# A Bed Constraint?

## Hospital Occupancy Rates and Readmission Episodes

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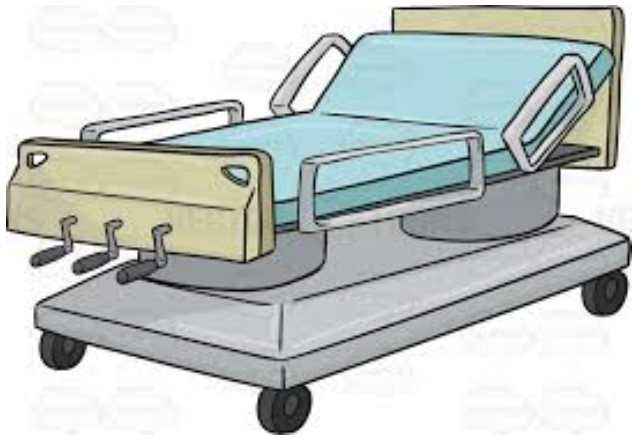
# Motivation

Portuguese Hospitals tend to be very crowded. Sometimes, people associate perceived lower treatment standards with hospital occupancy rates. Lets see if that is true.

High occupancy rates may lead to:

- Operational Failures
- Early Discharges



And cause negative outcomes such as:

- Readmissions
- Deaths

**This paper tries to assess whether occupancy rates are associated with readmission episodes possibly driven by early discharges.**

# Objective

**Are occupancy rates associated with the likelihood of readmission?**

1. Check how occupancy rates at discharge are related with readmissions
2. Determine if the effect is constant across age groups
3. Evaluate the relation between length of stay and occupancy

# Data

Data provided by the Portuguese Central Administration of the Health System (ACSS) containing yearly collected DRGs' (Diagnosis Related Groups) for all discharges in the Portuguese hospital centers.

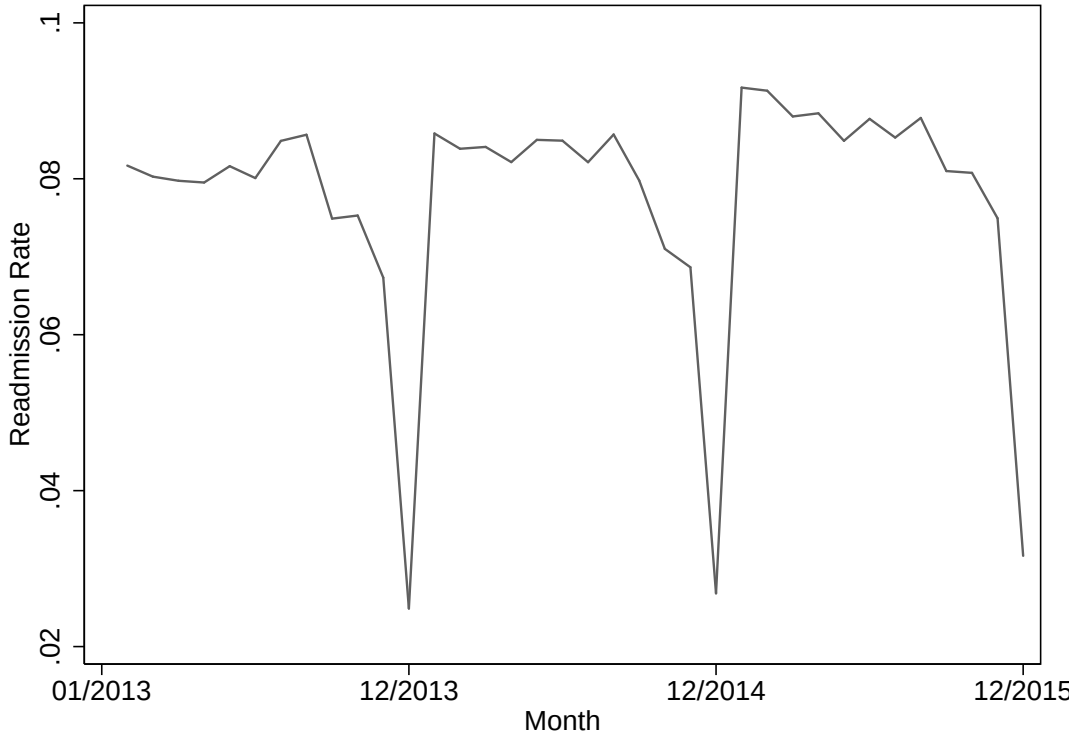
The number of beds are publicly available in the institutional site of ACSS for each hospital in each month.

