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ORIGINAL ARTICLE

EPIDEMIOLOGY CLINICAL PRACTICE AND HEALTH

# Related factors of postoperative half-year care utilization for health status and recovery in older adults with hip fracture: A retrospective study of Osaka National Health Insurance Data

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**Aim:** The aim of this study was to investigate the relationship between preoperative patient factors and postoperative half-year health care utilization reflecting recovery, common complications, comorbidities, and significant health concerns, identifying strong risk and protective factors.

**Methods:** This retrospective cohort study utilized linear, quantile, and ordinal regressions to analyze Osaka National Health Insurance data from 26 606 elderly patients who underwent hip fracture surgery between 2012 and 2018.

**Results:** The key factors associated with multiple postoperative care utilizations ( $P < 0.001$ ) included:

1 Compared with men, women were strongly negatively correlated with postoperative length of stay (LOS) at q90, diabetes prescriptions or drip injections, while showing strong positive associations with postoperative antihypertensive, antiosteoporosis, and antidementia prescriptions.

2 Age has a strong negative correlation with antiosteoporosis or diabetes prescriptions but strongly positive associations with indwelling urinary catheters or drip injections.

3 The preoperative 1-year LOS correlated positively with the postoperative LOS or indwelling urinary catheters, and the strongest associations were observed at q25 with the postoperative LOS. It was significantly and negatively associated with antihypertensive or antidementia prescriptions.

4 Many preoperative care utilizations were positive factors, and some were strong factors at q25 of the LOS.

**Conclusions:** Nuanced relationships between the female sex; preoperative LOS; antidementia, antiosteoporosis, antihypertensive and constipation prescriptions; indwelling catheters, and postoperative LOS were elucidated. These are key risks during shorter postoperative LOS, while male subgroups are at a higher risk during longer LOS duration. Patients with extended preoperative diabetes prescriptions or drip injections are at high risk of multiple postoperative care. *Geriatr Gerontol Int* 2025; ••: ••–••.

**Keywords:** aged, epidemiologic factors, hip fractures, patient outcome assessment, surgery.

## Introduction

Hip fractures, particularly among older adults, represent a significant and escalating health care challenge globally.<sup>1</sup> Japan is projected to experience a 1.36-fold increase in the prevalence of hip fractures by 2050.<sup>2</sup> Hip fractures are a leading cause of emergency surgery in older adults, often resulting in poor postoperative recovery and placing substantial burdens on health care systems,<sup>3</sup>

increasing the risk of morbidity, complication, frailty and disability, complicating or extending care.<sup>4</sup>

Patient outcomes following hip fractures are influenced by pre-existing health conditions and the quality of care provided.<sup>5</sup> Optimizing care benefits and mitigating adverse prognoses are crucial but present challenges for older postoperative survivors with preoperative comorbidities or medical histories.<sup>6</sup> Despite policies aiming at enhancing older adults' health and quality of life,

concerns about the health care system's capacity to deliver quality comprehensive care persist.<sup>7</sup> More comprehensive assessments of risk factors related to postoperative complications, morbidities or the protective factors promoting recovery are needed.<sup>8</sup>

Previous studies reported that 63% of patients were admitted due to nonsurgical systemic illnesses before the fracture.<sup>9</sup> A longer duration of preoperative comorbidities was associated with poorer outcomes, and time, rather than technique, is a critical factor.<sup>10</sup> Additionally, personalized care is crucial. Therefore, other than the need to evaluate a broader range of indicators, early, continuous monitoring of multiple individual-level factors (e.g. health status) already present before fractures, independent of specific care contexts, should be ensured.<sup>11</sup> Notably, unlike long-term outcomes  $\geq 6$  months following a fracture shaped by a complex interplay of biopsychosocial factors and care received, outcomes  $< 6$  months are primarily influenced by prefracture patient characteristics.<sup>12,13</sup> However, current findings primarily focus on postoperative immediate or short-term outcomes.<sup>14,15</sup> There is a need for a holistic understanding of the association between preoperative long-term, dynamic patient factor changes and postoperative outcomes.<sup>16</sup> Furthermore, there are issues of heterogeneous and even contradictory associations or studies confined to small samples and limited settings.<sup>17,18</sup>

Japanese health insurance data enables retrospective cohort studies to explore factors over extended periods, reduce sample selection bias and ensure reliable epidemiological results. Claims information, derived from standardized billing records across medical institutions, ensures accuracy.<sup>19</sup>

Given the regional variations in aging rates and Osaka's higher hip fracture rates,<sup>20</sup> this study leveraged large-scale administrative data from Osaka Prefecture's universal health insurance to examine:

- The comprehensive, dynamic relationships between preoperative patient factors and the first postoperative half-year health status and recovery, measured by length of stay (LOS), prescriptions or intensive resource utilization
- The strong risk and protective factors associated with multiple postoperative health care utilization outcomes

## Methods

This retrospective cohort study adhered to the Strengthening of the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Appendix I). Additionally, we followed methods to ensure real-world data quality and adhered to the recommendations of the International Society for Pharmacoeconomics and Outcomes Research and the International Society for Pharmacoepidemiology Special Task Force on Real-World Evidence.<sup>21,22</sup>

### Data source and sample size

We included 26 606 older patients from the National Health Insurance (NHI) database (Kokuho Database) who were admitted for hip fracture surgery in Osaka Prefecture between April 2012 and December 2018. Seasonal variations in fracture profiles, including postoperative systemic complications and annual hospitalization fluctuations, were considered to ensure an adequate sample size and statistical power.<sup>23</sup>

### Inclusion criteria

Participants meeting the following criteria were included:

1. The patient was diagnosed with hip fracture (*International Classification of Diseases, Tenth Revision, S72x*) and underwent surgery. To prevent duplication, only the first surgery during the study period was considered for patients who were hospitalized more than once and underwent multiple surgeries.
2. One to five types of surgeries (Appendix II) within 5 days following a fracture. This time frame is based on: (i) Japanese clinical guidelines; (ii) the average time from hospital admission to surgery is typically 4.5 to 5 days in practice<sup>24</sup>; (iii) the critical window between fracture and surgery, as prolonged waiting times can significantly impact postoperative outcomes<sup>24,25</sup>; (iv) previous studies on antiplatelet drug half-life suggest a 5-day cutoff for identifying benefits of early surgery over delayed surgery<sup>26</sup> and (v) significant differences in outcomes (e.g. lower risk of severe complications) for patients with antiplatelet or warfarin therapy who undergo early surgery ( $< 5$  days) than delayed surgery ( $> 5$  days).<sup>27</sup>
3. Age  $\geq 65$  years at baseline, continuously enrolled in the NHI program and with complete data for at least 1 year before and 6 months after surgery.

### Data extraction and preprocessing

We assessed the preoperative demographic factors (age and sex). Older adults with hip fractures or older surgical patients often require increased health care services. Therefore, the study encompassed health care utilization as a proxy for: (i) common illnesses, (ii) complications or comorbidities significantly affecting these patients' outcomes or (iii) those conditions that are mainly preventable.<sup>28–31</sup> Specifically, we observed preoperative outpatient service utilization days and preoperative and postoperative health care utilization status, including LOS, physician order-based prescriptions and clinical intensive resource utilization. Intensive resource utilization was defined on the basis of literature indicating the high resource demands for routine care involving urinary catheters, pressure ulcers, or certain intravenous medications.<sup>32,33</sup> The prescribed drugs were classified following the World Health Organization–recommended Anatomical Therapeutic Chemical classification system.

### Data preparation

Data were prepared for statistical analysis by converting the monthly frequency of physician orders into annual counts of months. For simplicity, the months of physician orders are referred to as the corresponding prescription or care. Previous studies have shown that significant functional health recovery primarily occurs within the first 6 months postoperatively, and determining this can provide a comprehensive picture of short- and long-term outcomes.<sup>34</sup> We hypothesized that the nuanced associations of preoperative demographics and 1-year care utilization variables with postoperative half-year LOS, prescriptions, intensive resource utilization and that strongly associated factors of multiple postoperative care could be identified.

### Statistical analysis

All analyses were performed using RStudio software version 4.3.0. We reported the effect sizes, including the standardized regression coefficients ( $\beta$ ), the dummy variable's regression coefficient (B) and 95% confidence intervals (CIs), with significance level set at 0.05. The generated histograms indicated nonnormal data distributions. Robust statistical methods were used to identify outliers and heteroscedasticity.<sup>35</sup>

Multiple linear regression was used to assess the relationships between independent variables and postoperative LOS. These were fitted using the “lm” function in R. To account for extreme values and nonnormal distributions, we employed quantile regressions at the 25th, 50th, 75th and 90th percentiles using the “rq” function in the quantreg package of R.<sup>36</sup> All dependent variables were incremented by 1, log-transformed and then included in linear and quantile regressions.<sup>37</sup> In all regressions, we virtualized the sex variable and selected the male sex as the reference group and used the z-score to standardize other independent variables.<sup>38,39</sup> Unlike mean-based regression, different quantiles revealed how the relationship between independent variables and the outcome variable (LOS) varies across outcome levels (Appendix III, Figure III.1).

