Department of Pharmacy[1], Gifu University Hospital; Laboratory of Advanced Medical Pharmacy[2], Gifu Pharmaceutical University, Gifu; Faculty of Nursing Science[3], Tsuruga Nursing University, Fukui; Department of Neurology[4], Gifu University Graduate School of Medicine, Gifu, Japan

Effectiveness of polypharmacy measures consisting of a pharmacist check followed by a multidisciplinary team review in patients with polypharmacy admitted to a neurology ward

S. Yamada[1], S. Nishida[1,*], Y. Hayashi[2,3], K. Kunieda[4], N. Yoshikura[4], N. Asai[1], M. Yamada[1], D. Watanabe[1], S. Shimizu[1], H. Fujii[1], T. Niwa[1], H. Iihara[1], R. Kobayashi[1,2], T. Shimohata[4], A. Suzuki[1,2]

Received April 24, 2025, accepted July 14, 2025

Corresponding author: Shohei Nishida, Department of Pharmacy, Gifu University Hospital, 1-1 Yanagido, Gifu, Gifu 501-1194, Japan
nishida.shohei.x3@f.gifu-u.ac.jp

Pharmazie 80: 102-107 (2025) *doi:10.1691/ph.2025.5555*

Patients with neurological disease are at high risk of polypharmacy. We previously reported that a countermeasure against polypharmacy which combined a pharmacist check followed by a multidisciplinary team review was useful for diabetes patients with polypharmacy. We evaluated this polypharmacy countermeasure in neurology patients with polypharmacy admitted to our neurological ward. A single-center, retrospective observational study was conducted at Gifu University Hospital. Study participants included neurology patients taking six or more drugs on admission to the neurology ward between June 2021 and April 2023. Of 435 patients admitted to the neurology ward, 24.4% (106/435) [≥65 years old, 28.3% (79/276) patients; < 65 years old, 16.7% (27/159) patients] were taking six or more drugs at admission. Prescription content was optimized in 62 patients, and a total of 212 drugs were discontinued. The median number of medications significantly decreased from 9.0 (interquartile range, 7–10) at admission to 8.0 (interquartile range, 6.25-10) at discharge ($p < 0.001$). On multivariate analysis, the number of drugs taken on admission and length of hospital stay were significant factors which contributed to drug reduction, while concomitant use of immunosuppressive drugs was a significant factor in increasing the number of drugs. This countermeasure for polypharmacy, which combined a pharmacist check followed by a multidisciplinary team review, was useful in older and non-older patients with polypharmacy on a neurology ward.

1. Introduction

Development of various types of medications for chronic and acute diseases has contribute to improving patient lifespan and quality of life. However, patients with multimorbidity (multiple conditions) need to use multiple medications. The regular use of five or more medications is commonly called polypharmacy (World Health Organization 2019; Delara et al. 2022; Halli-Tierney et al. 2019). Patients with multimorbidity are therefore at risk for drug-drug interactions and adverse drug reactions (ADR). Importantly, the elderly are at particular risk because of changes with aging that affect pharmacokinetics, including slowed absorption, increases in volume of distribution, and reduced drug clearance (Onder et al. 2002; Gurwitz et al. 2003). Moreover, polypharmacy is independently associated with falls, worse clinical outcomes, prolonged hospital stays, and increased medical costs (Davies et al. 2020; Masnoon et al. 2017). Reducing inappropriate or potentially inappropriate medications and ensuring that multiple medications are appropriate is therefore an important public health goal (World Health Organization 2019).

Patients with neurological diseases, including dementia, Parkinson's disease (PD), multiple sclerosis (MS), and epilepsy, are at high risk of polypharmacy due to their complex symptomatology (Chapman et al. 2023; Frahm et al. 2021). The risk of polypharmacy is recognized not only in older but also non-older patients (Menditto et al. 2019). Thuermann et al. (2002) reported that 2.7% of patient admissions to the neurological ward were caused by ADRs and that 18.7% of patients experienced an ADR during hospitalization. Additionally, we previously showed that 28% of patients aged ≥65 years with neurological diseases experienced severe ADRs during hospitalization (Nishida et al. 2018). Importantly, the incidence of severe ADR was also correlated with the number of drugs. Thus, a reduction in medications in patients admitted to the neurological ward is considered an effective process outcome for polypharmacy countermeasures.

Several studies of polypharmacy-related interventions have been reported, and shown some evidence of being able to reduce the number of medications, potentially inappropriate medications (PIMs), and/or potential prescribing omissions (PPO) (Keller et al. 2024). However, few reports have been limited to inpatients in the neurology department. In their study of 432 elderly patients who were primarily treated for neuromuscular diseases and admitted to and discharged from our hospital, Hayashi et al. (2017) reported that multidisciplinary medication review using electronic medical records significantly reduced the number of drugs taken by elderly inpatients receiving polypharmacy (Hayashi et al. 2017). However, participants were limited to elderly patients aged ≥65 years, and patient factors that reduced the number of medications by intervention during hospitalization were unclear.

