

# BMJ Open Association between potentially inappropriate medications at discharge and unplanned readmissions among hospitalised elderly patients at a single centre in Japan: a prospective observational study

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## ABSTRACT

**Objective** To determine the prevalence of potentially inappropriate medication (PIM) use at admission and discharge among hospitalised elderly patients and evaluate the association between PIMs at discharge and unplanned readmission in Japan.

**Design** A prospective observational study conducted by using electronic medical records.

**Participants** All consecutive patients aged 65 years or older who were admitted to the internal medicine ward were included. Patients who were electively admitted for diagnostic procedures were excluded.

**Main outcome measures** The primary outcome was 30-day unplanned readmissions. The secondary outcome was the prevalence of any PIM use at admission and discharge. PIMs were defined based on the Beers Criteria. The association between any PIM use at discharge and the primary outcome was evaluated by using logistic regression.

**Results** Seven hundred thirty-nine eligible patients were included in this study. The median patient age was 82 years (IQR 74–88); 389 (52.6%) were women, and the median Charlson Comorbidity Index was 2 (IQR 0–3). The proportions of patients taking any PIMs at admission and discharge were 47.2% and 32.2%, respectively. Of all the patients, 39 (5.3%) were readmitted within 30 days after discharge for the index hospitalisation. The use of PIMs at discharge was not associated with an increased risk of 30-day readmission (OR 0.93; 95% CI 0.46 to 1.87). This result did not change after adjusting for patient age, sex, number of medications, duration of hospital stay and comorbidities (OR 0.78; 95% CI 0.36 to 1.66).

**Conclusion** The prevalence of any PIM use at discharge was high among hospitalised elderly patients in a Japanese hospital. Although the use of PIMs at discharge was not associated with an increased risk of unplanned readmission, given a lack of power of this study due to a low event rate, further studies investigating this association are needed.

**Trial registration number** UMIN000027189.

## Strengths and limitations of this study

- This is the first prospective observational study investigating the use of potentially inappropriate medications and unplanned readmissions in Japan.
- When possible, we contacted the principal physicians prescribing the medications to collect accurate information on the medications.
- The 95% CI of the OR for the primary outcome was wide due to an unexpectedly low event rate.
- A single-centre study design limited the generalisability of the results.
- The data on readmission might be inaccurate due to the use of electronic medical records to acquire the data.

## INTRODUCTION

Inappropriate prescribing, which encompasses potentially inappropriate medications (PIMs) and potentially inappropriate omissions,<sup>1</sup> is a relevant public health concern for older patients. Potentially inappropriate medications are defined as medications that potentially have more harmful effects than beneficial effects for elderly individuals, who are defined as 65 years and older.<sup>2</sup> The use of PIMs in elderly patients has been associated with an increased risk of several adverse outcomes.<sup>3–6</sup> Therefore, the use of PIMs should be avoided if possible.<sup>1,2</sup>

Nonetheless, the use of PIMs is common among elderly patients,<sup>7,8</sup> particularly in long-term care facilities<sup>9</sup> and acute care settings.<sup>10</sup> The prevalence of PIMs has been reported to be 20%–70% in elderly patients with acute illnesses.<sup>10–15</sup> Furthermore, the use of PIMs at discharge is also common because hospitalisation often contributes to an increased use of PIMs.<sup>16</sup> However, few studies have ever been

conducted to investigate the effect of PIM use at discharge from hospitalisation on patient outcomes.<sup>17–19</sup> After hospital discharge, medication-related harm is common among elderly patients.<sup>20 21</sup> Furthermore, given that the use of PIMs is an independent risk factor for hospitalisation among elderly patients dwelling in the community and nursing care facilities,<sup>4 6</sup> the use of PIMs at hospital discharge may increase the risk of unplanned readmissions. Therefore, we investigated the association between the use of PIMs at hospital discharge and unplanned readmissions among hospitalised elderly patients. In addition, we determined the prevalence of PIMs at admission and discharge among hospitalised elderly patients because there are few studies investigating these prevalence rates in Japan.<sup>11 12</sup>

## METHODS

### Study design and settings

A prospective observational study was conducted by using the database of the National Hospital Organization Tochigi Medical Center from May 2017 to November 2018. The National Hospital Organization Tochigi Medical Center is a 350-bed community general hospital that is one of the largest acute care hospitals in Utsunomiya in Japan. This research was registered at the University Hospital Medical Information Network (UMIN) clinical registry on 29 April 2017.