For ordinal outcome variables, including postoperative specific prescriptions, urinary catheters, intravenous injections, or severe pressure ulcer treatments (measured over 0–6 months), we

performed ordinal regression analysis using the “polr ()” function in the MASS package of R. This method is specifically designed for ordinal logistic regression of response variable categories with a meaningful order that lacks inherent numeric distance.<sup>40</sup> These outcomes is divided into three ordered categories: “0”, representing one subgroup, and the nonzero values split into two additional subgroups based on half of their distribution. Parallel regression assumptions were made using Brant’s test. When these assumptions were not met ( $P < 0.05$  in the ‘Omnibus’ check), independent variables with the lowest  $P$ -values in the parallel line test were iteratively removed until the assumptions were satisfied. The likelihood ratio test indicated a good model fit ( $P < 0.05$ ).

Finally, to control the cumulative error rate across all regression models, we employed multiple comparison methods to adjust the  $P$ -values, based on guidelines or studies.<sup>41–44</sup> Given the non-normal distribution of our data and the many independent variables (average, 10–12) in a regression, the Holm–Bonferroni

**Table 1** Demographic and clinical characteristics of study participants ( $n = 26\,606$ )

| Variables                                                                                                                     | Value                     |                |             |             |             |             |
|-------------------------------------------------------------------------------------------------------------------------------|---------------------------|----------------|-------------|-------------|-------------|-------------|
|                                                                                                                               | Mean (SD), range          | IQR/ $n$ (%)   | Quantile 25 | Quantile 50 | Quantile 75 | Quantile 90 |
| Preoperative Age (years)                                                                                                      | 85.09 $\pm$ 5.76 (65–108) | 8              | 81          | 85          | 89          | 93          |
| Young-old (65–74 years) group                                                                                                 |                           | 278 (1.04)     |             |             |             |             |
| Middle-old (75–84 years) group                                                                                                |                           | 12 600 (47.36) |             |             |             |             |
| Old-old (85–100 years) group                                                                                                  |                           | 13 616 (51.18) |             |             |             |             |
| Super-old (>100 years) group                                                                                                  |                           | 112 (0.42)     |             |             |             |             |
| Preoperative Sex                                                                                                              |                           |                |             |             |             |             |
| Male                                                                                                                          |                           | 4560 (17.14)   |             |             |             |             |
| Female                                                                                                                        |                           | 22 046 (82.86) |             |             |             |             |
| Preoperative 1-year LOS (days)                                                                                                | 17.32 $\pm$ 49.54 (0–366) | 9              | 0           | 0           | 9           | 49          |
| Preoperative 1-year outpatient utilization (days)                                                                             | 37.29 $\pm$ 40.61 (0–366) | 31             | 14          | 26          | 45          | 80          |
| Preoperative 1-year prescriptions or intensive care utilizations                                                              |                           |                |             |             |             |             |
| Antiosteoporosis prescriptions                                                                                                | 2.63 $\pm$ 4.38 (0–12)    | 4              | 0           | 0           | 4           | 12          |
| Constipation prescriptions                                                                                                    | 4.10 $\pm$ 4.70 (0–12)    | 9              | 0           | 1           | 9           | 12          |
| Antidiabetic prescriptions                                                                                                    | 1.39 $\pm$ 3.53 (0–12)    | 0              | 0           | 0           | 0           | 8           |
| Antibacterial prescriptions                                                                                                   | 0.02 $\pm$ 0.32 (0–12)    | 0              | 0           | 0           | 0           | 0           |
| Antihypertensive prescriptions                                                                                                | 3.61 $\pm$ 4.89 (0–12)    | 9              | 0           | 0           | 9           | 12          |
| Antidementia prescriptions                                                                                                    | 1.77 $\pm$ 3.84 (0–12)    | 0              | 0           | 0           | 0           | 10          |
| Indwelling urinary catheters                                                                                                  | 0.18 $\pm$ 0.62 (0–12)    | 0              | 0           | 0           | 0           | 1           |
| Preoperative 1-year prescriptions or intensive care utilizations                                                              |                           |                |             |             |             |             |
| Drip injections                                                                                                               | 0.60 $\pm$ 1.29 (0–12)    | 1              | 0           | 0           | 1           | 2           |
| Severe pressure ulcer treatments                                                                                              | 0.01 $\pm$ 0.14 (0–9)     | 0              | 0           | 0           | 0           | 0           |
| LOS for the first postoperative half-year                                                                                     | 61.92 $\pm$ 47.39 (0–184) | 67             | 23          | 55          | 90          | 126         |
| Number of months with physician orders for prescriptions or intensive care utilizations for the first postoperative half-year |                           |                |             |             |             |             |
| Antiosteoporosis prescriptions                                                                                                | 1.39 $\pm$ 2.06 (0–6)     | 3              | 0           | 0           | 3           | 5           |
| Constipation prescriptions                                                                                                    | 2.51 $\pm$ 2.19 (0–6)     | 4              | 0           | 2           | 4           | 6           |
| Antidiabetic prescriptions                                                                                                    | 0.63 $\pm$ 1.61 (0–6)     | 0              | 0           | 0           | 0           | 4           |
| Antibacterial prescriptions                                                                                                   | 0.01 $\pm$ 0.14 (0–6)     | 0              | 0           | 0           | 0           | 0           |
| Antihypertensive prescriptions                                                                                                | 1.44 $\pm$ 2.17 (0–6)     | 3              | 0           | 0           | 3           | 5           |
| Antidementia prescriptions                                                                                                    | 0.84 $\pm$ 1.83 (0–6)     | 0              | 0           | 0           | 0           | 4           |
| Indwelling urinary catheters                                                                                                  | 0.14 $\pm$ 0.52 (0–6)     | 0              | 0           | 0           | 0           | 0           |
| Drip injections                                                                                                               | 0.48 $\pm$ 0.87 (0–6)     | 1              | 0           | 0           | 1           | 2           |
| Severe pressure ulcer treatments                                                                                              | 0.02 $\pm$ 0.22 (0–5)     | 0              | 0           | 0           | 0           | 0           |

IQR, interquartile range.; LOS, length of stay; SD, standard deviation.

**Table 2** Linear and quantile regression of preoperative patient factors on LOS for first postoperative half-year

| Dependent variables                              | Independent variables                                  | Model 1: Quantile regression                                                                                   |                    |         |         |          |                  |                    |         |        |        |                  |                    |         |         |         |
|--------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------|---------|---------|----------|------------------|--------------------|---------|--------|--------|------------------|--------------------|---------|---------|---------|
|                                                  |                                                        | Quantile 25                                                                                                    |                    |         |         |          | Quantile 50      |                    |         |        |        | Quantile 75      |                    |         |         |         |
|                                                  |                                                        | Coefficient (SE)                                                                                               | 95%CI              | P-value | P_holm  | P_bh     | Coefficient (SE) | 95%CI              | P-value | P_holm | P_bh   | Coefficient (SE) | 95%CI              | P-value | P_holm  | P_bh    |
| LOS for the first postoperative half-year (days) | Female (reference: male)                               | -0.068 (0.031)                                                                                                 | (-0.130 to -0.007) | 0.030*  | 0.120   | 0.039*   | -0.028 (0.015)   | (-0.058 to 0.001)  | 0.063   | 0.313  | 0.090  | -0.033 (0.012)   | (-0.056 to -0.010) | 0.004** | 0.022*  | 0.006** |
|                                                  | Age (years)                                            | -0.041 (0.012)                                                                                                 | (-0.064 to -0.018) | 0.001** | 0.003** | 0.001**  | 0.003 (0.006)    | (-0.009 to 0.014)  | 0.64    | 1      | 0.64   | 0.01 (0.004)     | (0.001 to 0.018)   | 0.021*  | 0.085   | 0.028*  |
|                                                  | Preoperative 1-year medical service utilization (days) | 0.253 (0.012)                                                                                                  | (0.229 to 0.276)   | 0***    | 0***    | 0***     | 0.168 (0.006)    | (0.156 to 0.179)   | 0***    | 0***   | 0***   | 0.107 (0.004)    | (0.099 to 0.116)   | 0***    | 0***    | 0***    |
|                                                  | LOS                                                    | 0 (0.012)                                                                                                      | (-0.024 to 0.024)  | 0.996   | 1       | 0.996    | -0.01 (0.006)    | (-0.021 to 0.002)  | 0.111   | 0.443  | 0.144  | 0.001 (0.005)    | (-0.008 to 0.01)   | 0.887   | 1       | 0.909   |
|                                                  | Outpatient utilization                                 | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                    |         |         |          |                  |                    |         |        |        |                  |                    |         |         |         |
|                                                  | Antidementia prescriptions                             | -0.145 (0.012)                                                                                                 | (-0.168 to -0.122) | 0***    | 0***    | 0***     | -0.081 (0.006)   | (-0.092 to -0.07)  | 0***    | 0***   | 0***   | -0.018 (0.004)   | (-0.026 to -0.009) | 0***    | 0***    | 0***    |
|                                                  | Antistomatoporiasis prescriptions                      | 0.119 (0.012)                                                                                                  | (0.095 to 0.143)   | 0***    | 0***    | 0***     | 0.057 (0.006)    | (0.045 to 0.068)   | 0***    | 0***   | 0***   | 0.026 (0.004)    | (0.017 to 0.034)   | 0***    | 0***    | 0***    |
|                                                  | Antibacterial prescriptions                            | 0.006 (0.012)                                                                                                  | (-0.017 to 0.028)  | 0.619   | 1       | 0.67     | 0.004 (0.006)    | (-0.007 to 0.014)  | 0.521   | 1      | 0.564  | 0 (0.004)        | (-0.009 to 0.008)  | 0.909   | 1       | 0.909   |
|                                                  | Antihypertensive prescriptions                         | 0.092 (0.012)                                                                                                  | (0.069 to 0.115)   | 0***    | 0***    | 0***     | 0.048 (0.006)    | (0.037 to 0.059)   | 0***    | 0***   | 0***   | 0.017 (0.004)    | (0.009 to 0.026)   | 0***    | 0.001** | 0***    |
|                                                  | Antidiabetic prescriptions                             | 0.061 (0.012)                                                                                                  | (0.038 to 0.084)   | 0***    | 0***    | 0***     | 0.043 (0.006)    | (0.032 to 0.054)   | 0***    | 0***   | 0***   | 0.024 (0.004)    | (0.015 to 0.032)   | 0***    | 0***    | 0***    |
| Severe pressure ulcer treatments                 | Constipation prescriptions                             | -0.127 (0.012)                                                                                                 | (-0.151 to -0.104) | 0***    | 0***    | 0***     | -0.061 (0.006)   | (-0.073 to -0.05)  | 0***    | 0***   | 0***   | -0.02 (0.004)    | (-0.029 to -0.012) | 0***    | 0***    | 0***    |
|                                                  | Indwelling urinary catheters                           | -0.093 (0.012)                                                                                                 | (-0.116 to -0.07)  | 0***    | 0***    | 0***     | -0.043 (0.006)   | (-0.055 to -0.032) | 0***    | 0***   | 0***   | -0.015 (0.004)   | (-0.023 to -0.006) | 0.001** | 0.004** | 0.001** |
|                                                  | Drip injections                                        | -0.018 (0.012)                                                                                                 | (-0.042 to 0.006)  | 0.132   | 0.395   | 0.155    | -0.005 (0.006)   | (-0.016 to 0.007)  | 0.404   | 1      | 0.477  | 0.005 (0.004)    | (-0.004 to 0.014)  | 0.249   | 0.747   | 0.294   |
|                                                  | Severe pressure ulcer                                  | -0.04 (0.012)                                                                                                  | (-0.063 to -0.018) | 0***    | 0.003** | 0.001*** | -0.013 (0.006)   | (-0.024 to -0.002) | 0.023*  | 0.137  | 0.037* | -0.013 (0.004)   | (-0.022 to -0.005) | 0.002** | 0.009** | 0.003** |

