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Research Article

Analysis of fall risk increasing drugs on Morse Fall Scale in geriatric patients (a study at geriatric outpatient clinic Airlangga University Teaching Hospital)

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Abstract

Falls are the geriatric syndromes that become one of the main causes of injury, even death in the elderly. It is known that one of the risk factors for falling is the use of certain drugs that have the effect of orthostatic hypotension, sedation, balance disruptions, and other side effects. This study aims to examine the risk of falling based on Morse scale of geriatric patient that use fall-risk drug. Retrospective data were taken from e-prescriptions for geriatric patients and interviews with the patients to determine the risk of falling based on the Morse scale. The results showed that 115 patients who used the fall-risk drug had an average risk of falling from mild to moderate. The high fall-risk drug used by most patients was gabapentin (43%), the moderate fall-risk drug was candesartan (60%), and the low fall-risk drug was furosemide (9%). Patients with the total of 71% received a combination of two to four fall-risk drugs. Total MFRS of ≥6 was 53% patients, meaning that the patients' using of drugs needed to be evaluated. From the results of statistical analysis, it was found that the number of fall risk drugs received by patients was not associated to the risk of falling in geriatric patients, while increasing the dose of high fall-risk drugs such as gabapentin, increased the fall risk level in geriatric patients. From the result of this study, it is known that fall-risk drugs are widely used by patients, hence it is necessary to increase the awareness of falling in geriatric patients.

Keywords

geriatric patients, fall risk increasing drugs, Morse Fall Scale, Medication Fall Risk Score, antihypertension, gabapentin

Introduction

The number of elderly people in Indonesia is approximately 9.92% of its total population or 26.82 million people. The elderly population is projected in 2045 to reach one-fifth of the total population of Indonesia (Badan Pusat Statistik 2020). The increase in the number of elderly has an impact on increasing the prevalence of chronic diseases, thereby increasing hospitalization and health costs (Hailu et al. 2020). Geriatric patients often experience worsening clinical and physiological conditions in several common organ systems, which are associated with increased morbidity and mortality (Kim and Miller 2017). The accumulation of disturbance conditions on multiple

systems and the inability of individuals to compensate for these disorders make the elderly vulnerable to situational changes referred to as geriatric syndromes (Gupta et al. 2015; Magnuson et al. 2019). Geriatric syndromes which include a decrease in several physiological systems including musculoskeletal, cardiovascular, visual, vestibular, coordination, postural responses, and cognitive function have been shown to increase the risk of falling in elderly patients so as to increase the cost of health services that must be borne by the patient (Ambrose et al. 2013).

Falls are one of the geriatric syndromes (Gupta et al. 2015). Around 30% of the elderly in Indonesia fall every year (Noorratri et al. 2020). WHO defines a fall as an event when a person suddenly changes body position, lying down, unintentionally on the ground or on the floor or in a lower place (Huang et al. 2012). Falls are one of the main causes of injury and death in elderly patients (Ambrose et al. 2013). With age, the ability to adapt to falls decreases which causes elderly patients to often experience hip or hip fractures (Dipiro et al. 2020). Moreover, elderly patients who have experienced fractures due to falls have a high risk of falling again (Correa-Pérez et al. 2019).

Several studies have found various risk factors for falls in elderly patients which include: cognitive impairment, impaired strength or function of the lower extremities, balance disruptions, visual disturbances, nocturia, as well as the amount and effect of drugs taken (Kane et al. 2013). The risk of falling is a multifactorial problem related to intrinsic factors (cannot be modified) and extrinsic factors (can be modified) (Huang et al. 2012; Michalcova et al. 2020). Intrinsic factors are factors related to aging such as changes in pharmacodynamics and pharmacokinetics in the elderly, the presence of comorbidities (comorbid), muscle weakness, impaired vision and hearing resulting in impaired balance, mobility, and activities of daily living. While extrinsic factors include unsafe environments, such as furniture that is not sturdy and lighting is not good, as well as drugs consumed which will cause falls . (Huang et al. 2012; Kane et al. 2013; Michalcova et al. 2020).

Fall risk increasing drugs generally work by affecting the cardiovascular system or the central nervous system (Lee et al. 2021). Drugs acting on the central nervous system, can increase the risk of falling because it cause sedation, dizziness, cognitive impairment, balance disruption, and brain perfusion (Cuevas-Trisan 2019; Gray et al. 2019). Drugs that act on the central nervous system, including antidepressants, antipsychotics, hypnotics, drugs to treat bipolar and dementia, have been shown to increase the risk of falls in the elderly by 47% (Ambrose et al. 2013). In a retrospective study done by Costa-Dias et al. (2014), it was shown that patients who received drug therapy from the central nervous system group were ten times more likely to fall. For example, the use of antidepressants with the TCA (Tricyclic Antidepressant) and SSRI (Selective Serotonin Reuptake Inhibitor) groups can significantly increase the risk of falling. Furthermore, benzodiazepines and antipsychotics are also associated with an increased risk of falling (Seppala et al. 2018).

In a meta-analysis study, it was reported that antihypertensives are known to increase the risk of falls due to impaired balance, dizziness, and orthostatic hypotension (de Vries et al. 2018).The use of diuretics, such as loop diuretics and thiazides can cause orthostatic hypotension due to an extracellular fluid imbalance which can lead to hypovolemia. In a cross-sectional study of ER patients, it was shown that the thiazide group was the most common cause of falls compared to other diuretic groups (Ravioli et al. 2021).