The aim of this study was to determine whether multidisciplinary polypharmacy measures, which our research team has previously shown to be effective on diabetes wards (Nishida et al. 2023), are

useful on neurology wards, and to determine which drugs are more likely to be reduced and in which patients.

2. Investigations and results

2.1. Patient background

A total of 435 patients were admitted to the neurology ward at Gifu University Hospital during the study period. Of these, 24.4% (106/435 patients) were taking six or more medications on admission, with those aged ≥65 years and <65 years accounting for 28.6% (79/276) and 17.0% (27/159), respectively (Table 1A). Pharmacists checked their medications using a prescription checklist (Nishida et al. 2023).

Table 1A: Rate of patients with polypharmacy in a neurology ward

Total number of patients	435	
≥ 65 years old	276	63.4%
< 65 years old	159	36.6%
Taking 6 or more medications	106	24.4%
≥ 65 years old	79	28.6%
< 65 years old	27	17.0%

Table 1B shows the demographics of patients with polypharmacy. Of the 106 patients, 56 (52.8%) were male and 50 (47.2%) were female, and median age was 72 years (IQR: 64.3–79.8). The median number of medications taken on admission was 9 (IQR: 7–10). The most common disease was Parkinson's disease or syndrome (n = 29, 27.3%), followed by amyotrophic lateral sclerosis (n = 21, 19.8%), autoimmune peripheral neuropathy (n = 11, 10.3%), cerebrovascular disease (n = 8, 7.5%), and inflammatory myopathy (n = 6, 5.7%) and spinal spondylosis (n = 6, 5.7%).

Table 1B: Demographics of patients with polypharmacy on admission in a neurology ward

Sex, n (%)		
Male	56	(52.8%)
Female	50	(47.2%)
Age, median age (IQR)	72	(64.3–79.8)
Median number of medications (IQR)	9	(7–10)
Main disease treated, n (%)		
Parkinson's disease or syndrome	29	(27.3%)
Amyotrophic lateral sclerosis	21	(19.8%)
Autoimmune peripheral neuropathy	11	(10.3%)
Cerebrovascular disease	8	(7.5%)
Inflammatory muscle disease	6	(5.7%)
Spinal spondylosis	6	(5.7%)
Cerebellar ataxia	4	(3.8%)
Hydrocephalus	4	(3.8%)
Multiple sclerosis or NMOSD	3	(2.8%)
Epilepsy	3	(2.8%)
Myasthenia Gravis	2	(1.9%)
Others	9	(8.5%)

IQR: Interquartile range

2.2. Prescription optimization through checklist results and multidisciplinary collaborative review

Based on the results of the prescription checklist conducted by the pharmacist, a medical conference consisting of physicians, pharmacists, nurses, dietitians, physical therapists, and speech-language pathologists reviewed the need to continue or discontinue medications in each patient. Prescription content was optimized in 58.5% (n = 62) of patients, and a total of 212 drugs were discontinued. The median number of medications taken by each patient with polypharmacy on admission significantly decreased, from 9.0 (IQR: 7–10) on admission to 8.0 (IQR: 6.25–10) on discharge (p<0.001; Fig. 1). Table 2A shows the distribution of the number of discontinued drugs. 43.4% of patients (n = 46) were able to reduce one or more medications by discharge.

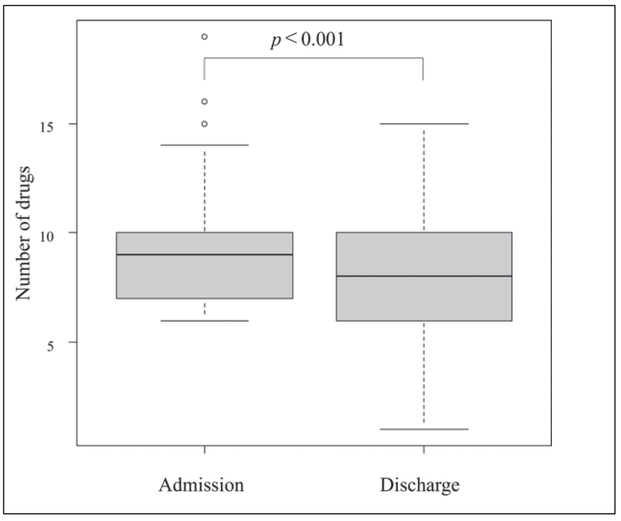

Fig. 1: Number of drugs being taken on admission and discharge. Data were compared by *Wilcoxon signed rank sum test*.

