons with pressure ulcers within 1 year of hospital discharge [8, 9].

Preventing pressure ulcers can be nursing intensive. Studies have suggested that pressure ulcer development can be directly affected by the number of nurses and time spent at the bedside. The frequent assessment and effective skin care prevent the development of pressure ulcer [10]. Changing patients position every two hours and use of pressure relieving mattress also reduce developing of pressure ulcer because turning patients every 2 hours promotes comfort, reduces pressure, increases circulation, exercises joints, and promotes muscle tone [1, 11].

Once PU is developed, it can provide wound healing process by change of dressing, continued wound assessment, and proper nutrition. High protein diet was indicated because high amount of protein is lost through the wound. However the cost of treatment has been estimated as 2.5 times that of prevention; implementing a pressure ulcer prevention program remains essential. When the stage of PU increases, the cost of treatment also increases; as a result, stage IV of PU requires high cost [12–14]. So the purpose of this study was to assess the prevalence and associated factors of pressure ulcer among hospitalized patients in Felegehiwot referral hospital.

2. Methods

A community based cross-sectional study was conducted in Felegehiwot referral hospital, Bahir Dar, from March 25, 2013, to May 1, 2013. Bahir Dar is the capital city of Amhara region which is found 564 KM away from Addis Ababa. Felegehiwot hospital is one of the referral hospitals in Amhara region. The hospital is expected to give service for five million people for the nearby zones and woreda people. This hospital has different wards. Among these wards medical ward, surgical ward, and gynecological wards are important to this research with the total bed number of 256, 84 from medical ward, 140 from surgical ward, and 32 from gynecological ward.

The source populations were all admitted patients in Felegehiwot referral hospital. And the study populations were those patients who have been admitted in medical, surgical, and gynecological wards in Felegehiwot referral hospital during study period. All admitted patients who were staying in hospital greater than or equal to 24 hours were included in the study. Those patients who have been admitted for the second time during data collection period and patients who developed pressure ulcer before admission in Felegehiwot referral hospital were excluded from the study.

The sample size was determined by using a single population proportion formula considering the following assumptions: prevalence (p) of pressure ulcer 50% to get the larger sample size, $Z =$ standard normal distribution value at 95% confidence level of $Z_{\alpha/2} = 1.96$, and margin of error (w) = 5%. This gave a sample size of 384 admitted patients. Adding a 10% nonresponse rate, the total sample size was 422. Final sample was selected based on bed number by systematic sampling technique from each ward. The first study unit was taken by lottery method.

Data was collected by face to face interviews using a structured and pretested questionnaire, prepared check lists, and physical examination. Four B.S. nurses were used to collect data. Two health officers were assigned to supervise the data collection process. Training was given for both data collectors and supervisors. Data entry was done by using EPI Info version 3.5.3 statistical software and exported to SPSS version 20.0 software package for analysis. The presence of association between independent and dependent variables was assessed using odds ratio with 95% confidence interval by applying logistic regression model.

Ethical clearance was obtained from the Department of Nursing, University of Gondar. An official letter of cooperation was delivered to the administrations of the hospital. Study participants were given information about the fact that they have full right not to participate in the study if they were not willing. To ensure confidentiality anonymity was explained clearly to participants. Nursing care was given for those patients who have developed pressure ulcer during study period.

3. Results

3.1. Sociodemographic Characteristics. A total of 422 admitted patients in Felegehiwot referral hospital were included in this study with the response rate of 100%. Overall, 57.3% (242) and 82.9% (350) respondents were rural residents and Orthodox Christianity followers, respectively. Proportion of females were 49.3% (208), the majority of the study participants were found in the age range of 18–32 (50.2%), and the median age of the respondents was 32 years (interquartile range = 24.5–45 years). Majority of the respondents (64.5%) were married and 18.5% (78) participants were single. About 36% (152) of the respondents were not educated and 12.1% (51) respondents completed grade 10 (Table 1).