Note: The dataset provides an individual identification code that allows the researcher to check readmission episodes.

## The sub-sample:

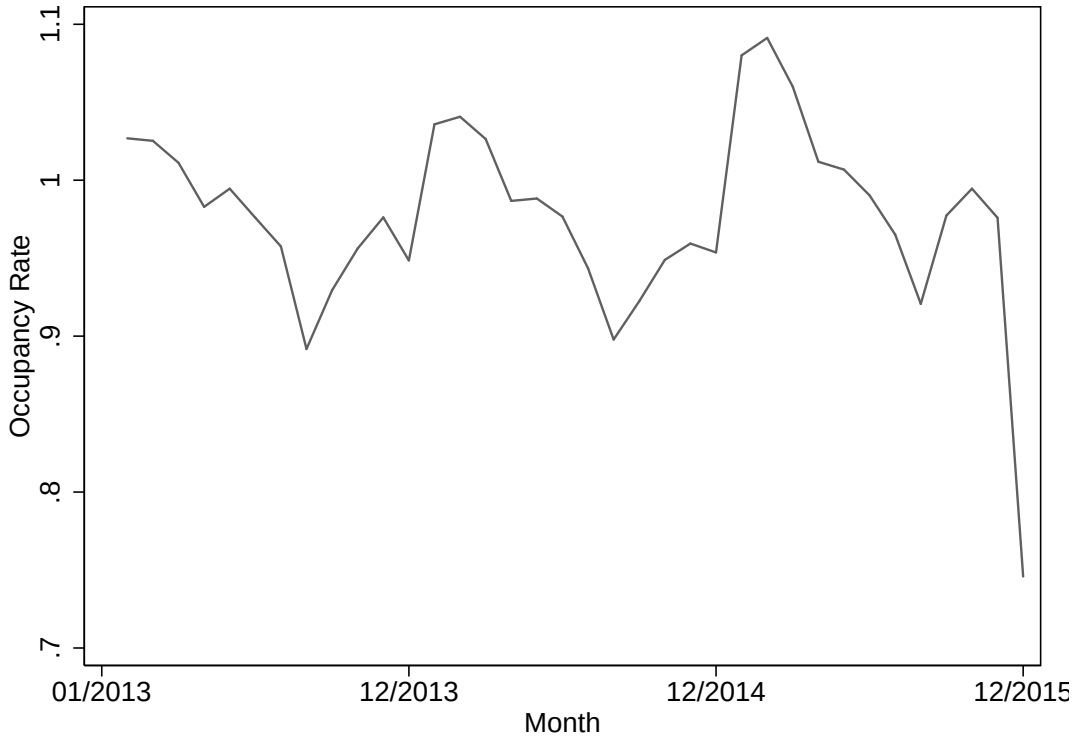
* Years of 2014, 2015 and 2016 (No December) and a total of 41 hospitals.
* Only **inpatients** whose DRG belongs to the **7 more prevalent** Major Categories of Diagnosis in the sample: the respiratory system (18.79%), circulatory system (18.22%), musculoskeletal system (16.45%), digestive system (15.47%), nervous system (11.53%), urinary system (10.66%) and hepatobiliary system (8.88%).

# Data - Readmissions




- Counted at the index admission
- Two approaches:
  - Standard: 30 days
  - Conservative: 30 days and same MDC
- Averages 8% in the Standard and 4% in the Conservative

# Data - Occupancy




- Number of patients hospitalized in each day dividing by the number of beds
- Occupancy is counted at discharge (or in relation to discharge day)
- Averages 97.31% (overestimated)

# Methodology

The baseline model:

$$y_{iht} = \alpha + \beta Occupancy_{iht} + \gamma X_{it} + \theta DRG_{it} + \tau_y \times \tau_m \times \tau_w \times \tau_h + \varepsilon_{iht} \quad (1)$$

Where:

- $y_{iht}$ corresponds to a readmission being generated after individual $i$ is discharges in hospital $h$ at day $t$.
- $Occupancy_{iht}$ is the occupancy rate in the day of discharge (or days just prior to discharge)
- $X$ contains a set of control variables such as age, gender, number of procedures.
- $DRG$ are DRG fixed effects interacted with severity level.
- $\tau_y \times \tau_m \times \tau_w \times \tau_h$ are an interaction between year/month/week and hospital fixed effects.