Table 2: Number of discontinued drugs

Number of discontinued drugs	Number of patients	%
≥ 6	7	13.6
5	3	2.83
4	2	1.89
3	10	9.43
2	10	9.43
1	14	13.2
0	33	31.1
-1	16	15.1
-2	6	5.66
-3	4	3.77
-5	1	0.94

As shown in Table 3, the most common category of discontinued drugs was gastrointestinal drugs (n = 39, 18.4%), followed by Parkinson's disease drugs (n = 23, 10.8%), vitamins (n = 19, 9.0%), analgesics (n = 18, 8.5%), sleeping pills (n = 16, 7.5%), herbal drugs (n = 12, 5.7%), antihypertensive drugs (n=11, 5.2%), hypoglycemic agents (n=7, 3.3%), antiepileptic drugs (n=7, 3.3%), antitussive expectorants (n=7, 3.3%), dysuria remedies (n=7, 3.3%), and others (n=46, 21.7%). Pharmacists collaborated with other medical staff, including physicians and nurses, in following-up with these patients after discontinuation until discharge and confirming that their clinical status had not deteriorated during the hospitalization (Table 3).

The most common reason for discontinuation in each patient was "unnecessary use (because of already improved symptoms) (n=83, 39.0%)", followed by "ineffective for current symptoms (n = 55, 26.0%)", "risk of adverse drug reactions (n = 48, 23.0%)", and

Table 3: Drug categories discontinued by multidisciplinary team review

Drug category	n (%)	Number of patients with symptoms, n	
		Admission	Discharge
Gastrointestinal drugs	39 (18.4)	0 [a]	0 [a]
Parkinson's disease drugs	23(10.8)	0 [b]	0 [b]
Vitamins	19 (9.0)	0 [c]	0 [c]
Analgesics	18 (8.5)	0 [d]	0 [d]
Sleeping drugs	16(7.5)	0 [e]	0 [e]
Antihypertensive drugs	11 (5.2)	4(121.7±15.7/77.7±7.5) [f]	4 (121.1±15.8/76.9±12.2) [f]
Diabetic drugs	7(3.3)	0 [g]	0 [g]
Antiepileptic agents	7(3.3)	0 [h]	0 [h]
Cough suppressants and decongestants	7(3.3)	0 [i]	0 [i]
Dysuria medications	7(3.3)	0 [j]	0 [j]
Others	46 (21.7)	–	–

[a] Gastrointestinal hemorrhage, [b] exacerbation of Parkinson's symptoms, [c] symptoms associated with each vitamin deficiency, [d] pain, [e] insomnia, [f] lightheadedness (mean blood pressure ± SD), [g] hyperglycemia, [h] epileptic seizure, [i] worsening respiratory symptoms, [j] urinary dysfunction

"overtreatment (n = 26, 12.0%)" (Fig. 2). The reasons for the drug reductions given here were determined in consultation with the neurologist and a pharmacist.

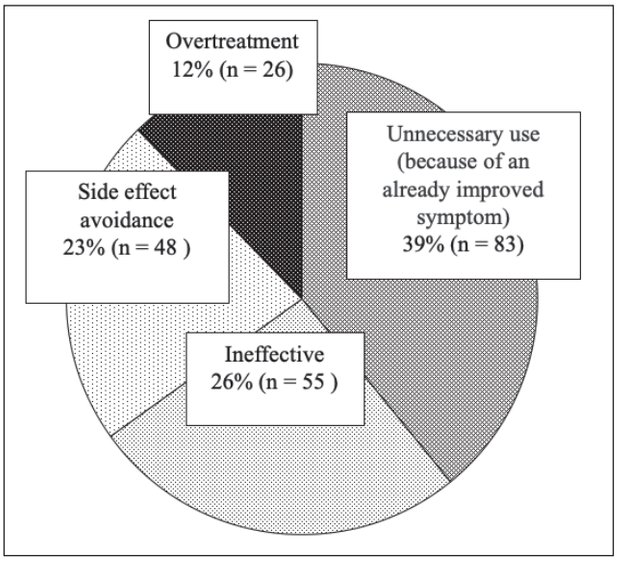

Fig. 2: Reasons for drug discontinuation in neurological patients with polypharmacy

Table 4: Factors influencing the reduction in medications in patients with polypharmacy

Factors	Odds ratio	95% confidence interval	*p*-value
Age	0.999	0.961–1.040	0.971
Number of drugs	1.230	1.030–1.470	0.025
Period of hospitalization	1.050	1.020–1.090	0.003
Use of immunosuppressants	0.194	0.048–0.783	0.021

2.3. Factors influencing the reduction of medications in patients with polypharmacy

Multivariate analysis revealed that the number of medications on admission (OR, 1.23; 95% CI, 1.03-1.47; p=0.025) and duration of hospital stay (OR, 1.05; 95% CI, 1.02-1.09; p=0.003) were significant factors in reducing the number of drugs (Table 4). In contrast, the use of immunosuppressive agents was shown to be a significant factor in increasing the number of drugs (OR, 0.19; 95%CI, 0.048-0.783; p=0.021).