3.2. Prevalence and Stages of Pressure Ulcer. A total of 71 pressure ulcers were detected in 422 patients, with the prevalence rate of 16.8%. The prevalence of pressure ulcer was higher in male respondents (42) than in female respondents (29). Based on EPUAP grading scale, 62% (44) and 26.8% (19) patients developed stage I and stage II pressure ulcer, respectively. Among ulcer developed patients, 2.8% (2) constituted advanced stage (stage IV) of pressure ulcer. Of those who developed pressure ulcer, most of the participants 70.4% (50) developed sacral area and 10% (7) patients developed pressure ulcer at both sacral and shoulder area (Figure 1).

3.3. Length of Stay in Hospital and Change of Patients' Position. Almost half of admitted patients (49%) in Felegehiwot referral hospital had 7–20 days length of stay in the hospital and 42.7% (180) patients were discharged before 7 days, whereas 8.3% (35) patients stayed in hospital for more than 20 days. The median hospital length of stay was 8 (interquartile range of 4–13) days. From the total individuals who developed pressure ulcer, 98.6% have not used pressure relieving device; however, only one patient applied air ring as pressure relieving device. Among the total pressure ulcer

TABLE 1: Sociodemographic characteristics of the respondents who were admitted at Felegehiwot referral hospital, Bahir Dar, Ethiopia (N = 422).

Variables	Frequency	Percent
Age		
18–32	212	50.2
33–53	135	32
≥54	75	17.8
Sex		
Female	208	49.3
Male	214	50.7
Religion		
Orthodox	350	82.9
Muslim	61	14.5
Protestant	7	1.7
Others	4	0.9
Place of residence		
Urban	180	42.7
Rural	242	57.3
Marital status		
Married	272	64.5
Single	78	18.5
Divorced	45	10.7
Widowed	27	6.4
Educational status		
Not educated	152	36
Read and write	31	7.3
Grades 1–4	59	14
Grades 5–8	70	16.6
Grades 9–10	59	14
≥grade 11	51	12.1

developed respondents 93% (66) have not changed their position by nurses. Of patients' changed their position, 67.8% (40) changed their position every 2 to 3 hours, 10% (6) changed their position every 4 hours, and 8.6% (5) changed their position 4 times per day, whereas 13.6% (8) patients changed their position less than 4 times/days.

3.4. Factors Associated with Pressure Ulcer. Fourteen independent variables were analyzed in logistic regression with dependent variable of pressure ulcer to know their association. Those variables which were significant at $P \leq 0.2$ entered into multivariate logistic regressions. This multivariate analysis had identified that length of stay in hospital, sensory perception, and friction and shear had significant association with pressure ulcer. Those participants who had stayed in hospital ≥ 21 days were 6 times (95% CI: 2.55, 15.00) more likely to develop pressure ulcer than those participants who had stayed ≤ 6 days. Participants who had slightly limited sensory perception were 3.3 times (95% CI: 1.39, 7.75) at higher risk to develop pressure ulcer than those who had no

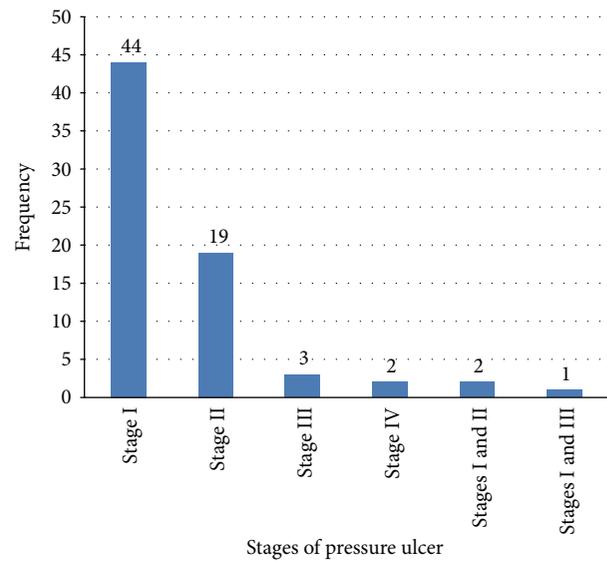


FIGURE 1: Stages of pressure ulcer in patients who were admitted at Felegehiwot referral hospital, Bahir Dar, 2013.

impairment in sensory perception. Those participants who had problem in friction and shearing forces were 4.5 times (95% CI: 1.56, 12.93) more likely to develop pressure ulcer than those who had no apparent problem (Table 2).