$\Longrightarrow$ The paper uses a Linear Probability Model

# Results: Occupancy at Discharge and Readmission Likelihood

| Dependent variable: Readmission Episodes | | | | |
|---|---|---|---|---|
| | Standard | Conservative | Standard | Conservative |
| Occupancy at Discharge | 0.008 | 0.008 | | |
| | (0.008) | (0.005) | | |
| Turnover Rate | 0.053*** | 0.025*** | | |
| | (0.003) | (0.002) | | |
| Occupancy Rate Variation | | | -0.107*** | -0.059*** |
| | | | (0.006) | (0.005) |
| Male | 0.008*** | 0.006*** | 0.008*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Number of Procedures | 0.002*** | 0.000*** | 0.002*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

Are discharges decided within the same day?

# Results: Occupancy One Day Before Discharge and Readmission Likelihood

| Dependent variable: Readmission Episodes | | | | |
|---|---|---|---|---|
| | Standard | Conservative | Standard | Conservative |
| Occupancy One Day Before Discharge | 0.070*** | 0.036*** | | |
| | (0.008) | (0.006) | | |
| Turnover Rate t-1 | -0.006* | -0.002 | | |
| | (0.003) | (0.002) | | |
| Occupancy Rate Variation t-1 | | | 0.041*** | 0.015** |
| | | | (0.007) | (0.004) |
| Male | 0.008*** | 0.006*** | 0.008*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Number of Procedures | 0.002*** | 0.000*** | 0.002*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Should the effect be linear?