Elderly patients tend to have two or more chronic or multi-morbid conditions, such as hypertension, arthritis, heart disease, cancer, diabetes, asthma, chronic bronchitis or emphysema, and stroke, thus requiring many drugs to be used for therapy or prophylaxis (Dipiro et al. 2020). Therefore, elderly patients often receive polypharmacy therapy (Christie 2019). Polypharmacy can be beneficial if used properly, but polypharmacy also has the potential to have negative effects, namely reducing patient compliance, side effects, increasing the use of health services due to adverse effects, falls, cognitive impairment and mortality (Davies et al. 2020). Polypharmacy can be a risk factor for falls due to increased harmful drug interactions or increased effects of drugs (Freeland et al. 2012). It is known that an individual's increased risk of falling is the result of the cumulative burden of using fall-risk drugs or interactions with the fall-risk drugs taken. A study conducted by Wilson et al., reported that an increase in the number of fall risk drugs taken, namely sedative and anticholinergic drugs was significantly associated with an increased risk of falling. Similarly, a study conducted by Callisaya et al., reported that increasing the daily dose of antihypertensives (one of the drugs at risk of falling), increases the risk of falling in the elderly (Zia et al. 2017). With age, there is a decrease in liver and kidney function, an increase in total body fat, metabolic changes, a decrease in drug clearance, so that with polypharmacy there will be an increased risk of experiencing drug side effects or the risk of falling (Dagli and Sharma 2014; Ming et al. 2021).

The risk of falling can be prevented by developing an effective fall prevention strategy. An important component of the prevention strategy is to provide an assessment of the patient's fall risk. Fall risk assessment can help health professionals to identify patients at high risk of falling so that they can develop prevention strategies for these patients. The fall risk assessment instrument commonly used in hospitals is the St. Thomas's risk assessment tool in falling elderly inpatients (STRATIFY), Morse Fall Scale (MFS), and Hendrich Fall Risk Model (HFRM II). Of the three instruments, the MFS instrument or Morse Fall Scale is the most widely used by more than 30% of hospitals and has been shown to be effective in assessing patient falls. It was shown that there was an association between MFS scores and the incidence of falls in acute care (Jewell et al. 2020).

The Agency for Healthcare Research and Quality (AHRQ) provides a recommendation to use the Medication Fall Risk Score (MFRS) as an instrument to assess

the risk of drug-induced falls in patients. This MFRS instrument which is used in conjunction with STRATIFY or MFS, can support fall risk assessment and can plan interventions for patients. In the MFRS instrument, fall risk increasing drug are classified according to their level of risk. Analgesic drugs, including opioids, antipsychotics, anticonvulsants, and benzodiazepines, are classified as high-risk drugs for falls. Antihypertensive drugs, cardiac, antiarrhythmic, antidepressants are included in the class of drugs that are at moderate-risk, while diuretic drugs are classified as low-risk drugs causing falls in elderly patients (Ganz et al. 2013). The fall risk classification based on the MFS instrument combined with MFRS yields a sensitivity of 82% and a specificity of 67% so that it has a high predictive value (Yazdani and Hall 2017). By knowing the value of the patient's fall risk score, pharmacists can evaluate the treatment therapy that the patient is undergoing (Ganz et al. 2013).

Based on the description above, the incidence of falls in geriatric patients has various risk factors, including the use of fall risk increasing drugs. Consequently, this study needs to be carried out in the hope of providing information regarding the use of drugs that increase the risk of falling. With this information, guidelines or fall prevention strategies can be made, thereby providing services to geriatric patients so as to improve the quality of health services.

Method

Patients and data collection

This study was an observational study and conducted to observe and analyzed the effect of fall risk drugs on the Morse scale. Data were collected in a retrospective, cross-sectional design, by conducting an interview with patients using the Morse scale and observing the retrospective data of e-prescribing for geriatric patients at the Geriatric Outpatient Clinic. Data collection was carried out from April to June 2022. The research instrument used in this study was a data collection sheet in the form of a Morse scale questionnaire and e-prescribing for geriatric patients obtained from the Outpatient Pharmacy. The inclusion criteria in this study were elderly patients (≥60 years old) at the Geriatric Outpatient Clinic, who received and consumed treatment of fall-risk drugs at least for a month prior to the sampling time (April–June 2022), the patients agreed to be a part of this study, and their data were complete. The exclusion criteria in this study were the geriatric patients who just received the fall-risk drugs in the same day within the sampling time. Sampling method in this study was purposive sampling, where the sample was not randomly selected and was chosen because it met the inclusion criteria. The sampling process ended when the total number of samples was met or until the specified time limit. This research was approved by the Research Ethics Commission of the Airlangga University Hospital and was declared to have passed the ethical review with a Certificate of Passing the Ethics Review Number 030/KEP/2022.

Data analysis

Presentation of patient demographic data (age and gender), patient diagnosis results, treatment therapy profile (type, amount, dose, frequency, and duration of drug use), as well as the results of Morse scale calculations and MFRS scores are presented descriptively in the form of frequency (n) and percentage (%). Data analysis using statistics was used to determine the relationship between drug use (amount of drug, drug dose, and MFRS score) with the risk of falling as measured using the Morse scale. The data obtained were tested for normality. If the results of the normality test showed that the data was normally distributed (sig. >0.05), then the data would be tested using the Pearson correlation method. If the results of the normality test showed that the data was not normally distributed (sig. <0.05), then the data would be tested using the Spearman Rho's method.

Results

Of the 115 patients taken, geriatric patients who received fall-risk drugs were 65 female patients (57%) and male geriatric patients as many as 50 patients (43%). According to a study conducted by Rahmawati in 2019, geriatric patients who use fall risk drug were more female than male (Rahmawati et al. 2019). In accordance with the report from the Central Statistics Agency (BPS) in 2020, the number of elderly women in Indonesia was more than men because the life expectancy of women is higher than that of men (Badan Pusat Statistik 2020).