### Inclusion and exclusion criteria

All consecutive patients aged 65 years and older who were admitted to the internal medicine ward in our hospital from 1 May 2017 to 31 May 2018, and alive at discharge were included. For patients who experienced multiple admissions during the study period, only the first admission was included because the inclusion of multiple admissions for the same patient might result in excessive intensification of the effects of patient characteristics on the outcomes. Patients who were transferred to other hospitals or other wards in our hospital for more intensive or specialised care were excluded. In our hospital, patients were transferred from the internal medicine ward to other wards for surgical procedures. Because surgical patients might have a different risk of readmission than internal medicine patients, patients who were transferred to other wards in our hospital were excluded. We also excluded patients who were electively admitted for diagnostic or intervention procedures because the readmission risk for these patients is lower than that of patients hospitalised due to acute medical problems. Patients whose data regarding medications at admission or discharge were missing were also excluded. During the study period, 1707 adult hospitalised patients were screened. Of those, 739 patients were included in the final analysis (detailed information is shown in a online supplementary figure).

### Data collection

We collected data from the electronic medical records of the National Hospital Organization Tochigi Medical

Center. Information on age, sex, Charlson Comorbidity Index (CCI),<sup>22</sup> primary diagnosis for admission, social history and medical history were extracted from the electronic medical records at the time of the index admission. For information on a disease or syndrome, a patient was considered not to have a disease or syndrome if there was no documentation of them in the electronic medical records. In our hospital, pharmacists routinely compile a comprehensive medication list after admission. All medications used during hospitalisation were managed by the principal physician caring for the patients. Therefore, information on medication at admission was obtained by using the comprehensive medication list or medical records documented by the physicians, while information on medication at discharge was based on the discharge prescription issued by the principal physicians. If information on prescribed medications was missing or unclear in the electronic medical records, we contacted the principal physicians and collected accurate information on the medications if possible. We included regularly used medications but not as-needed medications because collecting accurate information on the frequency of use of as-needed medications was not possible. Topical medications, eye drops and intranasal infusers were excluded. Over-the-counter (OTC) drugs were also excluded because information on these drugs was not sufficiently collected as part of the usual care in this hospital. Information on 30-day readmission was also collected using the electronic medical records of the National Hospital Organization Tochigi Medical Center until 30 November 2018.

### Outcome measures

The primary outcome was 30-day unplanned readmission. Unplanned readmissions to the emergency department that did not result in hospitalisation were not included. In the original version of the protocol, we planned to evaluate the 30-day unplanned readmissions only. However, the 30-day unplanned readmission rate was unexpectedly low during the study period. Therefore, 90-day readmissions were also evaluated. The secondary outcome was any use of PIMs. The prevalence of any PIM use at admission and discharge was evaluated. Based on the previous research,<sup>11</sup> we defined PIMs based on the 2015 Beers Criteria of the American Geriatric Society.<sup>2</sup> Based on a previous study,<sup>11</sup> we used only two of the five parts of the Beers Criteria, that is, PIM use in older adults and PIM use in older adults due to drug-disease or drug-syndrome interactions that may exacerbate the disease or syndrome. However, regarding proton-pump inhibitors (PPIs), based on previous studies<sup>11 23</sup> and guidelines,<sup>24–26</sup> their use was judged to be potentially inappropriate if there were none of the following indications: (1) active peptic ulcer disease; (2) gastro-oesophageal reflux disease; (3) use of non-steroidal anti-inflammatory drugs; (4) use of antiplatelet therapy and at least one risk factor (history of peptic ulcer disease, dual antiplatelet therapy or concomitant use of anticoagulants or corticosteroids);

(5) pathological hypersecretory conditions and (6) *Helicobacter pylori* eradication therapy.