# Results: Readmission and Occupancy Intervals

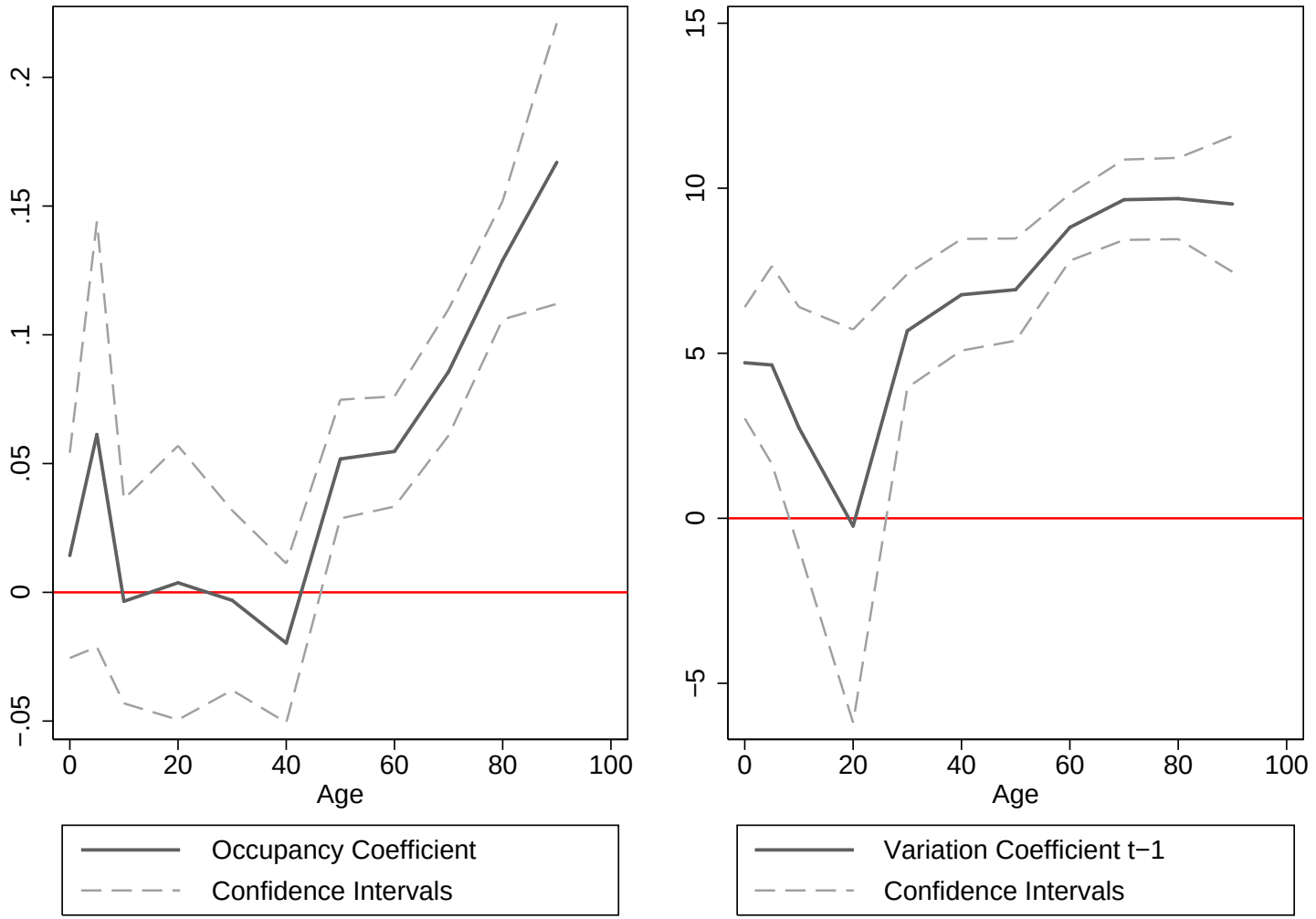
| Dependent variable: Readmission Episodes | | | | |
|---|---|---|---|---|
| | Standard t | Conservative t | Standard t-1 | Conservative t-1 |
| Occupancy Rate > 110% t-1 | 0.014*** | 0.008*** | 0.019*** | 0.010*** |
| | (0.002) | (0.002) | (0.002) | (0.001) |
| Occupancy Rate [105%, 110%] t-1 | 0.009*** | 0.006*** | 0.012*** | 0.007*** |
| | (0.002) | (0.001) | (0.001) | (0.001) |
| Occupancy Rate [100%, 105%] t-1 | 0.007*** | 0.005*** | 0.010*** | 0.006*** |
| | (0.002) | (0.001) | (0.001) | (0.001) |
| Occupancy Rate [95%, 100%] t-1 | 0.006*** | 0.004*** | 0.007*** | 0.004*** |
| | (0.002) | (0.001) | (0.001) | (0.001) |
| Occupancy Rate [90%, 95%] t-1 | 0.003 | 0.003** | 0.003* | 0.003** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Occupancy Rate [85%, 90%] t-1 | 0.006*** | 0.003* | 0.007*** | 0.004** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Turnover Rate t-1 | 0.001 | 0.001 | | |
| | (0.002) | (0.002) | | |
| Occupancy Rate Variation t-1 | | | 0.068*** | 0.029*** |
| | | | (0.007) | (0.005) |
| Male | 0.008*** | 0.006*** | 0.008*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Number of Procedures | 0.002*** | 0.000*** | 0.002*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

Does it affect all patients in the same way?

# Results: Occupancy and Readmissions by Age Groups

Figure: Coefficients of Occupancy Rates on Readmissions



Since we are talking about early discharges, what about length of stay?