For age distribution, subjects were divided into three classifications, which are young elderly (60–69 years), middle elderly (70–79 years), and old elderly (≥80 years). From the results obtained, geriatric patients who use fall-risk drugs were dominated by middle-aged patients, as many as 59 patients (51%). In contrast to the research conducted by Rahmawati in 2019, geriatric patients who use fall-risk drugs were dominated by young elderly people, followed by middle and old elderly male (Rahmawati et al. 2019). According to a report from the Central Statistics Agency in 2020, the highest number of elderly people in Indonesia was the young elderly (Badan Pusat Statistik, 2020). The disease condition of geriatric patients was one of the intrinsic factors that can lead to falls (Kane et al. 2013). Geriatric patients generally have two or more diseases. In Table 1, it is seen that the majority (57%) of geriatric patients who received fall-risk drugs with two diseases. In Fig. 1, the type of disease that dominates geriatric patients is hypertension as many as 96 patients (83%) and diabetes mellitus as many as 92 patients (80%). Since geriatric patients have two or more diseases, it would have an impact on the

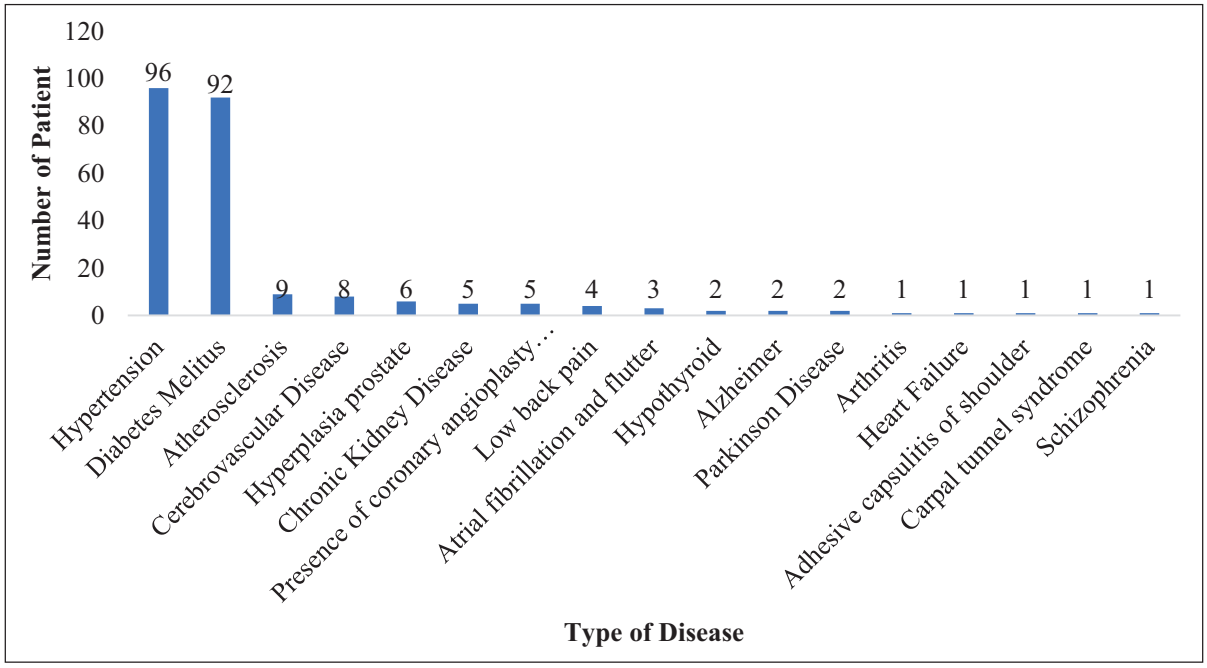

Figure 1. Type of disease in geriatrics.

number of drugs received by the patient. In Table, it is seen that 75 patients (65%) received five to nine drugs and 22 patients (19%) received ten to fourteen drugs.

Table 1. Subject characteristic.

Subject characteristic		Total n (%)
Gender	Male	50 (43)
	Female	65 (57)
Age	60–69 (young elderly)	42 (37)
	70–79 (middle elderly)	59 (51)
	≥80 (old elderly)	14 (12)
Number of diseases	1 Disease	13 (11)
	2 Diseases	66 (57)
	3 Diseases	28 (24)
	4 Diseases	8 (7)
Number of drugs	<5 drugs	18 (16)
	5–9 drugs (polypharmacy)	75 (65)
	10–14 drugs (excessive polypharmacy)	22 (19)

Patients who got more than 5 types of drugs were called polypharmacy and patients who got more than 10 types of drugs were called excessive polypharmacy (Fauziah et al. 2020).

In Table 2, the result of interviews related to the risk of falling for geriatric patients are presented. The instrument used to measure the risk of falling in geriatric patients was the Morse scale. In the Morse scale, there are five points in the form of risk factors for falls that may be experienced by patients including, history of falls in the last three months, secondary diagnosis, walking aids, gait, and mental status of the patient.

Fall-risk drugs that are received by geriatric patients at the Geriatric Outpatient Clinic are classified based on the level of the risk of falling according to Ganz et al. 2013. In Fig. 2, candesartan which is classified as moderate risk of falling is the most consumed drug by patients with a percentage of 60%, followed by nifedipine

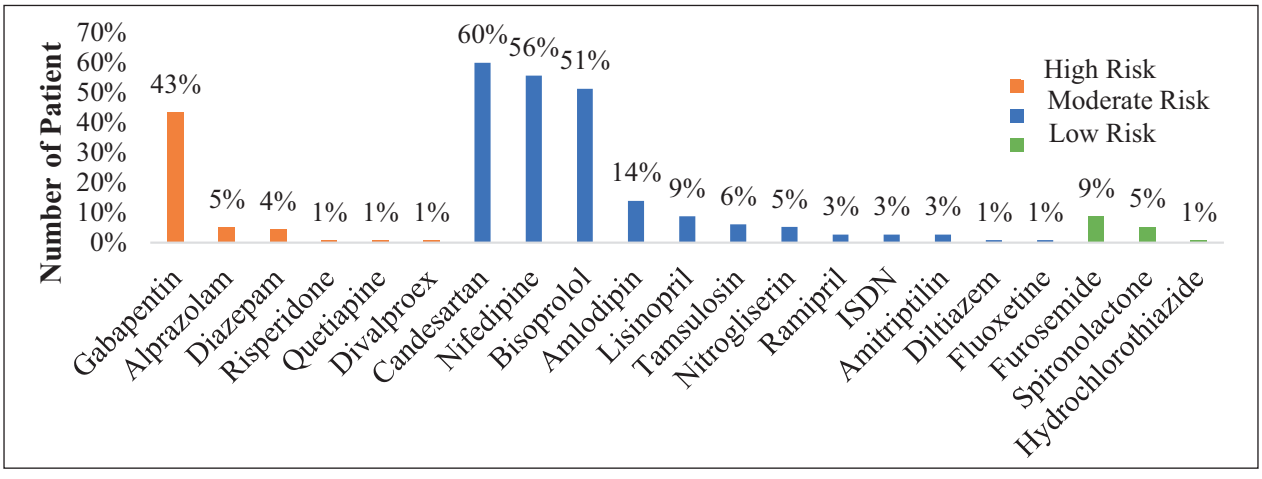

Figure 2. The use of fall risk drugs in geriatrics.