| Dependent variables                               | Independent variables                                                                                          | Model 1: Quantile regression |                           |         |         |         | Model 2: Multiple linear regression |                           |         |         |          |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------------------------|---------------------------|---------|---------|---------|-------------------------------------|---------------------------|---------|---------|----------|
|                                                   |                                                                                                                | Quantile 90                  |                           |         |         |         |                                     |                           |         |         |          |
|                                                   |                                                                                                                | Coefficient (SE)             | 95%CI                     | P-value | P_holm  | P_bh    | Coefficient (SE)                    | 95%CI                     | P-value | P_holm  | P_bh     |
| LOS for the first postoperative half- year (days) | Female (reference: male)                                                                                       | <b>-0.078 (0.015)</b>        | <b>(-0.107 to -0.048)</b> | 0***    | 0***    | 0***    | -0.077 (0.021)                      | (-0.118 to -0.035)        | 0***    | 0.002** | 0.001*** |
| Age (years)                                       | Preoperative 1-year medical service utilization (days)                                                         | 0.017 (0.006)                | (0.006 to 0.028)          | 0.002** | 0.02*   | 0.006** | -0.027 (0.008)                      | (-0.043 to -0.012)        | 0.001** | 0.003** | 0.001*** |
| LOS                                               | Outpatient utilization                                                                                         | <b>0.078 (0.006)</b>         | <b>(0.067 to 0.09)</b>    | 0***    | 0***    | 0***    | <b>0.172 (0.008)</b>                | <b>(0.156 to 0.188)</b>   | 0***    | 0***    | 0***     |
|                                                   | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization | 0.01 (0.006)                 | (-0.001 to 0.022)         | 0.081   | 0.487   | 0.132   | -0.002 (0.008)                      | (-0.018 to 0.015)         | 0.854   | 1       | 0.856    |
|                                                   | Antidementia prescriptions                                                                                     | -0.002 (0.006)               | (-0.013 to 0.009)         | 0.686   | 1       | 0.811   | <b>-0.098 (0.008)</b>               | <b>(-0.114 to -0.083)</b> | 0***    | 0***    | 0***     |
|                                                   | Antidiabetes prescriptions                                                                                     | 0.015 (0.006)                | (0.003 to 0.026)          | 0.011*  | 0.088   | 0.022*  | <b>0.086 (0.008)</b>                | <b>(0.07 to 0.102)</b>    | 0***    | 0***    | 0***     |
|                                                   | Antibacterial prescriptions                                                                                    | 0.001 (0.006)                | (-0.01 to 0.012)          | 0.842   | 1       | 0.842   | 0.004 (0.008)                       | (-0.011 to 0.019)         | 0.628   | 1       | 0.742    |
|                                                   | Antihypertensive prescriptions                                                                                 | 0.014 (0.006)                | (0.003 to 0.025)          | 0.012*  | 0.088   | 0.022*  | <b>0.07 (0.008)</b>                 | <b>(0.054 to 0.086)</b>   | 0***    | 0***    | 0***     |
|                                                   | Antidiabetic prescriptions                                                                                     | 0.028 (0.006)                | (0.017 to 0.039)          | 0***    | 0***    | 0***    | 0.058 (0.008)                       | (0.042 to 0.073)          | 0***    | 0***    | 0***     |
|                                                   | Constipation prescriptions                                                                                     | -0.004 (0.006)               | (-0.015 to 0.007)         | 0.467   | 1       | 0.607   | <b>-0.097 (0.008)</b>               | <b>(-0.113 to -0.081)</b> | 0***    | 0***    | 0***     |
|                                                   | Indwelling urinary catheters                                                                                   | -0.001 (0.006)               | (-0.012 to 0.01)          | 0.819   | 1       | 0.842   | -0.007 (0.008)                      | (-0.073 to -0.041)        | 0***    | 0***    | 0***     |
|                                                   | Drip injections                                                                                                | 0.02 (0.006)                 | (0.009 to 0.032)          | 0***    | 0.004** | 0.001** | 0.001 (0.008)                       | (-0.015 to 0.018)         | 0.856   | 1       | 0.856    |
|                                                   | Severe pressure ulcer treatments                                                                               | 0.007 (0.006)                | (-0.003 to 0.018)         | 0.178   | 0.89    | 0.257   | -0.019 (0.008)                      | (-0.034 to -0.004)        | 0.014*  | 0.055   | 0.018*   |

Note: Bold indicates significant impact factors ( $P < 0.001$ ) with higher coefficients than many other factors during the short-term postoperative period and higher coefficients than their impact on multiple other quantiles.

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .

Percentiles such as the 25th, 50th (median), 75th, and 90th percentiles represent the cutoff values below which specific percentages of values fall.  $P$ -value: unadjusted  $P$ -value,  $P$ -holm:  $P$ -value adjusted using the Holm method.  $P$ -bh:  $P$ -value adjusted using the Benjamini-Hochberg method. Coefficients refer to the dummy variable's coefficient (B) for the sex variable and the Standardized Regression Coefficient ( $\beta$ ) for other independent variables. Each cell contains an SE provided in parentheses. 95% CI: Lower to upper bound of the 95% confidence interval. All numerical values were retained to three decimals to accurately report the regression results. CI, confidence interval; LOS, length of stay; SE, standard error.

method was selected as the primary method to assess the result robustness. The Benjamini-Hochberg method provides a supplementary adjustment. All analyses were conducted using the R function “p.adjust.” To identify strong predictors and control for the cumulative error rate, we focused on the independent variables with adjusted  $P$ -values  $< 0.001$  under both methods.

Statistical analyses were conducted in accordance with Statistical Analyses and Methods in the Published Literature (the SAMPL Guidelines). Data analysis and interpretation were discussed in author meetings, and a statistician confirmed all analyses.

## Results

### Patient's characteristics

Demographic and care utilization characteristics are summarized in Table 1. The mean age of the participants was 85.09 years, with 47.36% being middle-aged (75–84 years) and 51.18% old (85–100 years). The majority of the patients were female (82.86%).

The preoperative LOS and outpatient utilization showed substantial variability. The mean preoperative LOS was 17.32 days, median, 0 days). Outpatient utilization averaged 37.29 days, with a median of 26 days. Preoperative prescriptions and intensive resource utilization also varied, indicating that a subset of patients had prolonged and multiple care needs.

Postoperative care utilization was similarly skewed, with prolonged and multiple needs in a substantial proportion of patients. The mean postoperative half-year LOS was 61.92 [median, 55] days). Seventy-five percent of participants required prescriptions for 3 months and care for 1 month. Constipation prescriptions had the longest mean duration (2.51 months), followed by antihypertensive (1.44 months) and antiosteoporosis (1.39 months). Intensive care utilization was lower, with indwelling urinary catheters averaging 0.14 months and drip injections at 0.48 months.