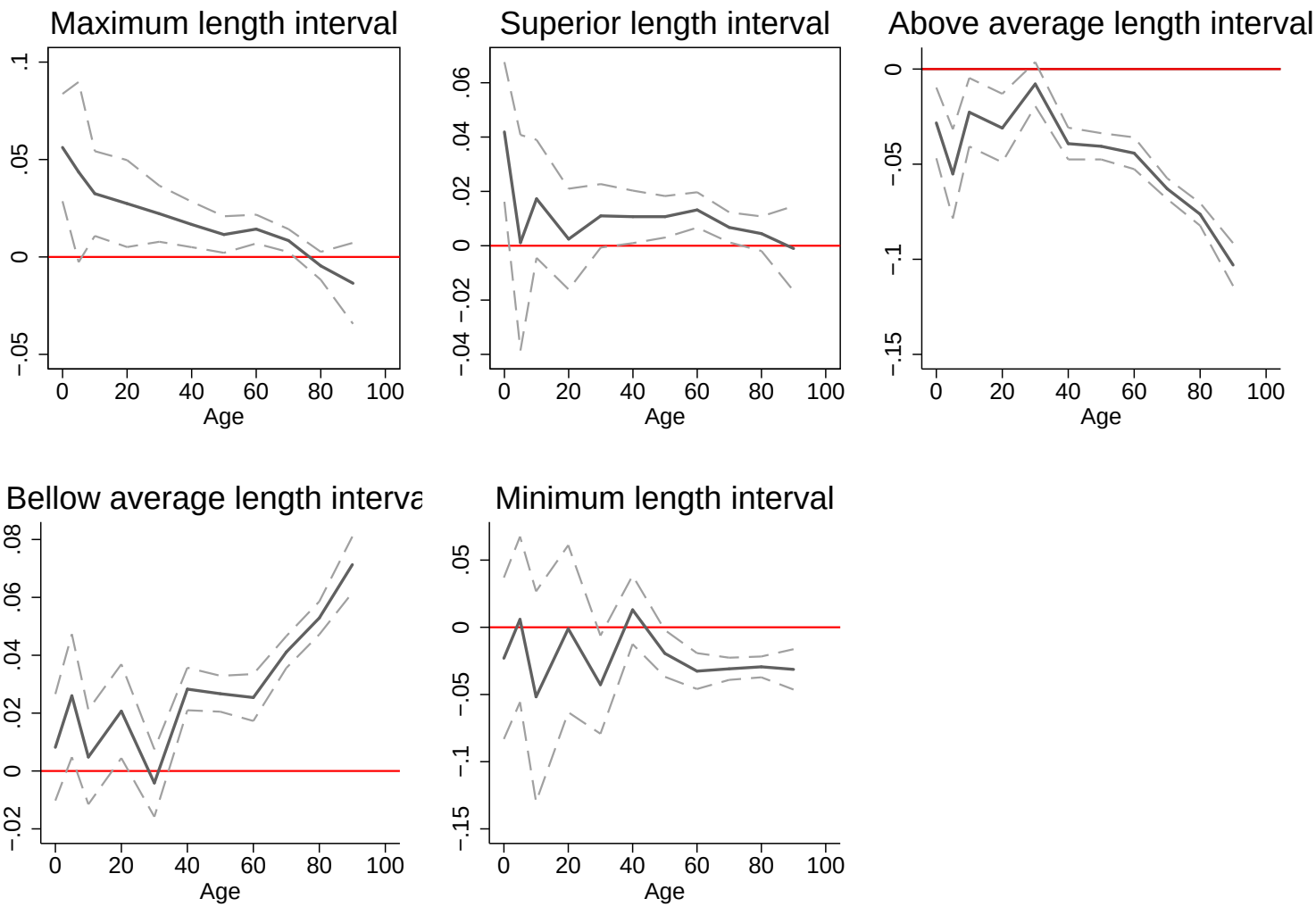
# Results: Occupancy and Length of Stay by Thresholds

| Dependent variable: Readmission | | | | |
|---|---|---|---|---|
| | Standard | Conservative | Standard | Conservative |
| Occupancy t-1 & Max Limit Length | 0.010*** | 0.004*** | | |
| | (0.002) | (0.001) | | |
| Occupancy t-1 & Superior Limit Length | 0.008*** | 0.002 | | |
| | (0.001) | (0.001) | | |
| Occupancy t-1 & Above Expected Length | -0.055*** | -0.029*** | | |
| | (0.001) | (0.001) | | |
| Occupancy t-1 & Below Expected Length | 0.035*** | 0.020*** | | |
| | (0.001) | (0.001) | | |
| Occupancy t-1 & Min Limit Length | -0.037*** | -0.016*** | | |
| | (0.003) | (0.002) | | |
| Turnover Rate t-1 | 0.021*** | 0.011*** | | |
| | (0.002) | (0.001) | | |
| Variation t-1 & Max Limit Length | | | 0.151** | 0.069* |
| | | | (0.049) | (0.029) |
| Variation t-1 & Superior Limit Length | | | 0.046 | 0.056* |
| | | | (0.038) | (0.025) |
| Variation t-1 & Above Expected Length | | | -0.143*** | -0.106*** |
| | | | (0.038) | (0.026) |
| Variation t-1 & Below Expected Length | | | 0.150*** | 0.106*** |
| | | | (0.037) | (0.027) |
| Variation t-1 & Min Limit Length | | | 0.116* | 0.081* |
| | | | (0.056) | (0.038) |
| Male | 0.008*** | 0.006*** | 0.009*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Number of Procedures | 0.001*** | -0.000*** | 0.002*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Results: Occupancy and Length of Stay Thresholds by Age Groups