(moderate risk of falling) at 56%, bisoprolol 51% (moderate risk of falling), and gabapentin 43% (high risk of falling).

Table 2. Morse fall risk in geriatrics.

Fall risk	Morse score	Mean	n (%)
No risk	0	0	8 (7)
Low Risk	<25	15±1,4	49 (43)
Moderate Risk	25–45	30±6,8	56 (49)
High Risk	>45	50	2 (2)

Fall-risk drugs that are included in high risk with an MFRS score of three are presented in Table 3. The highest fall-risk drug that geriatric patient used was Gabapentin with a percentage of 43%. Gabapentin has two dosage regimens, that are 1×100 mg in 27% of patients and 1×300 mg in 17% of patients. The longest duration of gabapentin use was one to five years for a dose of 1×100 mg and >5 years for a dose of 1×300 mg.

Table 3. High fall-risk drugs.

Fall risk drugs	n	%	Duration of use	n	%
Antipsychotic					
Risperidone 1×2 mg	1	1	>5 years	1	1
Quetiapine 1×200 mg	1	1	>5 years	1	1
Anticonvulsant					
Gabapentin	50	43			
1×100 mg	32	27	<1 year	11	10
			1–5 years	12	10
			>5 years	8	7
1×300 mg	18	17	<1 year	4	3
			1–5 years	6	5
			>5 years	9	8
Divalproex 1×250 mg	1	1	>5 years	1	1
Benzodiazepine					
Alprazolam	6	5			
1×0,25 mg	3	3	<1 year	1	1
			1–5 years	1	1
			>5 years	1	1
1×0,5 mg	3	3	<1 year	2	2
			1–5 years	1	1
Diazepam 1×2 mg	5	4	<1 year	4	3
			1–5 years	1	1

• Percentage based on the total number of patients receiving fall risk drugs.
• One patient can have more than one fall risk drugs.

Fall-risk drugs included in moderate risk with an MFRS score of two are presented in Table 4. The most moderate fall-risk drug that geriatric patient used was candesartan with a percentage of 60%. Candesartan has two dosage regimens, that are 1×8 mg for 34 patients and 1×16 mg for 35 patients. The duration of use of candesartan in geriatric patients >5 years.

Fall-risk drugs that are included in low risk with an MFRS score of one are presented in Table 5. The lowest fall-risk drug that geriatric patient used was furosemide with a percentage of 9%. The dosage regimen of furosemide received by the patient was 1×40 mg. The longest duration of furosemide use was more than five years.

Table 4. Moderate fall-risk drugs.

Fall risk drugs	n	%	Duration of use	n	%
Antihypertension					
Candesartan	69	60			
1×8 mg	34	30	>5 years	34	30
1×16 mg	35	30	>5 years	35	30
Bisoprolol	59	51			1
1×1,25 mg	1	1	1–5 years	1	11
1×2,5 mg	51	44	<1 year	13	11
			1–5 years	13	22
			>5 years	25	
1×5 mg	7	6	<1 year	1	1
			1–5 years	2	2
			>5 years	4	3
Nifedipine 1×30 mg	64	56	<1 year	12	10
			1–5 years	19	17
			>5 years	33	29
Amlodipine	16	14			
1×5 mg	7	6	<1 year	2	2
			1–5 years	3	3
			>5 years	2	2
1×10 mg	9	8	<1 year	1	1
			1–5 years	4	3
			>5 years	4	3
Lisinopril	10	9			
1×5 mg	5	4	<1 year	1	1
			1–5 years	2	2
			>5 years	2	2
1×10 mg	5	4	<1 year	2	2
			1–5 years	1	1
			>5 years	2	2
Tamsulosin 1×0,4 mg	7	6			
			<1 year	2	2
			1–5 years	4	3
			>5 years	1	1
Ramipril	3	3			
1×2,5 mg	1	1	>5 years	1	1
1×5 mg	2	2	>5 years	2	2
Nitrates					
Nitro-glycerine 1×2,5	6	5	1–5 years	2	2
mg			>5 years	3	3
Isosorbide Dinitrate	3	3	<1 year	1	1
1×5 mg			1–5 years	2	2
Antiarrhythmic					
Diltiazem 1× 200 mg	1	1	1–5 years	1	1
Antidepressant					
Amitriptyline 1×25 mg	3	3	<1 year	1	1
			1–5 years	2	2
Fluo×etine 1×20 mg	1	1	>5 years	1	1

Table 5. Low fall-risk drugs.

Fall risk drugs	n	%	Duration of use	n	%
Diuretics					
Hydrochlorothiazide 1×25 mg	1	1	<1 year	1	1
Furosemide 1×40 mg	10	9	<1 year	3	3
			1–5 years	3	3
			>5 years	4	3
Spironolactone 1×25 mg	6	5	<1 year	2	2
			1–5 years	1	1
			>5 years	3	3

• Percentage based on the total number of patients receiving fall risk drugs.
• One patient can have more than one fall risk drugs.

Table 6. Number of fall-risk drugs used by geriatrics.

Parameter	MFRS/ drugs combination	Number of patients	Morse fall scale (Number of patients/%[b])			
			No risk	Low risk	Moderate risk	High risk
Number of fall-risk drugs	Single	21 (18%)	5 (24)	6 (29)	10 (48)	0 (0)
	2–4 drugs	82 (71%)	5 (6)	38 (46)	39 (48)	0 (0)
	5–7 drugs	12 (10%)	0 (0)	3 (25)	7 (58)	2 (17)
Medication fall risk score	<6	54 (47%)	7 (6)	22 (22)	25 (22)	0 (0)
	≥6	61 (53%)	1 (1)	27 (27)	31 (27)	2 (2)

[a]Percentage based on the total number of patients receiving fall-risk drugs (n=115).
[b]Percentage based on total patients for each parameter.