### Detailed findings

#### Impact of preoperative demographic factors

Compared to male sex, female sex was negatively associated with postoperative LOS and strongly associated at q90 ( $B = -0.078$  [95% CI width = 0.059]; Table 2). Moreover, sex significantly influenced various postoperative prescriptions and intensive care utilizations. Specifically, female sex was strongly positively associated with postoperative antihypertensive, antiosteoporosis, or antidementia prescriptions, while showing negative associations with diabetes prescriptions or drip injections (Table 4).

Age has strong negative associations with antiosteoporosis or diabetes prescriptions ( $\beta = -0.165$  or  $-0.32$  [95% CI widths = 0.049 or 0.071], respectively), but strong positive associations with indwelling urinary catheters or drip injections ( $\beta = 0.136$  or  $0.159$  [95% CI widths = 0.081 or 0.053], respectively; Table 4).

#### Effects of preoperative medical service utilization

Preoperative 1-year LOS demonstrated strong positive correlations with postoperative LOS ( $\beta = 0.078$ – $0.253$  [95% CI widths = 0.017–0.047]; Tables 2 and 3) or indwelling urinary catheters ( $\beta = 0.08$  [95% CI width = 0.074]). The strongest association was observed at q25 with postoperative LOS. Conversely, preoperative LOS was strongly negatively associated with antihypertensive or antidementia prescriptions ( $\beta = -0.102$  or  $-0.073$  [95% CI widths = 0.057 or 0.069], respectively; Table 4).

**Table 3** 95% CI width for linear and quantile regressions of postoperative LOS for first postoperative half-year

| Dependent variables                              | Independent variables                                                                                          | Model 1: Quantile regression |              |              |              | Model 2: Multiple linear regression |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------------------------|--------------|--------------|--------------|-------------------------------------|
|                                                  |                                                                                                                | Quantile 25                  | Quantile 50  | Quantile 75  | Quantile 90  |                                     |
|                                                  |                                                                                                                | 95% CI Width                 | 95% CI Width | 95% CI Width | 95% CI Width | 95% CI Width                        |
| LOS for the first postoperative half-year (days) | Female (reference: male)                                                                                       | 0.123                        | 0.059        | 0.046        | 0.059        | 0.083                               |
|                                                  | Age (years)                                                                                                    | 0.046                        | 0.023        | 0.017        | 0.022        | 0.031                               |
|                                                  | Preoperative 1-year medical service utilization (days)                                                         |                              |              |              |              |                                     |
|                                                  | LOS (days)                                                                                                     | 0.047                        | 0.023        | 0.017        | 0.023        | 0.032                               |
|                                                  | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                              |              |              |              |                                     |
|                                                  | Antidementia prescriptions                                                                                     | 0.046                        | 0.022        | 0.017        | 0.022        | 0.031                               |
|                                                  | Antiosteoporosis prescriptions                                                                                 | 0.048                        | 0.023        | 0.017        | 0.023        | 0.032                               |
|                                                  | Antihypertensive prescriptions                                                                                 | 0.046                        | 0.022        | 0.017        | 0.022        | 0.032                               |
|                                                  | Antidiabetic prescriptions                                                                                     | 0.046                        | 0.022        | 0.017        | 0.022        | 0.031                               |
|                                                  | Constipation prescriptions                                                                                     | 0.047                        | 0.023        | 0.017        | 0.022        | 0.032                               |
|                                                  | Indwelling urinary catheters                                                                                   | 0.046                        | 0.023        | 0.017        | 0.022        | 0.032                               |
|                                                  | Drip injections                                                                                                | 0.048                        | 0.023        | 0.018        | 0.023        | 0.033                               |
|                                                  | Severe pressure ulcer treatments                                                                               | 0.045                        | 0.022        | 0.017        | 0.021        | 0.03                                |

This table did not report factors with all  $P$ -values  $> 0.05$  across linear and quantile regressions. The 95% CI width is calculated as the absolute value of the difference between the upper and lower bounds of the 95% CI. CI, confidence interval; LOS, length of stay.

#### *Influence of preoperative prescription or intensive resource utilization*

Preoperative antiosteoporosis or antihypertensive prescriptions were positively correlated with postoperative LOS with high correlations at q25 ( $\beta = 0.119$  or  $0.092$  [95% CI widths =  $0.048$  or  $0.046$ ], respectively). In contrast, preoperative indwelling urinary catheter use, constipation and antidementia prescriptions were negatively correlated. The high correlations are also at q25 ( $\beta = -0.093$ ,  $-0.127$ ,  $-0.145$  [95% CI widths =  $0.046$ – $0.047$ ]) and the q50 for antidementia prescriptions ( $\beta = -0.081$  [95% CI width =  $0.022$ ]; Tables 2 and 3).

In ordinal regressions, preoperative constipation prescriptions were strongly positively associated with postoperative indwelling urinary catheters ( $\beta = 0.119$  [95% CI width =  $0.081$ ]) and drip injections ( $\beta = 0.11$  [95% CI width =  $0.052$ ]). Preoperative severe pressure ulcer treatments were strongly positively associated with postoperative severe pressure ulcer treatments ( $\beta = 0.085$  [95% CI width =  $0.068$ ]). Additionally, preoperative diabetes prescriptions were strongly positively related to constipation or antihypertensive prescriptions ( $\beta = 0.074$  or  $0.257$  [95% CI widths =  $0.045$  or  $0.047$ ], respectively). Preoperative drip injections or antidementia prescriptions were also strongly positively related to constipation prescriptions ( $\beta = 0.076$  or  $0.182$  [95% CI widths =  $0.047$  or  $0.045$ ], respectively), indwelling urinary catheters ( $\beta = 0.099$  [95% CI width =  $0.070$ ]) or drip injections ( $\beta = 0.075$  [95% CI width =  $0.051$ ]; Table 4).

## Discussion

Distinct from previous studies,<sup>45–47</sup> we innovatively applied quantile regressions to large-scale health insurance data sets, revealing demographics and longer preoperative care utilization factors strongly associated with multiple postoperative outcomes. Notably, the preoperative LOS is the substantial risk of the whole

postoperative 6-month LOS. Outweighing the effects of other variables, it is the most significant independent risk factor for short-term postoperative LOS. Additionally, preoperative antidementia, antiosteoporosis, antihypertensive and constipation prescriptions and indwelling catheters are significant risks during a short LOS. In contrast, male patients exhibited a higher risk during a long postoperative LOS duration. Despite the limited clinical data, our findings can still guide future research on observed nonlinear effects, the development of local person-centered, integrated care and more equitable health care resource allocation policies.<sup>48,49</sup>

The prevalence of hip fractures was higher in women and middle- to old-old adults, consistent with previous studies.<sup>50</sup> Women experienced shorter postoperative LOS than men, particularly as they approached the 6-month postoperative mark, likely due to better recovery.<sup>51</sup> While both sexes improved from baseline to 6 months, with only men continuing to improve between half and 1 year.<sup>52</sup> Sex is a significant factor in some postoperative prescriptions and intensive care, with varied directions. These findings may contribute to known sex-based disparities in multifaceted health recoveries or care utilization.<sup>53</sup> Despite shorter LOS, older females following fracture surgery had more antiosteoporosis or antihypertensive prescriptions. Dementia, which is more prevalent in women aged  $> 80$  years, contributes to a higher prevalence of hip fractures in demented women. Conversely, men with diabetes in Japan are more susceptible to hip fractures.<sup>54</sup> Additionally, older men with hip fractures may have more access to postoperative nutritional supplements or intravenous treatments, which are crucial for improving outcomes and survival rates. Another possibility is that standardized, tailored care procedures or pathways can account for or address variations in patient sex and care preference.<sup>55</sup> Further research on the impact of provider and patient sex on health care interactions is needed.<sup>56</sup> Age also has diverse and significant effects on postoperative intensive care. Advanced age increases the likelihood of multiple critical illnesses and reliance on postoperative indwelling catheters and drip