3. Discussion

In this study, we evaluated the effectiveness of a polypharmacy measure with multidisciplinary collaboration which combines a pharmacist check followed by a multidisciplinary team review in a neurology ward. Despite the addition of medications for neurological diseases during hospitalization, the median number of medications in patients with polypharmacy on admission significantly decreased from admission to discharge. These results indicate that the use of this polypharmacy intervention from admission in older and non-older neurological inpatients with polypharmacy may be effective. Moreover, this intervention may be more useful for patients with a greater number of drugs and longer hospital stay.

24.4% (106/435) of the patients on admission to the neurological ward were taking six or more medications on admission in this study. 28.6% (79/276) of these patients were ≥65 years old and 17.0% (27/159) were <64 years. It is therefore notable that not only our older patients with neurology diseases were at risk of polypharmacy but also our non-older patients.

Patients with Parkinson's diseases or syndrome (24.5%) and amyotrophic lateral sclerosis (18.9%) accounted for a high proportion of these patients with polypharmacy. These results are consistent with previous reports (Chapman et al. 2023; Frahm et al. 2021). Both diseases require medications for various symptoms associated with progression of disease (Bhagavathula et al. 2022; Campins et al. 2017), and are considered to confer a high risk for the development of polypharmacy. Additionally, 25.5% of our patients with polypharmacy were aged under 65 years, 44% of whom had a decrease in the number drugs on discharge due to the present polypharmacy measure. These findings indicate that need for intervention against polypharmacy not only in elderly neurology patients.

The present polypharmacy measures significantly reduced the number of medications in neurology inpatients with polypharmacy, as we also found in our previous report in the diabetic ward (Nishida et al. 2023). 43.4% of patients with polypharmacy had a reduction of one or more medications at the time of discharge. The most common category of discontinued drugs was gastrointestinal drugs, followed by drugs for Parkinson's disease, vitamins, analgesics, sleeping pills, herbal medicines, and drugs for hypertension. These drug categories are largely consistent with those identified in our previous reports as candidates for cessation in inpatients (Hayashi et al. 2017; Nishida et al. 2023). Moreover, Campins et al. reported a randomized controlled trial in community-dwelling polymedicated elderly people in which gastric protectors, benzodiazepines, non-steroidal anti-inflammatory drugs (NSAIDs)/other analgesics, anti-hypertensives, anti-diabetics, inhalers, and laxatives were inappropriate drug categories, some of which we also identified (Campins et al. 2017). Care regarding these drug categories and regular review to determine whether such drugs

should be continued or discontinued may therefore be useful countermeasures for polypharmacy regardless of diseases field.

The most common reason for drug discontinuation was "symptoms for internal use already improved", followed by "due to ineffective", "to avoid side effects", and "due to overtreatment". These are also reasonably consistent with the reasons for drug discontinuation in our past polypharmacy measures on a diabetes ward (Nishida et al. 2023). One report noted that when statins were discontinued as a polypharmacy measure, the risk of all-cause mortality increased significantly (Rea et al. 2021), and that inappropriate drug reduction may be detrimental to the patient. We followed up with our present patients after drug discontinuation and confirmed that their clinical status had not deteriorated. It is important to note that the purpose of medication review is to improve the appropriateness of medications, reduce harm and improve outcomes, and not to reduce or stop medications (Balsom et al. 2020). In this study, pharmacists interviewed all patients and evaluated their medications on admission using a prescription review sheet. Several studies have reported that pharmacist-led interventions for polypharmacy are useful in reducing the number of medications in patients with polypharmacy (Lenander et al. 2014; Sellors 2003; Bregnhøj et al. 2009; Lenaghan et al. 2007). This suggests the importance of polypharmacy measures to review drugs that may have been administered without due diligence. It also suggests that this review should be conducted by pharmacists tasked with clarifying the purpose of a drug's use, who corroborated with physicians and careful evaluation of prescribed drugs at the time patients are admitted to the hospital.

Moreover, our multivariate analysis indicated that, even in neurology wards of acute care hospitals where systematic measures to address polypharmacy are in place, both the number of medications at admission and the length of hospital stay remain significantly associated with reduction in the number of medications during hospitalization.