In Table 6, the number of fall-risk drugs received by geriatric patients is presented. It was found that 71% of geriatric patients who received fall-risk drugs received a combination two to four fall-risk drugs. Of the patients with the combination, the average Morse fall risk score was low to moderate. Each fall-risk drug used by the patient was scored according to the level of risk of falling based on a classification by Ganz et al. 2013 called the Medication Fall Risk Score (MFRS). The MFRS classification based on the level of risk of falling from potential side effects of the drug that based on the literature. According to the MFRS, when the patient's medication scores sic, meaning that the patient is at high risk of falling so that drug use needs to be evaluated (Ganz et al. 2013).

For the sake of determining the correlation between the MFRS score and the risk of falling in geriatric patients, statistical tests were performed. The score data was first tested for normality using the Kolmogorov–Smirnov test to determine if the data were normally or not normally distributed. The result of the significance value of the normality test obtained 0.0 (<0.05), then the data was not normally distributed. In order to find out the correlation between variables, Spearman's non-parametric correlation test was used. From the results of the Spearman test, the result obtained a significance value of 0.034 (<0.05) so that it was stated that there was a significant correlation between variables. Then from the value of the correlation coefficient, the result is (+) 0.198, namely between variables there was a weak correlation (Akoglu 2018).

In order to determine the correlation between the number of drugs and the risk of falling in geriatric patients, statistical tests were carried out. The score data was first tested for normality using the Kolmogorov-Smirnov test, which was to determine if the data were normally or not normally distributed. The results of the significance value of the normality test obtained 0.0 (<0.05), then the data was not normally distributed. In exchange for finding out the correlation between variables, Spearman's non-parametric correlation test was used. From the results of the Spearman test, significance value of 0.080 (> 0.05) was obtained, so that it is stated that there was no significant correlation between variables. Then, from the value of the correlation coefficient, the result was (+) 0.161, namely between variables there was a weak correlation (Akoglu 2018).

In order to determine the correlation between drug dose and risk of falls in geriatric patients, a statistical test was conducted between the dose of one drug (which is Gabapentin, the most used of high fall-risk drugs) and Morse score. Gabapentin doses used by patients were 100 mg and 300 mg. The score data was first tested for normality using the Kolmogorov-Smirnov test to determine if the data were normally or not normally distributed. The results of the significance value of the normality test obtained 0.0 or less than 0.05, then the data was not normally distributed. To test the difference in the dose of gabapentin 100 mg and 300 mg, a non-parametric Mann-Whitney U test was carried out. The results of the significance value of the test were 0.008 or <0.05 so that there was a difference in the Morse scale mean in patients with a dose of gabapentin 100 mg and gabapentin. 300 mg.

To determine the correlation between the increase in gabapentin dose and the Morse scale, a non-parametric Spearman Rho's correlation test was carried out. From the results of the Spearman Rho's test, the results obtained a significance value of 0.006 (<0.05) so that it is stated that there is a significant correlation between variables. From the correlation coefficient value, the result is (+) 0.380, namely between variables having a moderate correlation (Akoglu 2018).

Discussion

This study aims to assess the risk of falling of fall-risk drugs in geriatric patients. One of the intrinsic risk factors for falls in elderly patients is the patient's disease condition (Kane et al. 2013). The number of diseases a person has will increase with age (Lu et al. 2021). In Table 1, it is shown that the number of geriatric patients who have more than two diseases has a larger percentage than those who have only one disease. This is in accordance with a study conducted by Lu et al. 2021 that more than half of geriatric patients had more than two diseases. From this stud, it is known that patients with more than one disease have a higher percentage of falling compared to those with only one disease (Lu et al. 2021). The number of diseases that geriatric patients have an effect on the patient's risk of falling, thus this is one of the fall risk assessments on the Morse scale. The number of diseases the patient has, indicates that the patient has polypharmacy (Morse 2009). In this study, as shown in Table 1, more than half (65%) of geriatric patients received more than five drugs or it was called polypharmacy and 19% of geriatric patients received more than ten drugs or it was called excessive

polypharmacy. Polypharmacy is associated with the risk of falling due to the possibility of drugs interactions, so that high attention is needed for patients with polypharmacy (Seppala et al. 2018). Therapeutic reconciliation is important in preventing drug side effects so that the role of pharmacists is needed (Costa-Dias et al. 2014).

Table 2 presents the results of interviews using the Morse scale to assess the risk of falling in geriatric patients at the Airlangga University Hospital who use drugs at risk of falling. The results showed that 43% of geriatric patients taking medication at risk of falling had a Morse fall risk score of mild and 49% moderate risk. This is in line with a study conducted by Annisa et al. 2019, that geriatric patients at the Internal Medicine Clinic Hospital in Madiun are more at risk for mild and moderate falls than at high risk.

In Fig. 2, it can be seen the distribution of fall-risk drugs based on risk level of the drug. The high fall-risk drugs were dominated by gabapentin which was used by fifty patients. This is in accordance with research by Rahmawati et al. 2019, that Gabapentin is the most high-risk drug used by geriatric patients. Gabapentin is an anticonvulsant group which is one of the first-line therapies to treat diabetic neuropathy, so it is widely used by geriatric patients with diabetes mellitus. Gabapentin binds to receptors on the $\alpha 2$-δ subunit calcium channel which prevents the release of the neurotransmitter so that it can effectively treat pain caused in patients with diabetic neuropathy (Pop-Busui et al. 2017). Due to its activity on the central nervous system, gabapentin is included in the drug at risk of falling because it causes side effects of dizziness, ataxia, and sedation (Haasum and Johnell 2017; Maximos et al. 2017). In addition, gabapentin has side effects in the form of a decrease in bone mineral density, thereby increasing the risk of falls and fractures (Ishida et al. 2017). The dose for elderly patients starts from the lowest dose of 100 mg before bedtime and slowly increases to see possible side effects (Pedowitz et al. 2021). In elderly patients, changes in brain size and weight occur and an increase in the proportion of body fat in the elderly makes drugs that act on the central nervous system including gabapentin penetrate more easily so that their effect on elderly patients will increase (Dipiro et al. 2017).