4. Discussion

In this study, the prevalence of pressure ulcer was 16.8%. This result was slightly higher than studies conducted in Brazil, Turkey, and Germany with prevalence of 12.7%, 10.4%, and 11.7%, respectively [15–17]. Higher prevalence in this study might be due to inappropriate nursing care and inadequate pressure relieving devices.

The prevalence rate lower than study conducted in Sweden (22.9%), Italy (27%), and Thailand (47.6%) was also found [18–20]. This discrepancy might be due to different characteristics of participants, disease condition of patients, and the variation of length of stay in hospital.

The study showed that presence of pressure ulcer was significantly associated ($P < 0.001$) with the use of pressure ulcer preventive devices [21, 22]; however, in this study 98.6% among pressure ulcer developed participants did not apply pressure relieving devices. The reason might be inadequacy of materials in the hospital or work overload of nurses in applying pressure relieving devices.

On this finding the age of the patient and length of stay in hospital were associated with the occurrence of pressure ulcer. As the age of the patient and length of stay in hospital increased, the development of pressure ulcer also increased. This finding was supported by the study conducted in Sweden; older age ($P = 0.004$) and more days of hospitalization ($P = 0.001$) were significantly associated with pressure ulcer [23]. Although age was predictor factor for pressure ulcer, it was not associated with the development of pressure ulcer in multiple logistic regressions in this study.

TABLE 2: Association between some selected variables and pressure ulcer in Felegehiwot referral hospital, Bahir Dar, Ethiopia, 2013 ($n = 422$).

Variables	Pressure ulcer		COR (95% CI)	AOR (95%)
	Yes	No		
Age				
18–32 years	30 (14.2%)	182 (85.8%)	1	
33–53 years	24 (17.8%)	111 (82.2%)	1.31 (0.73, 2.36)	
≥54 years	17 (22.7%)	58 (77.3%)	1.78 (0.91, 3.46)*	
Sex				
Male	42 (19.6%)	172 (80.4%)	1	
Female	29 (13.9%)	179 (86.1%)	0.66 (0.39, 1.11)*	
Religion				
Orthodox	60 (17.1%)	290 (82.9%)	1	
Muslim	8 (13.1%)	53 (86.9%)	0.73 (0.33, 1.61)	
Protestant	3 (42.1%)	4 (57.1%)	0.63 (0.79, 6.61)	
Others	0	4 (100%)	0.000 (0.00)	
Place of residence				
Urban	24 (13.3%)	156 (86.7%)	1	
Rural	47 (19.4%)	195 (80.6%)	1.57 (0.92, 2.68)*	
Educational status				
Illiterate	34 (22.4%)	118 (77.6%)	2.16 (0.85, 5.51)*	
Read and write	7 (22.6%)	24 (77.4%)	2.19 (0.66, 7.25)*	
Grades 1–4	6 (10.2%)	53 (89.8%)	0.85 (0.26, 2.82)	
Grades 5–8	10 (14.3%)	60 (85.7%)	1.25 (0.42, 3.69)	
Grades 9–10	8 (13.6%)	51 (86.4%)	1.18 (0.38, 3.65)	
>grade 10	6 (11.8%)	45 (88.2%)	1	
Marital status				
Married	43 (15.8%)	229 (84.2%)	1	
Single	12 (15.4%)	66 (84.6%)	0.97 (0.48, 1.94)	
Divorced	7 (15.6%)	38 (84.4%)	0.98 (0.41, 2.34)	
Widowed	9 (33.3%)	18 (66.7%)	2.66 (1.12, 6.320)**	
Length of stay				
≤6 days	14 (7.8%)	166 (92.2%)	1	1
7–20 days	45 (21.7%)	162 (78.3%)	3.29 (1.74, 6.23)**	3.71 (1.8, 7.9)
≥21 days	12 (34.3%)	23 (65.7%)	6.19 (2.55, 15.0)**	5.97 (1.98, 18)
Change of position				
No	66 (18.2%)	297 (81.8%)	2.40 (0.92, 6.23)*	
Yes	5 (8.5%)	54 (91.5%)	1	
Sensory perception				
Completely limited	7 (36.8%)	12 (63.2%)	5.54 (1.88, 16.36)**	1.39 (0.36, 5.32)
Very limited	18 (22.8%)	61 (77.2%)	2.8 (1.31, 6.00)**	1.57 (0.59, 4.16)
Slightly limited	32 (18.1%)	145 (81.9%)	2.1 (1.07, 4.10)**	3.29 (1.39, 7.75)
No impairment	14 (9.5%)	133 (90.6%)	1	1
Moisture				
Constantly moist	8 (32%)	17 (68%)	4.64 (1.48, 14.57)**	
Very moist	34 (26.8%)	93 (73.2%)	3.6 (1.51, 8.61)**	
Occasionally moist	22 (11.3%)	172 (88.7%)	1.26 (0.52, 3.09)	
Rarely moist	7 (9.2%)	69 (90.8%)	1	
Activity				
Bedfast	53 (34.4%)	101 (65.6%)	3.36 (1.24, 9.13)**	
Chairfast	8 (6.4%)	117 (93.6%)	0.44 (0.13, 1.43)*	
Walks occasionally	5 (4.7%)	101 (95.3%)	0.32 (0.09, 1.17)*	
Walks frequently	5 (13.5%)	32 (86.5%)	1	