Supporting this, several studies have also reported an association between the number of drugs and PIMs and duration of hospital stay (Aida et al. 2021, 2022; Albayrak and Demirbaş 2023; Fukuba et al. 2020; Nobili et al. 2011).

On the other hand, we found an increase in the number of drugs in patients on immunosuppressive agents, possibly due to the addition of prophylactic drugs for treatment-related adverse events, consistent with a previous report by Hayashi et al. (2017). Glucocorticoids, which are representative immunosuppressants used in patients with neuroimmunological disease, have many side effects. Given that the use of cortical steroids is reported to increase the incidence of peptic ulcers, they are often administered in combination with prophylactic PPIs and H_2 blockers (Narum et al. 2014). In addition, because they increase the risk of osteoporosis, cortical steroids are also often administered with prophylactic bisphosphonates or active vitamin D3 preparations (Weinstein et al. 2011). Furthermore, long-term use of steroids is associated with increased risk of infection, and ST combination therapy is often initiated to prevent against Pneumocystis pneumonia (Rodriguez et al. 2004). This addition of supportive therapies to corticosteroid treatment indicates the presence of an inverse correlation between the use of immunosuppressants and the ease of their tapering. Intervention for polypharmacy and monitoring for ADR in neurological patients receiving immunosuppressive agents are particularly important.

Several limitations of our study warrant mention. First, it was conducted under a retrospective and non-randomized observational design, and potentially relevant confounding factors may not have been excluded. Second, the sample size was small, and the data were obtained from a single institution. Third, we could not evaluate the influence of adverse drug reactions. Fourth, as patients were hospitalized for treatment purposes and the study was conducted in parallel with treatment for the current disease, we were unable to evaluate whether the reduction in medication produced any improvement in physical function. Finally, we were unable to continue follow-up of patients after discharge.

In conclusion, we found a high prevalence of polypharmacy in patients admitted to a neurology ward. The present countermeasure for polypharmacy, consisting of a pharmacist check followed by a multidisciplinary team review, was useful for reducing the number of medications among inpatients with polypharmacy in a neurology ward. Moreover, this intervention for polypharmacy may be useful for patients with a greater number of drugs and longer hospital stay.

4. Experimental

4.1. Study design

We conducted a single-center, retrospective, observational study at Gifu University Hospital, a 614-bed hospital affiliated with Gifu University. Patients with polypharmacy (≥ 6 drugs) who were admitted to the neurology ward between June 2021 and April 2023 were included. We defined polypharmacy as taking six or more drugs in this study based on the Japanese medical insurance system, which provides for a review of the prescription details of patients taking six or more regular medications and an additional medical reimbursement when the prescription content is optimized. Pharmacists recorded the discontinued drugs and the reason for discontinuation in the electronic medical record (HOPE EGMAIN-GX: FUJITSU LIMITED) of each patient during hospitalization. All data were extracted from our electronic medical records and retrospectively reviewed clinical records of patients who were already discharged from the hospital.

4.2. Prescription optimization through pharmacist prescription checking using a checklist and multidisciplinary collaborative review

Prescribing optimization based on the results of evaluation of a prescription checklist by multi-professional collaborative review was implemented in accordance with our previous report (Nishida et al. 2023). Figure 3 shows the work flow of the decision for drug discontinuation on admission based on the results of a prescription checklist conducted by pharmacists and evaluation by a multi-professional collaborative review in the neurology ward.

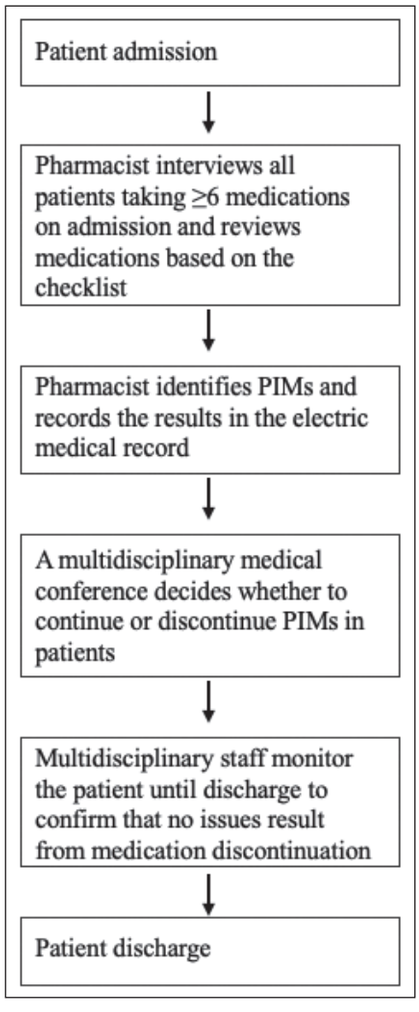

Fig. 3: Work flow of the decision to recommend drug discontinuation and evaluation by multidisciplinary team review. PIMs: potentially inappropriate medications