The second most high fall-risk drugs were benzodiazepines used by eleven patients (Table 3). This is in accordance with research by Annisa et al. 2019, that diazepam which is a benzodiazepine class is the second most common drug after gabapentin used by geriatric patients. In a research study done by Marron et al. 2020, benzodiazepine drugs were associated with falls in geriatric patients and the incidence of falls increased in patients who also experienced worsening sleep quality. The use of benzodiazepines for geriatric patients is to treat anxiety disorders, sleeping disorders and muscle relaxants (Gupta et al. 2021). Benzodiazepines work by binding to benzodiazepine receptors located on GABA-A receptors in the central nervous system. When benzodiazepines bind to the receptor, changes in the conformation of the GABA receptor lead to an increase in the binding affinity of GABA and increases the action of GABA in Cl- conductance causing an anti-anxiety and muscle relaxant effect (Neal 2016; Rahmawati et al. 2019). Because of its effect on the central nervous system, it is feared that geriatric patients experience an increased sensitivity to side effects and drug interactions of the benzodiazepine class and the potential for addiction. One of the side effects that can occur with the use of benzodiazepines is falling because benzodiazepines cause sedation, unstable gait and psychomotor incoordination. Benzodiazepines with long-term use also have the potential to cause irreversible cognitive impairment in the elderly (Gupta et al. 2021). In a study conducted by Seppala et al. 2018 long-acting benzodiazepines were more at risk of falling than short-acting benzodiazepines. In this study, there were two types of benzodiazepine drugs used by geriatric patients, there were alprazolam (six patients) and diazepam (five patients). Alprazolam is a short-acting benzodiazepine drug, while diazepam is a long-acting benzodiazepine drug. However, according to Beer's Criteria, all types of benzodiazepines increase the risk of cognitive impairment, delirium, falls, fractures, and motor vehicle accidents in the elderly, so that all types of benzodiazepines should be avoided by elderly patients (Fick et al. 2019).

Moderate-fall risk drugs are the most common fall-risk drugs used by geriatric patients (Fig. 2). There are several types of drug classes with a moderate risk of falling, there are antihypertensive drugs, heart drugs, antiarrhythmics, and antidepressants. The most used one is the antihypertensive group, namely candesartan with a percentage of 60% (Table 4). This is in accordance with research by Rahmawati et al. 2019, that said antihypertensives are a class of drugs at risk of falling that dominate geriatric patients. Candesartan is an Angiotensin Receptor Blocker (ARB) antihypertensive which works by inhibiting the action of angiotensin II which causes vasoconstriction and aldosterone secretion inhibition so that it can lower blood pressure (Katzung 2018). According to a study conducted by Tinetti et al. 2014, antihypertensives (including ACEI, ARBs, diuretics, -blockers, and CCBs) were associated with an increased risk of falls in elderly patients with hypertension. This is because antihypertensives generally have side effects that are also risk factors for falls, including dizziness, balance disruptions, and postural hypotension (Tinetti et al. 2014). In a study conducted by Callisaya et al. 2014, increasing daily doses of antihypertensives was associated with an increased risk of falls in geriatric patients. In a meta-analysis study conducted by Cheng et al. 2017, it was shown that the risk of falls and fractures increased with increasing age in ACE inhibitor users. Geriatric patients have a decreased compensatory response with increasing age so that they are more prone to hypotension due to the use of ACE inhibitors, which results in venous pooling and decreased cardiac output. Hypotension experienced by geriatric patients will have the effect of dizziness and will cause falls and fractures (Cheng et al. 2017). However, because antihypertensives are a broad group of drugs, exposure to antihypertensive drugs in some studies may differ. Recent research conducted by de Vries et al.

2018, mentioned that there was no relationship between the use of antihypertensives with an increased risk of falling. In a meta-analysis study conducted by Ang et al. 2018, it was stated that ARB and ACEI were not associated with fall risk. In fact, ACEI and ARB were associated with a reduced risk of falls in the elderly. This was because inhibition of the RAAS can increase baroreceptor sensitivity and increase vascular compliance, thereby reducing the incidence of orthostatic hypotension (Rivasi et al. 2020). In addition, the components of the RAAS, namely Angiotensin Converting-Enzyme (ACE) and Angiotensin II, were present in osteoblasts and osteoclasts, thereby stimulating bone resorption. Several animal studies had shown that inhibiting the angiotensin II pathway could prevent osteoporosis, increase bone mass and strength, and accelerate bone healing and remodeling. This would improve skeletal muscle function, slowed the decline in walking speed, and increased walking distance in elderly patients taking ACE inhibitors or ARBs (Kunutsor et al. 2017; Shea and Witham 2020). However, there is a 'first dose' phenomenon that may occur in patients with increased RAAS activity, so that with the use of ACEI and ARBs there will be vasodilation in blood vessels and downregulation of baroreceptors (Rivasi et al. 2020). Related to this, there is still controversy regarding the relationship between the use of antihypertensives, especially ACE inhibitors and ARBs, in increasing the risk of falling. However, because with increasing age there is a decrease in body function thereby increasing the risk of side effects that occur in the elderly, this still needs to be a wariness for geriatric patients who use antihypertensives.

The second most common moderate-risk drug was bisoprolol. Bisoprolol is a β-blocker antihypertensive. Based on data from the Irish Longitudinal on Aging (TILDA), it was reported that the -blocker group was associated with an increased risk of orthostatic hypotension in elderly patients, thereby increasing the risk of falling. This was due to the negative inotropic and chronotropic effects of β-blocker antihypertensives, thus interfering with the compensatory response to lowering blood pressure when standing. In addition, the inhibition of the juxtaglomerular and β-1 adrenergic presynaptic receptors would reduce RAAS activity and sympathetic outflow resulting in vasodilation (Rivasi et al. 2020). Bradycardia, decreased cardiac output, peripheral vascular vasoconstriction, can occur with the use of β-blocker, resulting in changes in mental status and causing falls (Butt et al. 2013). In a study conducted by Ham et al. 2017, it was stated that the use of non-selective β-blocker antihypertensives was associated with an increased risk of falling. This was because non-selectively β-blocker bind to β-1 receptors in the heart, β-2 in the lungs, smoothed muscle cells in the peripheral circulation, liver and in skeletal muscle cells. In addition to reducing heart rate and contractility, non-selective β-blocker also induced vasoconstriction of peripheral blood vessels to skeletal muscle which had a negative effect on skeletal muscle, therefore non-selective -blockers were more associated with the risk of falling (Ham et al. 2017).