Figure: Coefficients of Occupancy Rates on Length of Stay



# Conclusion

- Occupancy rates prior to discharge are associated with higher probability of readmission
- The effects differ across age groups, with the elderly being more affected
- Higher occupancy rates and being discharged with lower than expected length of stay is associated with readmissions.
- Again, older people are the ones suffering

* **Occupancy rates and readmission episodes appear to be linked though early discharges of older people**

# Thank you for your time!

# Other Results

# Other Results: Occupancy Two Days Before Discharge and Readmission Likelihood

| Dependent variable: Readmission Episodes | | | | |
|---|---|---|---|---|
| | Standard | Conservative | Standard | Conservative |
| Occupancy Two Days Before Discharge | 0.035*** | 0.022*** | | |
| | (0.009) | (0.005) | | |
| Turnover Rate t-2 | -0.016*** | -0.007*** | | |
| | (0.003) | (0.002) | | |
| Occupancy Rate Variation t-2 | | | 0.076*** | 0.033*** |
| | | | (0.008) | (0.007) |
| Male | 0.008*** | 0.006*** | 0.008*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Number of Procedures | 0.002*** | 0.000*** | 0.002*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Other Results: Occupancy Three Days Before Discharge and Readmission Likelihood

| Dependent variable: Readmission Episodes | | | | |
|---|---|---|---|---|
| | Standard | Conservative | Standard | Conservative |
| Occupancy Three Days Before Discharge | -0.006 | -0.000 | | |
| | (0.007) | (0.005) | | |
| Turnover Rate t-3 | -0.005 | -0.003 | | |
| | (0.003) | (0.001) | | |
| Occupancy Rate Variation t-3 | | | 0.022** | 0.018*** |
| | | | (0.007) | (0.004) |
| Male | 0.008*** | 0.006*** | 0.008*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Number of Procedures | 0.002*** | 0.000*** | 0.002*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Other Results - Occupancy by Months

| Dependent variable: Readmission | Standard Occupancy t-1 | Conservative Occupancy t-1 | Standard Variation t-1 | Conservative Variation t-1 |
|---|---|---|---|---|
| January | 0.038*** | 0.019** | 0.116*** | 0.058*** |
| | (0.007) | (0.007) | (0.024) | (0.017) |
| February | 0.042* | 0.053*** | 0.067 | 0.026 |
| | (0.021) | (0.006) | (0.034) | (0.028) |
| March | 0.017 | -0.001 | 0.100*** | 0.031* |
| | (0.016) | (0.007) | (0.018) | (0.015) |
| April | 0.057*** | 0.039* | 0.093*** | 0.032*** |
| | (0.012) | (0.020) | (0.026) | (0.008) |
| May | 0.032 | 0.018 | 0.077*** | 0.028 |
| | (0.020) | (0.017) | (0.021) | (0.018) |
| June | 0.053** | 0.035 | 0.087*** | 0.032* |
| | (0.017) | (0.019) | (0.016) | (0.014) |
| July | 0.065*** | 0.046*** | 0.015 | 0.024 |
| | (0.008) | (0.012) | (0.030) | (0.015) |
| August | 0.026 | -0.002 | 0.080** | 0.030 |
| | (0.014) | (0.011) | (0.031) | (0.015) |
| September | 0.012 | 0.010 | 0.008 | 0.009 |
| | (0.013) | (0.010) | (0.013) | (0.010) |
| October | 0.013 | 0.003 | 0.022 | 0.009 |
| | (0.009) | (0.014) | (0.017) | (0.011) |
| November | 0.026 | 0.022 | 0.060*** | 0.028 |
| | (0.020) | (0.013) | (0.015) | (0.016) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Other Results - Occupancy by Day of the Week