Table 5: Prescription check items and thresholds

Prescription check item	Threshold	YES/NO
Number of drugs	Patient is taking six or more oral medications	
65 years of age or older and taking PIMs	Patient is 65 years or older and using PIMs as defined by established guidelines	
Need to consider due to decreased ability to manage medications	Patients frequently forgets to take medications or unintentionally overdose	
Need to consider due to duplication of the same drug	Patient is taking multiple medications with the same therapeutic purpose	
Needs to be considered in terms of effectiveness and side effects	Medication is ineffective or is causing noticeable side effects	
Needs to be considered in terms of drug interaction	There are clinically significant interactions among the medications being taken	
Needs to be considered due to decreased swallowing function	Patient's ability to swallow has declined, making oral medication intake difficult	
Needs to be considered based on the patient's organ function	Dosage adjustments are necessary due to impaired organ function In cases of moderate to severe renal impairment (e.g., CCr < 60 mL/min) or moderate to severe hepatic impairment (e.g., Child-Pugh class B or C, ALBI score grade 2 or higher)	

CCr: Estimated creatinine clearance, ALBI score: Albumin-Bilirubin score

Pharmacists interviewed patients on admission about their medications, including current medications, the effects of the medications, and their intention to continue medication, and reviewed their medications based on the checklist. The checklist consisted of the following items: "Number of drugs at the time of admission", "65 years of age and older and taking PIMs", "Requires consideration due to decreased ability to manage medications", "Requires consideration due to duplication of the same drug", "Requires consideration with regard to effectiveness and side effects", "Requires consideration with regard to drug interaction", "Requires consideration with regard to decreased swallowing function", "Requires consideration with regard to the patients' organ function", and kidney and liver function parameters (Table 5). Pharmacists identified potentially inappropriate medications (PIMs) based on the results of checklist, and recorded the results in the patients' electronic medical record. Further, potential prescription omissions (PPOs) were evaluated and added during normal medical practice. Subsequently, the decision of whether or not to discontinue drugs extracted by pharmacists as PIMs was considered at a weekly multidisciplinary medical conference, consisting of physicians, pharmacists, nurses, dietitians, physical therapists, and speech-language pathologists, based on the results of checklist. The final decision to discontinue medications was made by physicians. If medications were discontinued, physicians and pharmacists explained the reasons to the patient and obtained their consent. After discontinuation, pharmacists collaborated with other multidisciplinary staff to monitor the patient from the perspective of each profession until discharge to confirm that the discontinuation did not have an adverse impact. The results of monitoring were shared at the weekly multidisciplinary medical conference.

4.3. Evaluation of the effectiveness of polypharmacy measures

The number of discontinued medications and reasons for discontinuation were investigated. The median number of drugs that patients were taking from admission to discharge was compared. Drugs and topicals (patches, ointments, eyedrops, ear drops, etc.) that were transiently administered during hospitalization were not included.

4.4. Exploration of factors involved in the change in the number of drugs

Factors influencing the change in the number of drugs at admission and discharge in patients who were admitted to the neurology ward were analyzed using logistic regression analysis, with adjustment for age, length of hospital stay, number of drugs at admission, and concomitant use of oral immunomodulators.

4.5. Statistical analysis

All statistical analyses were performed using EZR, (Kanda 2013) a modified version of R Commander with additional statistical functions frequently used in biostatistics. Patient characteristics were summarized at the median, 25th percentile, and 75th percentile levels for continuous variables. The Wilcoxon signed rank sum test was used to compare the number of drugs before and after intervention.
Logistic regression analysis was used to analyze factors related to the increase or decrease in the number of drugs, with a P value <0.05 considered statistically significant. Age, length of hospital stay, number of drugs at admission, and use of immunosuppressive agents were selected as factors in multivariate analysis.

4.6. Ethics approval

This study was conducted in accordance with the Guidelines for Human Research adopted by the Ethics Committee of Gifu University Graduate School of Medicine and as notified by the Japanese government (Institutional Review Board Approval No. 2022-180). Considering the retrospective nature of this study, the informed consent of subjects was not required.

Acknowledgments: We are grateful to all the study participants and the following medical staff: nurses Saori Hiraoka and Mayumi Ando; physiotherapist Yuki Hiishi; Speech therapist Keita Kitagawa and So Otsuka; and nutritionists Kanako Okochi and Kayoko Nishimura.