### Statistical analysis

We estimated that a sample of 650 patients would provide the study with a power of at least 80% to show an absolute difference of 8% for the primary outcome between the patients who took any PIMs at discharge and patients who did not. This estimate was determined assuming that 13% of elderly patients who took any PIMs at discharge would be readmitted within 30 days after discharge of the index hospitalisation (based on unpublished data of previous research<sup>11</sup>) and that 15% of hospitalised elderly patients with a medical illness would die during their hospitalisation.

The baseline and demographic characteristics of the study population were summarised by standard descriptive summaries (eg, the median and IQR for continuous variables and percentages for categorical variables). For the primary outcome, the proportion of patients who had unplanned readmission within 30 days after the index hospital discharge was calculated based on the presence of any PIM use at discharge. For the secondary outcome, the proportion of patients taking any PIMs at admission and discharge was calculated. The 95% CIs were calculated for these outcomes. The rates of reduction in the prevalence of any PIM use from admission to discharge were calculated, and a comparison between admission and discharge regarding the prevalence of PIM use was performed using the exact McNemar test. The number of medications at admission was compared with the number of medications at discharge using the Wilcoxon rank-sum test. These analyses for the secondary outcome were also conducted for subgroups of patients classified based on their principal diagnosis for admission. For the primary outcome, the proportion of patients who had unplanned readmission within 30 days after discharge was compared using Fisher's exact test between patients who took any PIMs at discharge and patients who did not. Multivariate analysis using binary logistic regression was also conducted to examine the association between the primary outcome and any PIM use at discharge by adjusting for age, sex, CCI, polypharmacy at discharge and duration of hospitalisation. Polypharmacy was defined as five or more medications based on a previous study.<sup>27</sup> The same analysis was also performed for the 90-day unplanned readmissions.

For the definition of PIM regarding PPIs, we used the original criteria instead of the 2015 Beers Criteria. Therefore, the association between unplanned readmissions and the use of PIMs based only on the 2015 Beers Criteria without conditional criteria regarding PPI use was also investigated. These analyses were performed using Stata V.15 (LightStone, Tokyo, Japan) or Excel statistical software package V.2.11 (Bellcurve for Excel; Social Survey Research Information, Tokyo, Japan). The threshold for significance was set at 5%.

### Patient and public involvement statement

No patients were involved in determining the research question or outcome measures, nor were they involved in developing plans to design or implement the study. No patients were asked for advice during the interpretation or writing up of the results of this study. We have no plans to disseminate the results of this research to study participants or the relevant patient community.

### RESULTS

The baseline characteristics of the 739 elderly hospitalised patients are shown in [table 1](#). Of those, the median patient age was 82 years (IQR 74–88), 389 (52.6%) were women, 93 (12.6%) were institutional residents, the median CCI was 2 (IQR 0–3) and the median number of medications at admission was 5 (IQR 3–8). The most common reasons for admission were acute heart failure (n=95, 12.9%), pneumonia or pneumonitis (n=64, 8.7%), stroke (n=53, 7.2%), acute coronary syndrome (n=41, 5.6%) or urinary tract infection (n=39, 5.3%).

The median number of medications at admission and discharge was 5 (IQR 3–8) and 4 (IQR 2–6), respectively. The number of medications significantly decreased from admission to discharge (see the online supplementary table S1). [Table 2](#) shows the prevalence of any PIM use at admission and discharge. The proportions of patients taking any PIMs at admission and discharge were 47.3% and 32.2%, respectively. The prevalence of any PIM use was significantly reduced from admission to discharge (reduction rate 0.32; 95% CI 0.25 to 0.38) (detailed information is shown in an online supplementary table S2). The most common subcategories of PIMs at discharge were PPIs (n=140, 18.9%), benzodiazepines (n=64, 8.7%), non-benzodiazepine hypnotics (n=29, 3.9%) and antipsychotics (n=15, 2.0%).