**Table 4** Ordinal regression of preoperative patient factors on number of months with physician orders for prescriptions or intensive resource utilization for first postoperative half-year

| Model: Dependent variables                                                                                               | Independent variables                                                                                          | Coefficient (SE)      | 95% CI                    | 95% CI width | P-value     | P_holm      | P_bh        | P in Omnibus | P for chi-square test |
|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|--------------|-------------|-------------|-------------|--------------|-----------------------|
| Model 1: Number of months with physician orders for antioestoporosis prescriptions for the first postoperative half-year | Female (reference: male)                                                                                       | <b>0.909 (0.037)</b>  | <b>(0.837 to 0.983)</b>   | <b>0.146</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> | 0.24         | 0                     |
|                                                                                                                          | Age (years)                                                                                                    | <b>-0.165 (0.013)</b> | <b>(-0.19 to -0.141)</b>  | <b>0.049</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                          | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                       |                           |              |             |             |             |              |                       |
|                                                                                                                          | Antibacterial prescriptions                                                                                    | 0.041 (0.011)         | (0.019 to 0.063)          | 0.044        | 0***        | 0.001**     | 0.001**     |              |                       |
|                                                                                                                          | Antidiabetic prescriptions                                                                                     | -0.038 (0.013)        | (-0.063 to -0.014)        | 0.049        | 0.002**     | 0.007**     | 0.003**     |              |                       |
|                                                                                                                          | Indwelling urinary catheters                                                                                   | -0.049 (0.014)        | (-0.078 to -0.022)        | 0.056        | 0***        | 0.002**     | 0.001**     |              |                       |
|                                                                                                                          | Drip injections                                                                                                | 0.027 (0.013)         | (0.002 to 0.051)          | 0.049        | 0.032*      | 0.064       | 0.038*      |              |                       |
|                                                                                                                          | Severe pressure ulcer treatments                                                                               | -0.022 (0.014)        | (-0.053 to 0.004)         | 0.057        | 0.115       | 0.115       | 0.115       |              |                       |
|                                                                                                                          | Female (reference: male)                                                                                       | 0.068 (0.03)          | (0.009 to 0.127)          | 0.118        | 0.024*      | 0.048*      | 0.028*      | 0.16         | 0                     |
|                                                                                                                          | Preoperative 1-year LOS (days)                                                                                 | 0.04 (0.012)          | (0.017 to 0.063)          | 0.046        | 0.001**     | 0.003**     | 0.001**     |              |                       |
| Model 2: Number of months with physician orders for constipation prescriptions for the first postoperative half-year     | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                       |                           |              |             |             |             |              |                       |
|                                                                                                                          | Antidementia prescriptions                                                                                     | <b>0.182 (0.012)</b>  | <b>(0.159 to 0.204)</b>   | <b>0.045</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                          | Antidiabetic prescriptions                                                                                     | <b>0.074 (0.011)</b>  | <b>(0.052 to 0.097)</b>   | <b>0.045</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                          | Indwelling urinary catheters                                                                                   | 0.014 (0.012)         | (-0.009 to 0.037)         | 0.046        | 0.243       | 0.243       | 0.243       |              |                       |
|                                                                                                                          | Drip injections                                                                                                | <b>0.076 (0.012)</b>  | <b>(0.053 to 0.1)</b>     | <b>0.047</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                          | Severe pressure ulcer treatments                                                                               | 0.034 (0.013)         | (0.009 to 0.06)           | 0.051        | 0.009**     | 0.026*      | 0.012*      |              |                       |
|                                                                                                                          | Female (reference: male)                                                                                       | 1.451 (0.392)         | (0.757 to 2.318)          | 1.561        | 0***        | 0.002**     | 0.002**     | 0.09         | 0                     |
|                                                                                                                          | Age                                                                                                            | -0.312 (0.089)        | (-0.488 to -0.138)        | 0.35         | 0***        | 0.005**     | 0.003**     |              |                       |
|                                                                                                                          | Preoperative 1-year LOS (days)                                                                                 | 0.057 (0.079)         | (-0.115 to 0.196)         | 0.311        | 0.466       | 1           | 0.64        |              |                       |
|                                                                                                                          | Preoperative outpatient utilization(days)                                                                      | 0.138 (0.069)         | (-0.006 to 0.266)         | 0.272        | 0.046*      | 0.366       | 0.126       |              |                       |
| Model 3: Number of months with physician orders for antibacterial prescriptions for the first postoperative half-year    | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                       |                           |              |             |             |             |              |                       |
|                                                                                                                          | Antidementia prescriptions                                                                                     | 0.043 (0.08)          | (-0.122 to 0.194)         | 0.316        | 0.593       | 1           | 0.652       |              |                       |
|                                                                                                                          | Antioestoporosis prescriptions                                                                                 | 0.226 (0.075)         | (0.077 to 0.371)          | 0.294        | 0.003**     | 0.024*      | 0.01*       |              |                       |
|                                                                                                                          | Antihypertensive prescriptions                                                                                 | 0.047 (0.081)         | (-0.114 to 0.205)         | 0.319        | 0.559       | 1           | 0.652       |              |                       |
|                                                                                                                          | Antidiabetic prescriptions                                                                                     | 0.09 (0.074)          | (-0.062 to 0.228)         | 0.29         | 0.225       | 1           | 0.353       |              |                       |
|                                                                                                                          | Constipation prescriptions                                                                                     | -0.032 (0.085)        | (-0.201 to 0.132)         | 0.333        | 0.709       | 1           | 0.709       |              |                       |
|                                                                                                                          | Indwelling urinary catheters                                                                                   | 0.072 (0.058)         | (-0.069 to 0.164)         | 0.233        | 0.212       | 1           | 0.353       |              |                       |
|                                                                                                                          | Drip injections                                                                                                | 0.082 (0.064)         | (-0.058 to 0.196)         | 0.254        | 0.204       | 1           | 0.353       |              |                       |
|                                                                                                                          | Female (reference: male)                                                                                       | <b>0.15 (0.034)</b>   | <b>(0.085 to 0.216)</b>   | <b>0.131</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> | 0.36         | 0                     |
|                                                                                                                          | Preoperative 1-year LOS (days)                                                                                 | <b>-0.102 (0.014)</b> | <b>(-0.131 to -0.074)</b> | <b>0.057</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
| Model 4: Number of months with physician orders for antihypertensive prescriptions for the first postoperative half-year | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                       |                           |              |             |             |             |              |                       |
|                                                                                                                          | Antibacterial prescriptions                                                                                    | 0.009 (0.012)         | (-0.016 to 0.033)         | 0.049        | 0.46        | 1           | 0.645       |              |                       |
|                                                                                                                          | Antidiabetic prescriptions                                                                                     | <b>0.257 (0.012)</b>  | <b>(0.234 to 0.281)</b>   | <b>0.047</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                          | Indwelling urinary catheters                                                                                   | -0.004 (0.013)        | (-0.03 to 0.022)          | 0.052        | 0.781       | 1           | 0.907       |              |                       |
|                                                                                                                          | Drip injections                                                                                                | 0.024 (0.013)         | (-0.001 to 0.05)          | 0.051        | 0.062       | 0.248       | 0.108       |              |                       |
|                                                                                                                          | Severe pressure ulcer treatments                                                                               | 0.001 (0.013)         | (-0.024 to 0.025)         | 0.049        | 0.907       | 1           | 0.907       |              |                       |

(Continues)