TABLE 2: Continued.

Variables	Pressure ulcer		COR (95% CI)	AOR (95%)
	Yes	No		
Mobility				
Completely immobile	42 (47.2%)	47 (52.8%)	6.55 (2.54, 16.93)**	
Very limited	13 (9.3%)	127 (90.7%)	0.75 (0.27, 2.11)	
Slightly limited	10 (7%)	133 (93%)	0.55 (0.19, 1.60)	
No limitation	6 (12%)	44 (88%)	1	
Nutrition				
Very poor	11 (27.5%)	29 (72.5%)	2.74 (1.17, 6.42)**	
Probably inadequate	42 (17.9%)	192 (82.1%)	1.58 (0.87, 2.87)*	
Adequate	18 (12.2%)	130 (87.8%)	1	
Friction and shear				
Problem	26 (48.1%)	28 (51.9%)	13.54 (6.13, 29.9)**	4.49 (1.56, 12.9)
Potential problem	33 (18.2%)	148 (81.8%)	3.25 (1.62, 6.52)**	1.89 (0.79, 4.54)
No apparent problem	12 (6.4%)	175 (93.6%)	1	1

NB: * $P \leq 0.2$, ** $P \leq 0.05$.

The logistic regression used backward LR for multivariate analysis.

On this finding, Braden subscales pressure ulcer risk assessment of sensory perception, activity, mobility, moisture, nutrition, and friction and shear were associated with development of pressure ulcer in binary logistic regression. A similar study was conducted in Sweden; these Braden scales were associated with the occurrence of pressure ulcer [9]; however, of the six Braden subscales, sensory perception and friction and shear were associated with pressure ulcer development in multiple logistic regression in this finding.

Patients with completely limited activity and who had moisture were liable to develop pressure ulcer. The presence of constant moisture and bedfast (completely limited activity) for long period of time facilitate skin laceration. This study also revealed the association between completely limited activity and moisture and pressure ulcer development in binary logistic regression. A similar study was conducted in Thailand, which revealed that occurrence of pressure ulcer was associated with the completely limited activity and presence of moisture [22]. However these two Braden subscales were not strongly associated with multiple logistic regressions in this investigation.

The major predictor of Braden subscale associated with developed pressure ulcer in hospitalized patients in this study was the problem of friction and shearing forces. When shear occurs, tissue layers slide over one another, blood vessels stretch and twist, and the microcirculation of the skin and subcutaneous tissue is disrupted. The present study investigated that the problem of friction and shearing was statistically significant and strongly associated with pressure ulcer development. This result was in agreement with the study conducted in Brazil [11]. The possible reason is due to the fact that friction and shearing problem lacerates skin forcefully.

Due to the fact that patients with completely limited sensory perception were liable to friction and shear problem, this finding revealed that highest prevalence of pressure ulcer was seen in patients with friction and shear problem. This is in

line with the study done in Germany [24]. The possible reason might be that completely limited sensory perception patients cannot perform activities and change their position without assistant and they are sliding down from the bed.