Of all patients, unplanned readmission within 30 days and 90 days after the index hospital discharge occurred in 39 (5.3%) and 98 (13.3%) patients, respectively (see the online supplementary table S3). The 30-day unplanned readmission rate in patients who took any PIMs at discharge and those who did not take any PIMs were 5.0% and 5.4%, respectively. [Table 3](#) shows the results of univariate and multivariate analyses for predictive factors for the 30-day and 90-day unplanned readmissions. Any PIM use at discharge was not significantly associated with an increased risk of 30-day unplanned readmissions (OR 0.93; 95% CI 0.46 to 1.87) and 90-day unplanned readmissions (OR 0.78; 95% CI 0.48 to 1.24). These results did not change after adjusting for patient age, sex, duration of hospitalisation, polypharmacy and comorbidity. When the original definition of PIM regarding PPI use was not used, any PIM use at discharge was not significantly associated with an increased risk of 30-day unplanned readmissions (OR 0.78; 95% CI 0.29 to 2.15) and 90-day unplanned readmissions (OR 0.52; 95% CI 0.26 to 1.07) (see the online supplementary table S4).

**Table 1** Characteristics of the 739 elderly patients admitted to the internal medicine ward based on the occurrence of a 30-day unplanned readmission after the index hospital discharge

Characteristics	Total (n=739)	The occurrence of a 30-day unplanned readmission	
		Yes (n=39)	No (n=700)
Age (year), median (IQR)	82 (74–88)	83 (75–89)	82 (74–88)
Women, n (%)	389 (52.6)	13 (33.3)	376 (53.7)
Institutional resident, n (%)	93 (12.6)	7 (17.9)	86 (12.3)
Charlson Comorbidity Index, median (IQR)	2 (0–3)	3 (1–4)	1 (0–3)
Number of medications at admission			
Median (IQR)	5 (3–8)	6 (3–9)	5 (3–8)
Five or more medications, n (%)	446 (60.4)	25 (64.1)	421 (60.1)
Number of medications at discharge			
Median (IQR)	4 (2–6)	4 (1–7)	4 (2–6)
Five or more medications, n (%)	288 (39.0)	19 (48.7)	269 (38.4)
Current smoker, n (%)	78 (10.6)	5 (12.8)	73 (10.4)
Regular alcohol drinker*, n (%)	116 (15.7)	8 (20.5)	108 (15.5)
Principal diagnosis for admission†, n (%)			
Acute heart failure	95 (12.9)	7 (17.9)	88 (12.6)
Pneumonia or pneumonitis	64 (8.7)	3 (7.7)	61 (8.7)
Stroke‡	53 (7.2)	2 (5.1)	51 (7.3)
Acute coronary syndrome	41 (5.6)	3 (7.7)	38 (5.4)
Urinary tract infection	39 (5.3)	1 (2.6)	38 (5.4)
Medical history, n (%)			
Stroke‡	134 (18.1)	7 (17.9)	127 (18.1)
Dementia	159 (21.5)	13 (33.3)	146 (20.9)
Diabetes mellitus	200 (27.1)	13 (33.3)	187 (26.7)
Ischaemic heart disease§	54 (7.3)	3 (7.7)	51 (7.3)
Asthma or COPD	93 (12.6)	5 (12.8)	88 (12.6)
Heart failure	99 (13.4)	8 (20.5)	91 (13.0)
Atrial fibrillation	76 (10.3)	3 (7.7)	73 (10.4)
Hypertension	519 (70.2)	29 (74.4)	490 (70.0)
Chronic kidney disease	90 (12.2)	5 (12.8)	85 (12.1)
Rheumatological disease	33 (4.5)	3 (7.7)	30 (4.3)
Dyslipidaemia	239 (32.4)	10 (25.6)	229 (32.7)
Duration of hospitalisation (day), median (IQR)	13 (7–25)	11 (6–32)	13 (7–25)

\*This excludes two patients with missing data.

†This presents the most frequent five reasons for admission.

‡Stroke includes ischaemic stroke, haemorrhagic stroke and subarachnoid haemorrhage.

§Ischaemic heart disease includes myocardial infarction and a history of percutaneous coronary intervention or coronary artery bypass graft surgery.

COPD, chronic obstructive pulmonary disease.

## DISCUSSION

The findings of this study showed that the prevalence of PIM use at admission and discharge among elderly hospitalised patients with acute medical illnesses is high in Japan, although the proportion of patients taking any PIMs decreased significantly from admission to discharge. The use of PIMs at discharge was not associated with an increased risk of short-term unplanned readmission.