Conflict of Interest: Shohei Nishida has received personal fees from Sumitomo Pharma, Abott Japan, Daiichi Sankyo, Novo Nordisk Japan, Sun Pharma outside the submitted work.

Hironori Fujii has received personal fees from Ono, Chugai, Taiho, Daiichi Sankyo, Kyowa Kirin outside the submitted work.

Hirotoshi Iihara has received personal fees from Eisai, Taiho, Astellas, AstraZeneca, Chugai, Daiichi Sankyo, Eli Lilly, Nippon Kayaku, Ohara, Sawai, Yakult outside the submitted work.

Takayoshi Shimohata owns stock of OhGood Inc.

Akio Suzuki has received personal fees from Toa Eiyo, Asahi Kasei, Daiichi Sankyo, Pfizer, Eisai, Nippon Shinyaku, Celltrion Healthcare Japan, Otsuka, Sandoz, Tsumura, Nipro, Taiho, Kyowa-Kirin, Nippon Chemiphar, Japan Blood Products Organization, Takeda, and Nippon Boehringer Ingelheim and grants for their institution from Nippon Kayaku, Asahi Kasei, Chugai, Taiho, Daiichi Sankyo, Japan Blood Products Organization, Mochida, and Sun Pharma outside the submitted work.

Other authors do not have conflict of interest.

Funding: This study was financially supported by a grant-in-aid for Scientific Research (C) (17K09231) from the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

References

Aida K, Azuma K, Mishima S, Ishii Y, Suzuki S, Oda J (2021) Potentially inappropriate medications at discharge among elderly patients at a single tertiary emergency medical institution in Japan: a retrospective cross-sectional observational study. Acute Med Surg 8: e711.

Aida K, Azuma K, Mishima S, Ishii Y, Suzuki S, Oda J, Honma H (2022) Potentially inappropriate medications at admission among elderly patients transported to a tertiary emergency medical institution in Japan. Acute Med Surg 9: e748.

Albayrak A, Demirbaş H (2023) Evaluation of potentially inappropriate medications use and medication complexity in elderly patients applying to community pharmacy in Turkey. BMC Geriatr 23: 655.

Balsom C, Pittman N, King R, Kelly D (2020) Impact of a pharmacist-administered deprescribing intervention on nursing home residents: a randomized controlled trial. Int J Clin Pharm 42: 1153–1167.

Bhagavathula A, Tesfaye W, Vidyasagar K, Fialova D (2022) Polypharmacy and hyperpolypharmacy in older individuals with Parkinson's disease: a systematic review and meta-analysis. Gerontology 68: 1081–1090.

Bregnhøj L, Thirstrup S, Kristensen M B, Bjerrum L, Sonne J (2009) Combined intervention programme reduces inappropriate prescribing in elderly patients exposed to polypharmacy in primary care. Eur J Clin Pharmacol 65: 199–207.

Campins L, Serra-Prat M, Gózalo I, López D, Palomera E, Agustí C, Cabré M; REMEI Group (2017) Randomized controlled trial of an intervention to improve drug appropriateness in community-dwelling polymedicated elderly people. Fam Pract 34: 36–42.

Chapman WD, Herink MC, Cameron MH, Bourdette D (2023) Polypharmacy in multiple sclerosis: Prevalence, risks, and mitigation strategies. Curr Neurol Neurosci Rep 23: 521–529.

Davies L E, Spiers G, Kingston A, Todd A, Adamson J, Hanratty B (2020) Adverse outcomes of polypharmacy in older people: systematic review of reviews. J Am Med Dir Assoc 21: 181–187.

Delara M, Murray L, Jafari B, Bahji A, Goodarzi Z, Kirkham J, Chowdhury M, Seitz DP (2022) Prevalence and factors associated with polypharmacy: a systematic review and Meta-analysis. BMC Geriatr 22: 601.

Eisen A, Weber M (1999) Treatment of amyotrophic lateral sclerosis. Drugs Aging 14: 173–196.

Frahm N, Hecker M, Zettl UK (2021) Polypharmacy in chronic neurological diseases: Multiple sclerosis, dementia and Parkinson's disease. Curr Pharm Des 27: 4008–4016.

Fukuba N, Nishida M, Hayashi M, Furukawa N, Ishitobi H, Nagaoka M, Takahashi Y, Fukuhara H, Yuki M, Komazawa Y, Sato S, Shizuku T (2020) The relationship between polypharmacy and hospital-stay duration: a retrospective study. Cureus 12: e7267.

Gurwitz JH, Field TS, Harrold LR, Rothschild J, Debellis K, Seger AC, Cadoret C, Fish LS, Garber L, Kelleher M, Bates DW (2003) Incidence and preventability of adverse drug events among older persons in the ambulatory setting. JAMA 289: 1107–1116.