Spastic muscles and paralysis increase the patient's vulnerability to pressure ulcers related to friction and shear. As the person slides down or is improperly pulled up in bed, friction resists this movement. Shear occurs when one layer of tissue slides over another, disrupting microcirculation of skin and subcutaneous tissue. This finding also investigated that friction and shearing force was strongly associated with the occurrence of pressure ulcer. This is in line with the study conducted in Thailand [20]. The reason is that mechanical forces contribute to pressure ulcer development.

In this study, it was revealed that the prevalence of pressure ulcer increased when hospitalization of patient increased. This implies that length of time was significantly associated with occurrence of pressure ulcer. This finding was in agreement with the study conducted in Sweden, more hospitalization of patients strongly associated with development of pressure ulcer [23]. This might be due to prolonged pressure and decrease of blood circulation in particular area.

Regarding hospitalization time, in this study, it was revealed that the prevalence of pressure ulcer increased with the increase of time of patient's stay in hospital. In multivariate analysis, the association between hospitalization time of more than 7 days and pressure ulcer occurrence was very strong. The development of pressure ulcer was strongly associated with long stay of patients in hospital. According to literature in Turkey pressure ulcers usually develop within the first two weeks of hospitalization [25]. This finding also investigated that majority of patients developed pressure ulcer staying in hospital for more than 20 days. When patients stay in hospital for long period of time, they will be exposed to hospital acquired infection and they will be susceptible to development of pressure ulcer. So that length of

stay in hospital was strongly associated with the development of pressure ulcer. This finding was supported by the study conducted in Brazil [8]. The possible reason of association between length of stay in hospital and occurrence of pressure ulcer is that patients may not get appropriate nursing care and adequate nutrition and they deteriorate with concomitant disease.

Patients with sensory loss, impaired level of consciousness, or paralysis may not be aware of the discomfort associated with prolonged pressure on the skin and, therefore, may not change their position themselves to relieve the pressure. This prolonged pressure impedes blood flow, reducing nourishment of the skin and underlying tissues, despite the fact that in this finding slightly limited sensory perception was associated with occurrence of PU. This finding was in agreement with the study conducted in Thailand; pressure ulcers were most developed in patients who had slight limitation in sensory perception [22]. The possible reason might be that most of respondents participating in this study had slightly limited sensory perception.

This study had also some limitations. The main limitations of this study were that pressure ulcer was done through cross-sectional rather than prospective (follow-up) study, lack of standardized questionnaire related to this specific topic, and lack of literature in Ethiopia which makes it difficult to compare results.

5. Conclusion

The prevalence of pressure ulcer was high among hospitalized patients. Prolonged length of stay in hospital, problem of sensory perception, and friction and shearing forces were significantly associated with the presence of pressure ulcer. Patients who had stayed in hospital for more than twenty days and had problem in friction and shear were more liable to develop pressure ulcer. Majority of ulcer developed patients did not change their position by the nurse frequently.

Appendix

Braden Scale Pressure Ulcer Risk Assessment

Sensory Perception. Sensory perception measures the individual ability to feel and report discomfort.

- (1) *Completely Limited.* The patient is unresponsive (does not moan, flinch, or grasp) to painful stimuli, due to diminished level of consciousness or sedation or limited ability to feel pain over most of the body.
- (2) *Very Limited.* The patient responds only to painful stimuli, cannot communicate discomfort except by moaning or restlessness, or has a sensory impairment which limits the ability to feel pain or discomfort over 1/2 of body.
- (3) *Slightly Limited.* The patient responds to verbal commands but cannot always communicate discomfort or the need to be turned or has some sensory

impairment which limits the ability to feel pain or discomfort in one or two extremities.

- (4) *No Impairment.* The patient responds to verbal commands and has no sensory deficit which would limit the ability to feel or voice pain or discomfort.

Moisture. Moisture measures the degree to which the skin is exposed to moisture.