This is the first study to investigate the impact of PIMs at discharge on unplanned readmissions among hospitalised elderly patients in Japan. Our findings are consistent with those of previous studies showing no association between the use of PIMs at discharge and short-term readmissions.<sup>17 19 28 29</sup> Given that significant associations between healthcare outcomes, such as hospitalisation, and the use of PIM in ambulatory settings

**Table 2** Temporal changes in the prevalence of PIM use among the 739 hospitalised elderly patients from admission to discharge based on subcategories of PIMs

Categories* of PIMs	Proportion of patients who took any PIM†			
	At admission	At discharge	Reduction rate (95% CI)	P value‡
Any PIM	349 (47.3)	238 (32.2)	0.32 (0.25 to 0.38)	<0.001
Proton pump inhibitors§	145 (19.6)	140 (18.9)	0.03 (-0.11 to 0.16)	0.69
Benzodiazepines	115 (15.6)	64 (8.7)	0.44 (0.34 to 0.53)	<0.001
Non-benzodiazepine hypnotics	44 (6.0)	29 (3.9)	0.34 (0.10 to 0.52)	0.01
Antipsychotics	37 (5.0)	15 (2.0)	0.59 (0.40 to 0.73)	<0.001
Non-cyclooxygenase-selective NSAIDs	32 (4.3)	4 (0.5)	0.83 (0.52 to 0.68)	<0.001
Anticholinergics for dementia	22 (3.0)	3 (0.4)	0.86 (0.59 to 0.95)	<0.001
Peripheral alpha-1 blockers	17 (2.3)	7 (1.0)	0.59 (0.23 to 0.78)	0.01
H <sub>2</sub> -receptor antagonists for dementia	13 (1.8)	4 (0.5)	0.69 (0.30 to 0.86)	0.004
Digoxin	8 (1.1)	2 (0.3)	0.75 (0.17 to 0.92)	0.03
Dipyridamole or ticlopidine	8 (1.1)	1 (0.1)	0.87 (0.22 to 0.98)	0.02

\*These included subcategories of PIMs that were used in >1% of all patients.

†PIMs were defined based on the 2015 American Geriatric Society Beers Criteria.

‡Comparisons of the proportion of patients taking PIMs at admission and discharge were performed using the exact McNemar test.

§The use of proton pump inhibitors was judged as potentially inappropriate unless there were any of the following indications: (1) active peptic ulcer disease; (2) gastro-oesophageal reflux disease; (3) eradication therapy for *Helicobacter pylori*; (4) pathological hypersecretory conditions; (5) use of NSAIDs or (6) use of antiplatelet therapy and at least one risk factor (history of peptic ulcer, dual antiplatelet therapy or concomitant use of anticoagulants or corticosteroids).

NSAIDs, non-steroidal anti-inflammatory drugs; PIM, potentially inappropriate medication.

and nursing care facilities have been reported in some studies,<sup>3-6</sup> the setting may affect the impact of PIMs on the healthcare outcomes among elderly patients. In fact, most randomised controlled trials<sup>18 30-36</sup> and prospective studies<sup>37 38</sup> investigating the effectiveness of interventions to improve the appropriateness of medications among hospitalised elderly patients reported that the intervention can improve the appropriateness of the medications but not the frequency of unplanned readmissions. It is

possible that the impact of PIMs on unplanned readmissions for elderly patients was small because other factors, such as comorbidities and premature discharge from the index hospitalisation, have largely contributed to unplanned readmissions.<sup>39-42</sup> Furthermore, there were a few readmissions due to adverse drug reactions in this study (see the online supplementary table S3). Given that PIMs at discharge may be associated with medication-related readmissions rather than all-cause readmissions,<sup>18</sup>

**Table 3** Univariate and multivariate analyses\* for predictive factors of 30-day and 90-day unplanned readmissions after the index hospital discharge