| Dependent variable: Readmission | Standard Occupancy t-1 | Conservative Occupancy t-1 | Standard Variation t-1 | Conservative Variation t-1 |
|---|---|---|---|---|
| Monday | 0.015 | 0.011 | 0.021 | 0.023 |
| | (0.010) | (0.007) | (0.026) | (0.021) |
| Tuesday | 0.032*** | 0.025*** | -0.021 | -0.033* |
| | (0.008) | (0.007) | (0.023) | (0.017) |
| Wednesday | 0.009 | 0.004 | 0.010 | 0.008 |
| | (0.008) | (0.005) | (0.020) | (0.016) |
| Thursday | 0.024** | 0.016* | -0.023 | -0.028 |
| | (0.008) | (0.007) | (0.025) | (0.015) |
| Friday | 0.023* | 0.008 | -0.008 | -0.011 |
| | (0.010) | (0.006) | (0.021) | (0.015) |
| Saturday | 0.014 | 0.009 | -0.006 | -0.008 |
| | (0.010) | (0.008) | (0.021) | (0.021) |
| Sunday | 0.021 | 0.009 | -0.020 | -0.009 |
| | (0.015) | (0.011) | (0.045) | (0.034) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Other Results: Occupancy by MCD

| Dependent variable: Readmission | Standard Occupancy t-1 | Conservative Occupancy t-1 | Standard Variation t-1 | Conservative Variation t-1 |
|---|---|---|---|---|
| Nervous | 0.065** | 0.017 | 0.046 | -0.008 |
| | (0.020) | (0.012) | (0.026) | (0.013) |
| Respiratory | 0.171*** | 0.095*** | 0.178*** | 0.088*** |
| | (0.021) | (0.017) | (0.022) | (0.018) |
| Circulatory | 0.070*** | 0.053*** | 0.069*** | 0.027* |
| | (0.017) | (0.012) | (0.017) | (0.012) |
| Digestive | 0.030 | 0.007 | 0.039** | 0.014 |
| | (0.017) | (0.008) | (0.015) | (0.009) |
| Hepatic | 0.098*** | 0.069** | 0.150*** | 0.106*** |
| | (0.027) | (0.023) | (0.030) | (0.021) |
| Musculoskeletal | 0.011 | -0.001 | 0.008 | 0.000 |
| | (0.010) | (0.006) | (0.017) | (0.009) |
| Urinary | 0.049* | -0.001 | 0.048 | 0.016 |
| | (0.024) | (0.020) | (0.034) | (0.024) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Other Results: Occupancy and Length of Stay

| Dependent variable: Length of Stay | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Occupancy at Discharge | 4.813*** | 8.087*** | | |
| | (0.363) | (0.321) | | |
| Occupancy One Day Before Discharge | | | 1.221*** | 1.093*** |
| | | | (0.245) | (0.242) |
| Turnover Rate | 7.112*** | | | |
| | (0.408) | | | |
| Occupancy Rate Variation | | -0.370 | | |
| | | (0.312) | | |
| Turnover Rate t-1 | | | 9.422*** | |
| | | | (0.445) | |
| Occupancy Rate Variation t-1 | | | | 9.533*** |
| | | | | (0.466) |
| Male | 0.050* | 0.049* | 0.048* | 0.048* |
| | (0.020) | (0.020) | (0.020) | (0.020) |
| Number of Procedures | 0.962*** | 0.962*** | 0.963*** | 0.963*** |
| | (0.006) | (0.006) | (0.006) | (0.006) |
| Age Groups | ✓ | ✓ | ✓ | ✓ |
| Year x Month x Week x Hospital FE | ✓ | ✓ | ✓ | ✓ |
| DRG x Severity FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 1,687,348 | 1,687,348 | 1,687,348 | 1,687,348 |

*Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Standard errors in parentheses.

# Other Results Occupancy and Length of Stay by Age Groups

Figure: Coefficients of Occupancy Rates on Length of Stay