The third most common moderate-risk drug was nifedipine. Nifedipine is a calcium channel blocker (CCB) antihypertensive. In addition to nifedipine, other CCB classes used by geriatric patients were amlodipine and diltiazem. In a study conducted by Butt et al. 2013, antihypertensives including CCBs can increase the risk of falling. Dihydropyridine CCBs are more likely to experience orthostatic hypotension and falls than non-dihydropyridine CCBs because of their peripheral vasodilating effects (Butt et al. 2013). However, non-dihydropyridine CCBs such as diltiazem can increase the risk of falling because of the potential for orthostatic hypotension due to negative inotropic chronotropic effects and decrease heart rate response, thereby impairing the cardiac compensatory response when standing. In addition, because of the reduced first-pass effect on the liver with increasing age, the bioavailability of diltiazem may increase in elderly patients. Meanwhile, amlodipine has a lower orthostatic hypotensive effect due to slow binding to calcium channels and slower onset of vasodilation (Rivasi et al. 2020). In addition, orthostatic hypotension is less common in CCBs with slow-release preparations such as nifedipine OROS (Butt et al. 2013).

Antihypertensives other than ACE inhibitors, ARBs, CCBs, and β-blocker, in this study geriatric patients received -blocker therapy, namely tamsulosin 1×0.4 mg which was used in patients with a diagnosis of prostatic hyperplasia. α-blocker can increase the risk of falling in geriatric patients because of the inhibition of the α-1 receptor, causing relaxation of vascular smooth muscle and vasodilation (Miller and Cumpston 2021). In a study conducted by Welk et al. 2015, patients who took specific α-blocker including tamsulosin could increase the risk of falling significantly, so it was necessary to be aware of the risk of falling in patients receiving -blocker therapy.

The nitrate class of drugs which is a moderate-fall risk drug was also found in this study. The nitrates used by geriatric patients were isosorbide dinitrate and nitroglycerin. Nitrates were used as angina therapy with the mechanism of nitric oxide release in smooth muscle so that it activates guanylyl cyclase and increases cGMP so that nitrates have a smooth muscle relaxation effect in vessels and vasodilation of venous return (Katzung 2018). Because of these effects, nitrates are known to increase the risk of hypotension and falls in elderly patients (Rivasi et al. 2020). In a study conducted by Testa et al. 2018, geriatric patients taking nitrates were significantly associated with falls due to hypotension. STOPP Fall recommended deprescribing vasodilator agents for heart disease in patients with hypotension, orthostatic hypotension, or dizziness (Seppala et al. 2021).

Antidepressants are also moderate-fall risk drugs. The antidepressant that was widely used by geriatric patients in this study was amitriptyline at a dose of 1×25 mg. Amitriptyline belongs to the tricyclic antidepressant (TCA) class. Amitriptyline was used to treat depressive disorders, but at low doses it could also be used as abdominal pain, neuropathic pain, and migraine prophylaxis (BNF 2015). According to a study conducted by Seppala et al. 2018, the

use of antidepressants, both TCAs and SSRIs, was significantly associated with the risk of falls in geriatric patients. This was because antidepressants have side effects such as sedation, balance disruptions, orthostatic hypotension, hyponatremia, and cardiac conduction disturbances. These side effects put patients who experience them at risk of falling (van Poelgeest et al. 2021). STOPP Fall recommends deprescribing antidepressants in elderly patients who have hyponatremia, orthostatic hypotension, dizziness, symptoms of sedation, or tachycardia (van Poelgeest et al. 2021)

Drugs with low risk of falling are diuretics. The most used diuretic is the loop diuretic group, namely furosemide 1×40 mg with a percentage of 9% (Table 5). Furosemide was used to treat persistent hypertension and edema (BNF 2015). Furosemide works by inhibiting the Na/K/Cl transporter in the ascending branch of the Henle loop, thereby increasing the excretion of NaCl and increasing Ca and Mg in the urine (Katzung 2018). Research conducted by de Vries et al. 2018, showed that the use of loop diuretics in the elderly was significantly associated with an increased risk of falling because loop diuretics have a stronger and faster diuretic effect than other diuretics so that extracellular fluid changes occur rapidly. Thus, loop diuretics are more likely to have orthostatic hypotensive effects, electrolyte disturbances, and urinary incontinence that will increase the risk of falls in the elderly compared to other diuretics (Seppala et al. 2021).

Table 6 shows the number of fall risk medications used by geriatric patients in this study. From the results of the study, it was found that almost three quarters of geriatric patients taking a combination of 2–4 drugs were at risk of falling. This needs to be watched out for because according to research conducted by Milos et al. 2014, patients who had fallen receiving the number of drugs had a higher risk of falling. The increased risk of falling can occur due to the cumulative burden of side effects caused by drugs at risk of falling or drug interactions (Zia et al. 2017). In addition, a scoring was carried out on fall risk drugs received by patients based on the Medication Fall Risk Score (MFRS), namely the classification by Ganz et al. 2013 according to the level of fall risk based on drug side effects. Patients with a total MFRS of more than or equal to six, their drug use needed to be evaluated by a clinical pharmacist (Ganz et al. 2013). From the results of the study, it was found that 53% of geriatric patients who received drugs at risk of falling had a total MFRS score of more than or equal to six, and amongst them there were two patients who had a high risk of falling based on the Morse scale.

In order to determine the relationship between the number of fall-risk drugs and the risk of falling in geriatric patients, a correlation analysis of the fall risk score based on the MFRS and the number of fall risk drugs received by the patient with the patient's Morse risk scale was carried out. From the results of the analysis, it was found that the total MFRS score was weakly correlated and significant with the Morse score (Table 7). Meanwhile, the number of fall-risk drugs received by the patient was not correlated (Table 7). Whereas, it can be concluded that the greater

Table 7. Correlation of morse and fall risk drug.