Variables	30-day readmission		90-day readmission	
	Unadjusted OR (95% CI)	Adjusted OR† (95% CI)	Unadjusted OR (95% CI)	Adjusted OR† (95% CI)
Age‡	1.02 (0.98 to 1.06)	1.03 (0.99 to 1.07)	1.02 (1.00 to 1.05)	1.03 (1.00 to 1.05)
Women	0.43 (0.21 to 0.85)*	0.43 (0.21 to 0.88)*	0.64 (0.41 to 0.98)*	0.63 (0.40 to 0.99)*
Charlson Comorbidity Index‡	1.38 (1.18 to 1.61)**	1.34 (1.14 to 1.58)**	1.27 (1.14 to 1.42)**	1.24 (1.10 to 1.40)**
Duration of hospitalisation‡	1.00 (0.99 to 1.02)	1.00 (0.98 to 1.01)	1.00 (0.99 to 1.01)	1.00 (0.99 to 1.01)
Polypharmacy§ at discharge	1.52 (0.80 to 2.90)	1.46 (0.71 to 3.01)	1.39 (0.91 to 2.13)	1.52 (0.80 to 2.90)
PIMs at discharge	0.93 (0.46 to 1.87)	0.78 (0.36 to 1.66)	0.78 (0.48 to 1.24)	0.64 (0.38 to 1.07)

The threshold for statistical significance was set at  $p < 0.05$ . Asterisks indicate a significant association between selected variables and unplanned readmissions; \* $p < 0.05$ , \*\* $p < 0.001$ .

†The following variables were adjusted for: age, sex, Charlson Comorbidity Index, duration of the index hospitalisation, number of medications at discharge and PIMs at discharge.

‡Continuous variables were used.

§Polypharmacy was defined as five or more medications.

PIM, potentially inappropriate medication.

the low rate of readmissions due to adverse drug reactions in the present study might have mitigated the impact of PIMs on unplanned readmissions. Nonetheless, our results should be interpreted cautiously because a 95% CI of the OR for the association between PIM use at discharge and unplanned readmission is wide due to an unexpectedly low rate of events.

In our study, polypharmacy (defined as the use of five or more medications) at discharge was not associated with an increased risk of unplanned readmissions. This finding is not consistent with that of previous studies showing that the number of medications or polypharmacy at discharge is an independent predictive factor for unplanned readmissions,<sup>28 43–47</sup> although one prospective cohort study reported no association between the number of medications at discharge and unplanned readmissions.<sup>37</sup> However, in the multivariate analysis for predictive factors for unplanned readmissions, the 95% CI of the OR of polypharmacy was wide in this study. It is possible that a lack of power due to a low readmission rate might explain why there was no statistically significant association between polypharmacy at discharge and unplanned readmissions in this study.

The prevalence of PIM use at admission and discharge among hospitalised elderly patients in this study was high, as similar studies conducted in Japan<sup>11 12</sup> and other countries<sup>10 13–15 17–19 28 29</sup> have reported. Although a reduction in the prevalence of PIM use from admission to discharge in this study was somewhat encouraging, one in three hospitalised elderly patients still received at least one PIM at discharge. Given the high prevalence of PIM use at discharge in hospitalised elderly patients, further studies are necessary to evaluate the effect of PIM use at discharge on clinical outcomes because few studies, including the present study, had a large enough sample size that was sufficient to determine the association between PIM use at discharge and clinical outcomes.<sup>17 19 28 29</sup>

Our results are consistent with those of recent studies<sup>11 48–50</sup> showing that the most common PIMs among hospitalised elderly patients were PPIs and benzodiazepines. Diuretics were the second most frequently used PIM in two of those studies<sup>48 49</sup> because PIMs were defined based on all five parts of the 2015 Beers Criteria in the two studies, unlike our study. Given the high prevalence of PIM use regarding PPIs and benzodiazepines, a strategy to focus on PPIs<sup>51</sup> and benzodiazepines<sup>52 53</sup> among hospitalised elderly patients is needed.