Halli-Tierney AD, Scarbrough C, Carroll D (2019) Polypharmacy: evaluating risks and deprescribing. Am Fam Physician 100: 32-38.

Hayashi Y, Godai A, Yamada M, Yoshikura N, Harada N, Koumura A, Kimura A, Okayasu S, Matsuno Y, Kinosada Y, Itoh Y, Inuzuka T (2017) Reduction in the numbers of drugs administered to elderly in-patients with polypharmacy by a multidisciplinary review of medication using electronic medical records. Geriatr Gerontol Int 17: 653–658.

Keller MS, Qureshi N, Mays AM, Sarkisian CA, Pevnick JM (2024) Cumulative update of a systematic overview evaluating interventions addressing polypharmacy. JAMA Netw Open 7: e2350963.

Kanda Y (2013) Investigation of the freely available easy-to-use software 'EZR' for medical statistics. Bone Marrow Transplant 48: 452–458.

Lenander C, Elfsson B, Danielsson B, Midlöv P, Hasselström J (2014) Effects of a pharmacist-led structured medication review in primary care on drug-related problems and hospital admission rates: a randomized controlled trial. Scand J Prim Health Care 32: 180–186.

Lenaghan E, Holland R, Brooks A (2007) Home-based medication review in a high risk elderly population in primary care – the POLYMED randomised controlled trial. Age Ageing 36: 292–297.

Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE (2017) What is polypharmacy? A systematic review of definitions. BMC Geriatr 17: 1–10.

Menditto E, Gimeno Miguel A, Moreno Juste A, Poblador Plou B, Aza Pascual-Salcedo M, Orlando V, González Rubio F, Prados Torres A (2019) Patterns of multimorbidity and polypharmacy in young and adult population: Systematic associations among chronic diseases and drugs using factor analysis. PLoS One 14: e0210701.

Narum S, Westergren T, Klemp M (2014) Corticosteroids and risk of gastrointestinal bleeding: a systematic review and meta-analysis. BMJ Open 4: e004587.

Nishida S, Hayashi Y, Suzuki A, Kobayashi R, Inuzuka T, Itoh Y (2018) Relationship between number of drugs and duration of hospital stay in older patients with neuromuscular diseases. Geriatr Gerontol Int 18: 1018–1024.

Nishida S, Kato T, Hayashi Y, Yamada S, Fujii H, Yamada M, Asai N, Shimizu S, Niwa T, Iihara H, Kubota S, Sakai M, Takahashi Y, Takao K, Mizuno M, Hirota T, Kobayashi R, Horikawa Y, Yabe D, Suzuki A (2023) Effectiveness of countermeasure for polypharmacy by multidisciplinary team review in patients with diabetes mellitus. J Diabetes Investig 14: 1202–1208.

Nobili A, Licata G, Salerno F, Pasina L, Tettamanti M, Franchi C, De Vittorio L, Marengoni A, Corrao S, Iorio A, Marcucci M, Mannucci PM; SIMI Investigators (2011) Polypharmacy, length of hospital stay, and in-hospital mortality among elderly patients in internal medicine wards. The REPOSI study. Eur J Clin Pharmacol 67: 507–519.

Onder G, Pedone C, Landi F, Cesari M, Della Vedova C, Bernabei R, Gambassi G (2002) Adverse drug reactions as cause of hospital admissions: results from the Italian Group of Pharmacoepidemiology in the elderly (GIFA). J Am Geriatr Soc 50: 1962–1968.

Rea F, Biffi A, Ronco R, Franchi M, Cammarota S, Citarella A, Conti V, Filippelli A, Sellitto C, Corrao G (2021) Cardiovascular outcomes and mortality associated with discontinuing statins in older patients receiving polypharmacy. JAMA Netw Open 4: e2113186.

Rodrigez M, Westergren T, Kemp M (2004) Prevention of infection due to Pneumocytis spp. in human immnunodeficiency virus-negative immunocompromised patients. Clin Microbiol Rev 17: 770–782.

Sellors J (2003) A randomized controlled trial of a pharmacist consultation program for family physicians and their elderly patients. CMAJ 169: 17–22.

Thuermann PA, Windecker R, Steffen J, Schaefer M, Tenter U, Reese E, Menger H, Schmitt K (2002) Detection of adverse drug reactions in a neurological department: comparison between intensified surveillance and a computer-assisted approach. Drug Saf 25: 713–724.

Weinstein RS (2011) Glucocorticoid-induced bone disease. N Engl J Med 365: 62–70.

World Health Organization, Medication safety in polypharmacy: technical report. 20 June 2019, Available at: https://www.who.int/publications/i/item/WHO-UHC-SDS-2019.11. Accessed 19 June 2024.