Variable	Kolmogorov-smirnov Significance	*Spearman*	
		Coeff. correlation	Sig.
Morse MFRS	0,000	(+) 0,198	0,034
Morse number of fall-risk drugs	0,000	(+) 0,161	0,085

the number of fall risk drugs received by the patient is not associated with the patient's risk of falling. However, the higher the MFRS value will increase the risk of falling in geriatric patients. A high MFRS value indicates that in addition to the large number of drugs consumed, the drugs consumed also provide a higher risk of falling, such as higher benzodiazepine values than antihypertensives. In MFRS, drugs that have an effect on the central nervous system will provide a higher risk of falling with a score of three because it will provide sedation, dizziness, postural disorders, balance disruptions, and cognitive disorders in geriatric patients (Ganz et al. 2013). In this study, it was found that the drug that was widely used by patients was antihypertensive which was included in the moderate risk, thus explaining the weak correlation of the MFRS score with the risk of falling. Research conducted by Seppala et al. 2018, drugs that act on the central nervous system such as antipsychotics, antidepressants, and benzodiazepines were consistently associated with the risk of falling. Supported by a study by Costa-Dias et al. 2014, patients using drugs that act on the central nervous system were ten times more likely to fall than patients who do not use central nervous system drugs. In a study conducted by de Vries et al. 2018, antihypertensives were inconsistent in relation to the risk of falling. It is supported by research by Bromfield et al. 2018, that the amount of antihypertensive used by patients was not associated with an increased risk of falling. Therefore, in this study, the number of drugs at risk of falling did not provide an overview of the risk of falling experienced by patients because it is dominated using drugs with moderate risk of falling (antihypertensives), but it is important to know which drugs provide a high risk of falling because of their effects on the central nervous system. In addition, in this study, geriatric patients were aware of the risk of falling due to aging, so that patients and caregivers were always careful to avoid falls.

To determine the relationship between the dose of fall-risk drugs and the risk of falling in geriatric patients, a correlation analysis of the dose of gabapentin with the results of the patient's Morse score was carried out. Gabapentin was used in this analysis because gabapentin is the most common high-fall risk drug used by patients. From the results of the analysis, it was found that there was a difference in the risk of falling in patients with gabapentin at a dose of 100 mg and a dose of 300 mg (Table 8). The increase in dose was significantly correlated with Morse score. Thus, it can be concluded that the higher the dose of gabapentin will increase the risk of falls in geriatric patients. This is in accordance with research by Muanda et al. 2022, increasing the dose of gabapentin could increase the risk of falling in geriatric patients because in geriatric patients kidney

Table 8. Correlation of morse and gabapentin doses.

Variable	Shapiro-wilk significance	Mann-Whitney U significance	
100 mg	0,006	0,008	
300 mg	0,03		
Variable	**Kolmogorov-Smirnov significance**	***Spearman***	
		Coeff. correlation	**Sig.**
Morse	0,001	(+) 0,380	0,006
Doses	0		

function would decrease with increasing age, thereby inhibiting the elimination process of gabapentin. In addition, geriatric patients experience increased blood-brain barrier permeability and increased body fat components, causing lipophilic gabapentin to more easily penetrate the blood-brain barrier and has a longer distribution (Annisa et al. 2019). However, this did not apply to all drugs at risk of falling due to differences in drug characteristics.

From the results of this study, it is hoped that it can increase awareness for geriatric patients and health workers against the risk of falling due to drug use. It is necessary to develop a good fall prevention strategy by evaluating the use of drugs at risk of falling in geriatric patients. A good fall prevention strategy is to identify the patient's fall risk. One way is to combine the MFRS with the Morse scale to identify the patient's risk of falling. In a study conducted by Yazdani and Hall 2017, combining MFRS with the Morse scale can increase its sensitivity and specificity in detecting the risk of falling in geriatric patients so as to increase awareness of the risk of falling in geriatric patients. A study conducted by Ming et al. 2021, that conducted a review of drugs used by geriatric patients was effective in preventing falls. In addition, in a study conducted by Michalcova et al. 2020, including medication as a fall risk factor in the fall risk assessment of geriatric patients helps prevent falls and improves the quality of care for geriatric patients in hospitals. Furthermore, pharmacists can play a role in preventing falls in geriatric patients by providing education to increase awareness of the risk of falls that may be experienced when taking medication and how to prevent falls. In order to prevent falls, patients and caregivers need to be educated about the importance of modifying the patient's environment or place of residence, using walking aids, and using appropriate footwear. Increasing awareness of the risk of falling can reduce the danger of falling due to drug use (Kruschke and Butcher 2017; Seppala et al. 2019).

This study has several limitations, including in assessing the patient's risk of falling, it is difficult to know whether the fall is a direct result of the drug or the presence of disease factors experienced by the patient. Another limitation of this study is that it did not assess the patient's compliance in taking the drug at risk of falling so that the drug data was only taken from e-prescribing without knowing whether the patient really took the drug at risk of falling. However, the results of this study can be useful to provide information about drugs at risk of falling so that they can be considered in the selection of drug therapy in elderly patients to prevent falls and increase awareness of elderly patients against the risk of falling due to drugs.

Conclusions

Based on the study on fall-risk drugs in geriatric patients conducted from April to July 2022 at the Geriatric Outpatient Clinic, Airlangga University Teaching Hospital, it can be concluded that the level of risk of falls based on the Morse scale in geriatric patients that used fall-risk drugs are mild to moderate. The most widely used high-fall risk drug was gabapentin at a dose of 1×100 mg with a duration of use of 1–5 years, a moderate-fall risk drugs were candesartan at a dose of 1×8 mg with a duration of use at a dose of >5 years, and a low-fall risk drugs was furosemide at a dose of 1×40 mg, with duration of use >5 years. The number of moderate-fall risk drugs did not increase the level of risk of falls in geriatric patients, while increasing the dose of high-fall risk drugs could increase the chance of falls.

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