### Implications for clinicians

The use of PIMs is common in an acute care setting. However, our findings and those of previous studies suggest that the use of PIMs at discharge is not associated with short-term unplanned readmissions. Nonetheless, the 95% CI of the OR for the primary outcome in this study was too wide to draw definitive conclusions. Moreover, a recent retrospective cohort study reported that hospitalisation was independently associated with potentially inappropriate prescribing in elderly patients,<sup>54</sup> which may

result in adverse events in the long term.<sup>3–6</sup> In addition, some prospective studies have reported that interventions to improve the appropriateness of medications among hospitalised elderly patients have reduced medication-related hospital revisits,<sup>55 56</sup> emergency department visits without hospitalisation,<sup>38</sup> 30-day unplanned readmissions<sup>57</sup> and adverse drug reactions.<sup>58 59</sup> Thus, given the high prevalence of PIM use, it is important to implement a strategy to improve medication appropriateness among hospitalised elderly patients.

### LIMITATIONS

First, this study was limited to a single centre and to elderly patients admitted to the internal medicine ward. Therefore, these findings may not be generalised to other wards and hospitals. Second, this was not a randomised controlled design. Therefore, some confounding factors might have introduced a bias. Third, adherence to and temporal changes in medication use after discharge were not evaluated in this research. Given that transitional care after discharge often causes a discrepancy between medications at discharge and after discharge,<sup>39 60</sup> the prescriptions at hospital discharge might not accurately reflect medications after discharge. Fourth, as-needed medications and OTC drugs were excluded in this study. Therefore, the prevalence of PIM use might have been underestimated. Fifth, all unplanned readmissions after the index hospital discharge could not be captured because we collected information only from the database of our hospital. Although the 30-day readmission rate obtained in this study was similar to that of other Japanese hospitals,<sup>61 62</sup> the targeted population was somewhat different. Sixth, the 95% CI of the ORs for the primary outcome was wide because the unplanned readmission rate was lower than we expected. Therefore, the association between any PIM use at discharge and unplanned readmissions needs to be investigated in future studies with a larger sample size or with high-risk populations for readmission. Seventh, we did not evaluate several important factors,<sup>40 41 63 64</sup> such as socioeconomic status and the time interval between hospital discharge and the first follow-up visit to physicians, which could affect unplanned readmissions. Eighth, we did not evaluate the preventability of unplanned readmissions. However, a recent study reported that there was no difference in the number of PIMs between hospitalised elderly patients who had experienced an avoidable readmission and those who had not.<sup>65</sup> Ninth, an association between disease-specific PIMs<sup>66</sup> and unplanned readmissions was not evaluated. Tenth, we adapted the definition of PIM regarding PPIs in the 2015 Beers Criteria. However, a recent study also adapted the PPI part of the 2015 Beers Criteria.<sup>28</sup> Eleventh, we used only the first two tables of the 2015 Beers Criteria. However, previous similar studies also used only one or two parts of the 2015 Beers Criteria.<sup>19 28</sup> Finally, the duration of hospital stays in Japan was longer than that in other countries.<sup>67</sup> Therefore, our findings might not be

applicable to countries other than Japan. However, in this study, the duration of hospitalisation was not associated with an increased risk of unplanned readmissions.

## CONCLUSIONS

The proportion of patients taking any PIMs at discharge was high among hospitalised elderly patients. Although the use of PIMs at discharge was not associated with an increased risk of short-term readmission after discharge, given a lack of power of this study due to a low event rate, further studies investigating this association are needed.

**Contributors** JK conceived and designed this study and wrote a draft of the protocol for this study. JK, TY and MK revised the protocol. JK collected and analysed the data and wrote a draft of the main paper. JK, TY and MK discussed the results and interpretations and were involved in critical revisions of the manuscript. JK, TY and MK read and approved the final version of the manuscript.

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**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** The protocol of this research was approved by the Medical Ethical Committee of the National Hospital Organization Tochigi Medical Center (No. 29-13). This research was conducted in accordance with the Ethical Guidelines for Epidemiological Research in Japan and the Declaration of Helsinki. The need for individual informed consent was formally waived by the Medical Ethical Committee of the National Hospital Organization Tochigi Medical Center because the de-identified data were collected from medical records without contact with the patients. However, according to the Japanese Ethical Guidelines, we displayed an opt-out statement in the waiting room and webpage of the hospital to provide the patients with information about the research and the opportunity to refuse the use of the data.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** All data relevant to the study are included in the article or uploaded as supplementary information.

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