- (1) *Constantly Moist.* The skin is kept moist almost constantly by perspiration, urine, and so forth; dampness is detected every time the patient is moved or turned.
- (2) *Very Moist.* The skin is often but not always moist. Linen must be changed at least once a shift.
- (3) *Occasionally Moist.* The skin is occasionally moist, requiring an extra linen change approximately once a day.
- (4) *Rarely Moist.* The skin is usually dry; linen only requires changing at routine intervals.

Activity. This includes degree of physical activity.

- (1) *Bedfast.* The patient is confined to bed.
- (2) *Chairfast.* This includes severely limited ability to walk or nonexistent one. The patient cannot bear his/her own weight and/or must be assisted into chair or wheelchair.
- (3) *Walks Occasionally.* The patient walks occasionally during day, but for very short distances, with or without assistance and spends the majority of each shift in bed or chair.
- (4) *Walks Frequently.* The patient walks outside the room at least twice a day and inside the room at least once every 2 hours during waking hours.

Mobility. This includes the ability to change and control body position.

- (1) *Completely Immobile.* The patient does not make even slight changes in his/her body or extremity position without assistance.
- (2) *Very Limited.* The patient makes occasional slight changes in his/her body or extremity position but is unable to make frequent or significant changes independently.
- (3) *Slightly Limited.* The patient makes frequent slight changes in his/her body or extremity position independently.
- (4) *No Limitation.* The patient makes major and frequent changes in his/her position without assistance.

Nutrition. Nutrition reflects the food intake pattern of the assessed person, as well as liquid supplements.

- (1) *Very Poor*. The patient never eats a complete meal, rarely eats more than 1/3 of any food offered, eats 2 servings or less of protein (meat or dairy products) per day, takes fluid poorly, does not take a liquid dietary supplement, or does not take any food by mouth and/or maintained on clear liquids or intravenous solutions for more than 5 days.
- (2) *Probably Inadequate*. The patient rarely eats a complete meal and generally eats only about 1/2 of any food offered. Protein intake includes only 3 servings of meat or dairy products per day. Occasionally the patient will take a dietary supplement or receives less than optimum amount of liquid diet or tube feeding.
- (3) *Adequate*. The patient eats over half of most meals, eats a total of 4 servings of protein (meat, dairy products) per day, occasionally will refuse a meal but will usually take a supplement when offered, or is on a tube feeding.

Friction/Shear. Friction and shear assess the person's ability to keep the skin free from contact with the wrinkle area.

- (1) *Problem*. The patient requires moderate to maximum assistance in moving. Complete lifting without sliding against sheets is impossible. The patient frequently slides down in bed or chair, requiring frequent repositioning with maximum assistance. Spasticity, contractures, or agitation leads to almost constant friction.
- (2) *Potential Problem*. The patient moves feebly or requires minimum assistance. During a move skin probably slides to some extent against sheets, chair, restraints, or other devices. The patient maintains relatively good position in chair or bed most of time but occasionally slides down.
- (3) *No Apparent Problem*. The patient moves in bed and in chair independently and has sufficient muscle strength to lift up completely during move and maintains good position in bed or chair.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Authors' Contribution

Haileyesus Gedamu wrote the proposal, participated in data collection, analyzed the data, and drafted the paper. Abdella Amano and Mignote Hailu approved the proposal with some revisions, participated in data analysis, and revised subsequent drafts of the paper. All authors read and approved the final paper. Abdella Amano and Mignote Hailu contributed equally to this work.

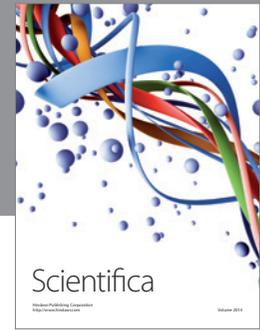
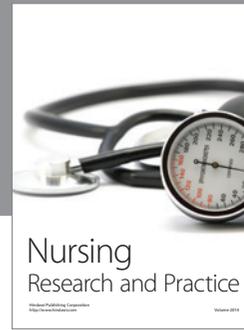
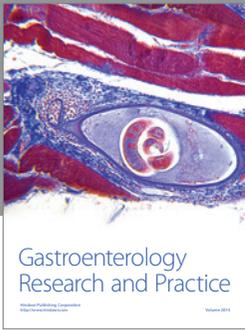
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