8 **Table 4** Continued

| Model: Dependent variables                                                                                             | Independent variables                                                                         | Coefficient (SE) | 95% CI             | 95% CI width | P-value | P_holm  | P_bh    | P in Omnibus | P for chi-square test |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------|--------------------|--------------|---------|---------|---------|--------------|-----------------------|
| Model 5: Number of months with physician orders for antidiabetic prescriptions for the first postoperative half-year   | Female (reference: male)                                                                      | -0.203 (0.043)   | (-0.286 to -0.118) | 0.168        | 0.000   | 0.000   | 0.000   | 0.06         | 0                     |
|                                                                                                                        | Age                                                                                           | -0.32 (0.018)    | (-0.356 to -0.285) | 0.071        | 0.000   | 0.000   | 0.000   |              |                       |
|                                                                                                                        | Preoperative 1-year LOS (days)                                                                | -0.033 (0.018)   | (-0.068 to 0.001)  | 0.069        | 0.065   | 0.323   | 0.129   |              |                       |
|                                                                                                                        | Preoperative 1-year number of months with physician orders for intensive resource utilization | -0.012 (0.018)   | (-0.047 to 0.022)  | 0.069        | 0.484   | 0.862   | 0.484   |              |                       |
|                                                                                                                        | Antidementia prescriptions                                                                    | 0.015 (0.014)    | (-0.015 to 0.042)  | 0.057        | 0.287   | 0.862   | 0.383   |              |                       |
|                                                                                                                        | Antibacterial prescriptions                                                                   | 0.039 (0.015)    | (0.008 to 0.068)   | 0.06         | 0.01*   | 0.061   | 0.027*  |              |                       |
|                                                                                                                        | Indwelling urinary catheters                                                                  | 0.023 (0.017)    | (-0.011 to 0.056)  | 0.067        | 0.183   | 0.732   | 0.293   |              |                       |
|                                                                                                                        | Drip injections                                                                               | 0.014 (0.016)    | (-0.02 to 0.043)   | 0.063        | 0.37    | 0.862   | 0.422   |              |                       |
|                                                                                                                        | Severe pressure ulcer treatments                                                              | 0.328 (0.044)    | (0.243 to 0.415)   | 0.172        | 0.000   | 0.000   | 0.000   | 0.14         | 0                     |
| Model 6: Number of months with physician orders for antidementia prescriptions for the first postoperative half-year   | Female (reference: male)                                                                      | 0.063 (0.015)    | (0.033 to 0.093)   | 0.06         | 0.000   | 0.000   | 0.000   |              |                       |
|                                                                                                                        | Age                                                                                           | -0.073 (0.018)   | (-0.108 to -0.039) | 0.069        | 0.000   | 0.000   | 0.000   |              |                       |
|                                                                                                                        | Preoperative 1-year LOS (days)                                                                | -0.018 (0.015)   | (-0.048 to 0.012)  | 0.06         | 0.243   | 0.487   | 0.278   |              |                       |
|                                                                                                                        | Preoperative 1-year number of months with physician orders for intensive resource utilization | -0.046 (0.022)   | (-0.094 to -0.008) | 0.086        | 0.036*  | 0.144   | 0.052   |              |                       |
|                                                                                                                        | Antiosteoporosis prescriptions                                                                | -0.053 (0.019)   | (-0.09 to -0.017)  | 0.073        | 0.005** | 0.025*  | 0.01**  |              |                       |
|                                                                                                                        | Antibacterial prescriptions                                                                   | 0.005 (0.016)    | (-0.027 to 0.035)  | 0.062        | 0.776   | 0.776   | 0.776   |              |                       |
|                                                                                                                        | Indwelling urinary catheters                                                                  | 0.026 (0.013)    | (0 to 0.051)       | 0.051        | 0.039*  | 0.144   | 0.052   |              |                       |
|                                                                                                                        | Drip injections                                                                               | 0.136 (0.021)    | (0.095 to 0.176)   | 0.081        | 0.000   | 0.000   | 0.000   | 0.08         | 0                     |
|                                                                                                                        | Severe pressure ulcer treatments                                                              | 0.08 (0.019)     | (0.042 to 0.116)   | 0.074        | 0.000   | 0.000   | 0.000   |              |                       |
| Model 7: Number of months with physician orders for indwelling urinary catheters for the first postoperative half-year | Age                                                                                           | -0.025 (0.023)   | (-0.071 to 0.019)  | 0.09         | 0.265   | 1       | 0.365   |              |                       |
|                                                                                                                        | Preoperative 1-year LOS (days)                                                                | 0.02 (0.02)      | (-0.02 to 0.059)   | 0.079        | 0.32    | 1       | 0.391   |              |                       |
|                                                                                                                        | Preoperative outpatient utilization(days)                                                     | 0.012 (0.021)    | (-0.03 to 0.052)   | 0.082        | 0.584   | 1       | 0.642   |              |                       |
|                                                                                                                        | Preoperative 1-year number of months with physician orders for intensive resource utilization | 0.006 (0.019)    | (-0.037 to 0.041)  | 0.078        | 0.745   | 1       | 0.745   |              |                       |
|                                                                                                                        | Antidementia prescriptions                                                                    | 0.067 (0.021)    | (0.027 to 0.108)   | 0.081        | 0.001** | 0.008** | 0.002** |              |                       |
|                                                                                                                        | Antiosteoporosis prescriptions                                                                | 0.054 (0.02)     | (0.014 to 0.093)   | 0.079        | 0.007** | 0.042*  | 0.013*  |              |                       |
|                                                                                                                        | Antibacterial prescriptions                                                                   | 0.119 (0.021)    | (0.078 to 0.159)   | 0.081        | 0.000   | 0.000   | 0.000   |              |                       |
|                                                                                                                        | Antihypertensive prescriptions                                                                | 0.099 (0.018)    | (0.064 to 0.134)   | 0.07         | 0.000   | 0.000   | 0.000   |              |                       |
|                                                                                                                        | Antidiabetic prescriptions                                                                    | 0.032 (0.014)    | (0.002 to 0.06)    | 0.058        | 0.024*  | 0.119   | 0.037*  |              |                       |
|                                                                                                                        | Consipation prescriptions                                                                     |                  |                    |              |         |         |         |              |                       |
|                                                                                                                        | Drip injections                                                                               |                  |                    |              |         |         |         |              |                       |
|                                                                                                                        | Severe pressure ulcer treatments                                                              |                  |                    |              |         |         |         |              |                       |
|                                                                                                                        |                                                                                               |                  |                    |              |         |         |         |              |                       |
|                                                                                                                        |                                                                                               |                  |                    |              |         |         |         |              |                       |

(Continues)

**Table 4** Continued

| Model: Dependent variables                                                                                                 | Independent variables                                                                                          | Coefficient (SE)     | 95% CI                  | 95% CI width | P-value     | P_holm      | P_bh        | P in Omnibus | P for chi-square test |
|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------------|-------------------------|--------------|-------------|-------------|-------------|--------------|-----------------------|
| Model 8: Number of months with physician orders for severe pressure ulcer treatments for the first postoperative half-year | Female (reference: male)                                                                                       | -0.11 (0.152)        | (-0.4 to 0.196)         | 0.596        | 0.467       | 1           | 0.608       | 0.25         | 0                     |
|                                                                                                                            | Age                                                                                                            | 0.215 (0.057)        | (0.103 to 0.326)        | 0.223        | 0***        | 0.002**     | 0.001**     |              |                       |
|                                                                                                                            | Preoperative 1-year LOS (days)                                                                                 | 0.084 (0.052)        | (-0.026 to 0.179)       | 0.205        | 0.106       | 0.745       | 0.172       |              |                       |
|                                                                                                                            | Preoperative outpatient utilization (days)                                                                     | 0.086 (0.054)        | (-0.026 to 0.187)       | 0.213        | 0.113       | 0.745       | 0.172       |              |                       |
|                                                                                                                            | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                      |                         |              |             |             |             |              |                       |
|                                                                                                                            | Antidementia prescriptions                                                                                     | 0.188 (0.047)        | (0.095 to 0.278)        | 0.183        | 0***        | 0.001**     | 0***        |              |                       |
|                                                                                                                            | Antiosteoporosis prescriptions                                                                                 | -0.021 (0.057)       | (-0.135 to 0.089)       | 0.224        | 0.717       | 1           | 0.717       |              |                       |
|                                                                                                                            | Antibacterial prescriptions                                                                                    | -0.059 (0.104)       | (-0.394 to 0.062)       | 0.456        | 0.571       | 1           | 0.619       |              |                       |
|                                                                                                                            | Antihypertensive prescriptions                                                                                 | 0.032 (0.055)        | (-0.076 to 0.138)       | 0.214        | 0.561       | 1           | 0.619       |              |                       |
|                                                                                                                            | Antidiabetic prescriptions                                                                                     | 0.086 (0.051)        | (-0.018 to 0.183)       | 0.201        | 0.093       | 0.741       | 0.172       |              |                       |
|                                                                                                                            | Constipation prescriptions                                                                                     | 0.162 (0.055)        | (0.055 to 0.269)        | 0.214        | 0.003**     | 0.03*       | 0.01**      |              |                       |
|                                                                                                                            | Indwelling urinary catheters                                                                                   | 0.077 (0.036)        | (-0.006 to 0.139)       | 0.145        | 0.034*      | 0.307       | 0.089       |              |                       |
|                                                                                                                            | Drip injections                                                                                                | -0.103 (0.066)       | (-0.242 to 0.018)       | 0.26         | 0.119       | 0.745       | 0.172       |              |                       |
|                                                                                                                            | Severe pressure ulcer treatments                                                                               | <b>0.085 (0.017)</b> | <b>(0.051 to 0.119)</b> | <b>0.068</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
| Model 9: Number of months with physician orders for drip injections for the first postoperative half-year                  | Female (reference: male)                                                                                       | -0.285 (0.036)       | (-0.355 to -0.215)      | 0.14         | 0***        | 0***        | 0***        | 0.07         | 0                     |
|                                                                                                                            | Age                                                                                                            | <b>0.159 (0.014)</b> | <b>(0.133 to 0.186)</b> | <b>0.053</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                            | Preoperative 1-year number of months with physician orders for prescriptions or intensive resource utilization |                      |                         |              |             |             |             |              |                       |
|                                                                                                                            | Antidementia prescriptions                                                                                     | <b>0.075 (0.013)</b> | <b>(0.05 to 0.101)</b>  | <b>0.051</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                            | Antiosteoporosis prescriptions                                                                                 | 0.024 (0.014)        | (-0.003 to 0.05)        | 0.053        | 0.077       | 0.369       | 0.11        |              |                       |
|                                                                                                                            | Antibacterial prescriptions                                                                                    | 0.019 (0.013)        | (-0.007 to 0.044)       | 0.051        | 0.139       | 0.418       | 0.174       |              |                       |
|                                                                                                                            | Antihypertensive prescriptions                                                                                 | 0.028 (0.013)        | (0.001 to 0.054)        | 0.053        | 0.038*      | 0.231       | 0.077       |              |                       |
|                                                                                                                            | Antidiabetic prescriptions                                                                                     | 0.024 (0.013)        | (-0.002 to 0.05)        | 0.052        | 0.074       | 0.369       | 0.11        |              |                       |
|                                                                                                                            | Constipation prescriptions                                                                                     | <b>0.11 (0.013)</b>  | <b>(0.084 to 0.136)</b> | <b>0.052</b> | <b>0***</b> | <b>0***</b> | <b>0***</b> |              |                       |
|                                                                                                                            | Indwelling urinary catheters                                                                                   | 0.017 (0.013)        | (-0.009 to 0.042)       | 0.051        | 0.201       | 0.418       | 0.223       |              |                       |
|                                                                                                                            | Severe pressure ulcer treatments                                                                               | 0.004 (0.013)        | (-0.022 to 0.028)       | 0.05         | 0.759       | 0.759       | 0.759       |              |                       |

Note: Bold indicates significant impact factors ( $P < 0.001$ ) with higher coefficients than many other factors during the short-term postoperative period and higher coefficients than their impact on multiple other quantiles.

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .

P-value: unadjusted P\_holm: P-value adjusted using the Holm method. P\_bh: P-value adjusted using the Benjamini-Hochberg method. Coefficients refer to the dummy variable's coefficient (B) for the sex variable and the standardized regression coefficient (β) for other independent variables. Each cell contains an SE provided in parentheses. 95% CI: Lower to upper bound of the 95% CI. Omnibus: Omnibus test of the parallel regression assumption. The coefficient and SE values were retained to three decimal places for precision in reporting the regression analysis results. Preoperative outpatient utilization (days): Preoperative 1-year outpatient utilization (days). CI, confidence interval; LOS, length of stay; SE, standard error.

injections. In contrast, antiosteoporosis and antidiabetic prescriptions were reduced. Given the complexity of hip fracture recovery and care, this potentially reflects polypharmacy, complicating treatment regimens and reducing potentially inappropriate medications.<sup>57</sup> Additionally, there is a significant interaction between age, sex and postoperative antiosteoporosis prescriptions, as highlighted by Hoit's research.<sup>58</sup> Overall, these findings underscore the need for individualized clinical decision making. Further investigation is warranted to explore the impact of residual confounders, such as social support or access to care, as well as the comprehensive effects of all factors.

Quantile regression highlights the importance of considering the distribution of LOS when examining newly identified preoperative prescriptions or intensive care determinants, specifically during postoperative short-term LOS. Early acute postoperative prognosis is characterized by a high concentration of complications and rehabilitation challenges.<sup>59</sup> Multiple preoperative health statuses or comorbidities significantly influence postoperative short-term LOS. Almost all preoperative care was positively related to multiple postoperative care, indicating poor prognoses. Generally, constipation reductions shorten the LOS by reducing complications and promoting early mobilization.<sup>60</sup> Most current studies found the postoperative overuse of urinary catheters on postoperative LOS. The risk of infection rises with extended catheterization, underscoring the importance of timely removal and regular assessment of the necessity for continued use.<sup>61,62</sup> Few previous studies directly addressed associations of these preoperative and postoperative variables.<sup>63,64</sup> Comparatively, our study explored and found that preoperative constipation prescriptions or physician orders for indwelling urinary catheters were strongly negative factors of postoperative LOS. The impact of preoperative urinary catheter management on postoperative LOS is inherently complex, requiring consideration of diverse strategies and interventions.<sup>65,66</sup> Due to the complexity surrounding the definition of constipation, discrepancies between patients and health care providers can affect its identification and treatment.<sup>60</sup> In future studies, comprehensive and in-depth assessments and validations of these factors, including care processes, are essential.

However, there is no correlation between preoperative outpatient utilization and postoperative LOS, which is supported by previous studies that showed postoperative outpatient utilization was more likely to be influenced by established regular visits to health care providers' habits or patterns.<sup>67</sup> Notably, care coordination models and the availability of rehabilitation beds vary across countries, with East Asian hospitals often discharging patients more quickly. Overall, optimizing multifaceted preoperative care and understanding whether limited access to hospitalization is due to health status, preferences, care coordination models, availability or comprehensive impacts are crucial.<sup>68,69</sup>

Notably, the discrepancies in sampling, research methodologies, data sources and scope of the data variables examined may explain the different impacts of some variables on postoperative care utilization across studies.<sup>70,71</sup> Prioritizing these preoperative care utilization factors for older patients with hip fracture remains crucial.

This study has several limitations. First, the exploratory and retrospective design limits the ability to construct a standardized hypothetical-deductive framework, draw causal interpretations and control for all confounding factors. Second, certain patients, such as those who dropped out, were excluded. Moreover, the unavailability of crucial and precise information (e.g. exact survival times) for censored data during the study period limited the survival analysis. No formal sample size calculation was performed because previous studies did not assess all variables of interest.

Therefore, potential selection biases were introduced.<sup>72</sup> Additionally, health insurance administrative data have inherent shortcomings such as clinical information adequacy issues. Specifically, the data may not fully represent all study groups or capture all necessary variables, thus limiting clinical insights. Overall, the cases included may not completely align with all original patient trends or characteristics. Nevertheless, the large sample size supports the generalizability of our findings. Finally, while quantile regression is insightful, it focuses on specific quantiles rather than the entire distribution and is sensitive to outliers in the tails.<sup>73</sup> Future research should encompass the entire population and integrate complete and accurate health data from all available sources, including death certificates and facility and prescription details, for thorough analysis. Additionally, prospective longitudinal studies or randomized controlled trials are required to improve the study design. More comprehensive preoperative risk assessment and exploration of care disparities are needed to enable targeted interventions. Clinical practice should use insurance data to support interventions for high-risk older adults.<sup>74</sup>

In conclusion, our study revealed complex relationships between preoperative demographic characteristics, preoperative health care utilization and multiple postoperative half-year care utilization. Key factors such as sex, age, preoperative 1-year LOS and new preoperative prescriptions or intensive care utilization in clinical decision making is crucial.

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## Disclosure statement

The authors declare no conflict of interest.

## Data Availability Statement

Research data are not shared.

## Ethics statement

This study was approved by the institutional review board of the University Hospital (approval number: 19073) and adhered to the ethical standards of the 1964 Declaration of Helsinki and its amendments.

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## Patient consent statement

Informed consent was waived following Japanese Ethical Guidelines.

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## Appendix I

### STROBE statement—Checklist of items that should be included in reports of cohort studies

|                          | Item No         | Recommendation                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Title and abstract       | 1               | (a) Indicate the study's design with a commonly used term in the title or the abstract.<br>(b) Provide in the abstract an informative and balanced summary of what was done and what was found.                                                                                                                                                                                                                  |
| Introduction             |                 |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Background/rationale     | 2               | Explain the scientific background and rationale for the investigation being reported.                                                                                                                                                                                                                                                                                                                            |
| Objectives               | 3               | State specific objectives, including any prespecified hypotheses.                                                                                                                                                                                                                                                                                                                                                |
| Methods                  |                 |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Study design             | 4               | Present key elements of study design early in the paper.                                                                                                                                                                                                                                                                                                                                                         |
| Setting                  | 5               | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.                                                                                                                                                                                                                                                                                 |
| Participants             | 6               | (a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>(b) For matched studies, give matching criteria and number of exposed and unexposed.                                                                                                                                                                                               |
| Variables                | 7               | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.                                                                                                                                                                                                                                                                        |
| Data sources/measurement | 8 <sup>†</sup>  | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.                                                                                                                                                                                                                            |
| Bias                     | 9               | Describe any efforts to address potential sources of bias.                                                                                                                                                                                                                                                                                                                                                       |
| Study size               | 10              | Explain how the study size was arrived at.                                                                                                                                                                                                                                                                                                                                                                       |
| Quantitative variables   | 11              | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.                                                                                                                                                                                                                                                                                    |
| Statistical methods      | 12              | (a) Describe all statistical methods, including those used to control for confounding.<br>(b) Describe any methods used to examine subgroups and interactions.<br>(c) Explain how missing data were addressed.<br>(d) If applicable, explain how loss to follow-up was addressed.<br>(e) Describe any sensitivity analyses.                                                                                      |
| Results                  |                 |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Participants             | 13 <sup>†</sup> | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed<br>(b) Give reasons for non-participation at each stage<br>(c) Consider use of a flow diagram                                                                                                                  |
| Descriptive data         | 14 <sup>†</sup> | (a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders.<br>(b) Indicate number of participants with missing data for each variable of interest.<br>(c) Summarize follow-up time (e.g. average and total amount).                                                                                                             |
| Outcome data             | 15 <sup>†</sup> | Report numbers of outcome events or summary measures over time.                                                                                                                                                                                                                                                                                                                                                  |
| Main results             | 16              | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included.<br>(b) Report category boundaries when continuous variables were categorized.<br>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. |
| Other analyses           | 17              | Report other analyses done – e.g. analyses of subgroups and interactions and sensitivity analyses                                                                                                                                                                                                                                                                                                                |
| Discussion               |                 |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Key results              | 18              | Summarize key results with reference to study objectives.                                                                                                                                                                                                                                                                                                                                                        |
| Limitations              | 19              | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.                                                                                                                                                                                                                                                      |
| Interpretation           | 20              | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.                                                                                                                                                                                                                                      |
| Generalizability         | 21              | Discuss the generalizability (external validity) of the study results.                                                                                                                                                                                                                                                                                                                                           |
| Other information        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Funding                  | 22              | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based.                                                                                                                                                                                                                                                   |

<sup>†</sup>Give information separately for exposed and unexposed groups.

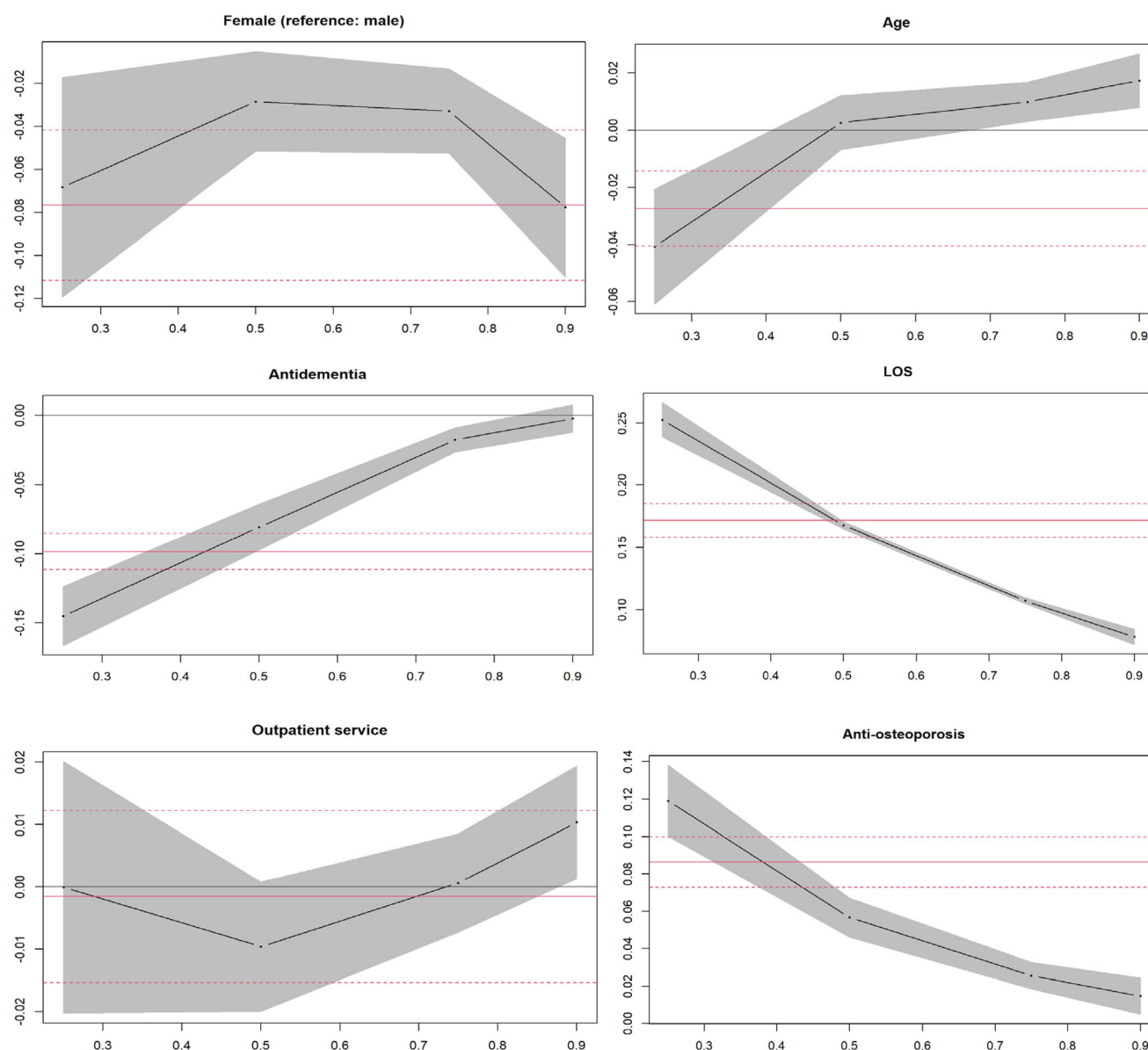
An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLOS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

## APPENDIX II

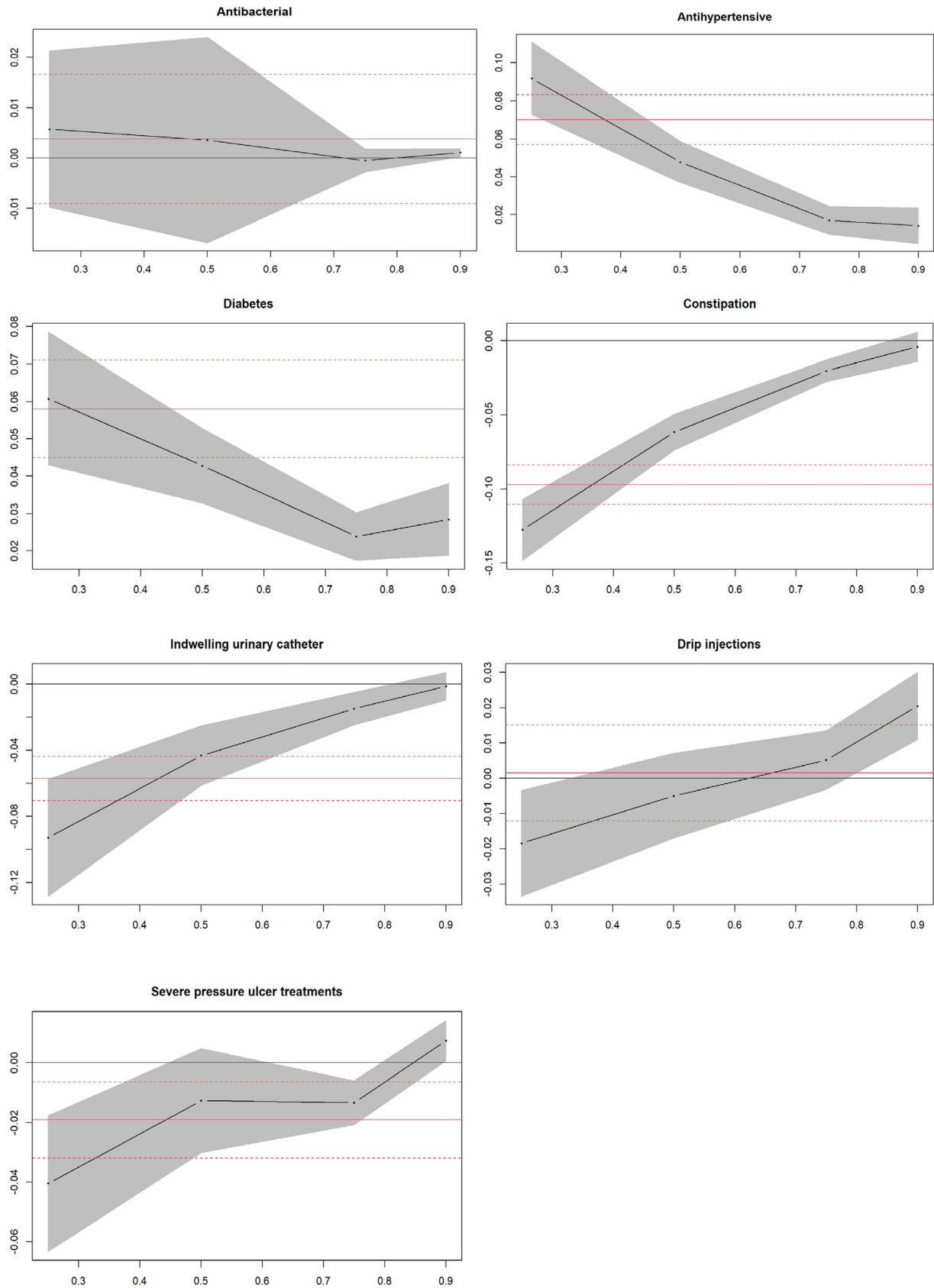
| Five types of surgeries |                                                               |                   |
|-------------------------|---------------------------------------------------------------|-------------------|
| Category numbers        | Medical Procedure                                             | Name Billing code |
| K046-00                 | Open reduction of fracture (thigh)                            | 150019210         |
| K073-00                 | Open reduction of intra-articular fracture (hip)              | 150042710         |
| K073-02                 | Arthroscopic open reduction of intra-articular fracture (hip) | 150353310         |
| K081-00                 | Artificial femoral head replacement (hip)                     | 150049510         |
| K082-00                 | Total hip replacement (hip)                                   | 150050410         |

These types of surgeries were identified on the basis of a single national list of official medical fees based on standard disease codes or medical procedure codes in the Ministry of Health, Labour and Welfare. The list can refer to the website: <https://shinryohoshu.mhlw.go.jp/shinryohoshu/paMenu/doPaDetailSpNext&100>.

## APPENDIX III



**Figure III.1** Preoperative factors associated with LOS within first postoperative half-year in linear regressions and the regressions for each quantile. The  $x$ -axis represents each percentile point of the dependent variable (LOS), and the results for each independent variable are shown starting from the 25th percentile (0.25). The solid red line represents the standardized regression coefficient or dummy variable's regression coefficient for multiple linear regressions; red dashed lines show their 95% confidence intervals. The black lines represent the standardized regression coefficient or dummy variable's regression coefficient for quantile regressions, while gray areas indicate 95% confidence intervals. LOS: Preoperative one-year LOS (days). Outpatient service: Preoperative one-year days of outpatient utilization. Antidementia: Preoperative 1-year number of months with physician orders for antidementia prescriptions. Antiosteoporosis: Preoperative 1-year number of months with physician orders for antiosteoporosis prescriptions. Antibacterial: Preoperative 1-year number of months with physician orders for antibacterial agents. Antihypertensive: Preoperative 1-year number of months with physician orders for antihypertensive agents. Diabetes: Preoperative 1-year number of months with physician orders for agents for diabetes mellitus. Constipation: Preoperative 1-year number of months with physician orders for constipation prescriptions. Indwelling urinary catheter: Preoperative 1-year number of months with physician orders for indwelling urinary catheters. Drip injections: Preoperative 1-year number of months with physician orders for drip injections. Severe pressure ulcer treatments: Preoperative 1-year number of months with physician orders for severe pressure ulcer treatments.



**Figure III.1** Continued