**Accuracy of Pressure Ulcer Events in U.S. Nursing Home Ratings**

**Supplementary Appendix**

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1. **Details of MDS pressure ulcer items**

Pressure ulcers are classified into six stages based on the degree of tissue loss. Different stages are associated with different severity that requires different treatments, and Stage 4 pressure ulcers are often considered the most difficult and expensive pressure ulcers to treat1. Appendix Table S1 lists the NPUAP definitions of pressure ulcer stages, corresponding descriptions about each stage in MDS, and ICD9-CM and ICD10-CM codes. Appendix Table S2 lists complete pressure ulcer items in MDS 3.0.

1. **Creation and interpretation of individual and nursing home-level variables for dual status, race, and pressure ulcer severity**

We used centering within context (CWC) method2 to create individual and nursing home-level variables for dual status, race, and pressure ulcer severity defined as the highest-staged pressure ulcer in diagnoses, to disaggregate the within- and between-nursing home effects of the same variable.

The dual status variable was a binary indicator of whether the beneficiary was dually eligible for Medicare and Medicaid in the month of hospital admission. We first calculated the proportion of dually eligible residents in each nursing home each year using all MDS assessments for 100% sample of Medicare fee-for-service beneficiaries from 2011 - 2017. We then derived the individual-level dual status variable by subtracting the percentage of dually eligible residents from the binary indicator. Therefore, the coefficient of the individual-level dual status variable represents the difference on reporting rate between a dually eligible resident and a non-dually eligible resident in the same nursing home (or conditioning on the nursing home proportions of residents who are dually eligible for Medicare and Medicaid). The coefficient of the nursing home-level dual variable measures the mean difference of reporting rates for a nursing home composed entirely of dually eligible residents and one composed of zero such residents.

Race was a categorical variable denoted as $x\_{ij}$ with $k$ categories, $i$ for individual $i$ and $j$ for nursing home $j$, and we created dummy code for each race category $x\_{1ij}, x\_{2ij}, … x\_{(k-1)ij}$. We first used all MDS assessments for 100% sample of Medicare fee-for-service beneficiaries within each year from 2011 – 2017 to calculate nursing home race mix, $\overbar{x}\_{1j}, \overbar{x}\_{2j},… \overbar{x}\_{(k-1)j}$, each representing the percentage of Medicare fee-for-service beneficiaries in nursing home$ j$ that belonged to each group of the categorical variable, e.g., the percentage of Medicare fee-for-service beneficiaries who are Black in nursing home$ j$. Each dummy code of the variable was then separated to two parts: the individual-level race variable, $x\_{1ij}-\overbar{x}\_{1j}$, and the nursing home-level race variable, $\overbar{x}\_{1j}$. Variation of the individual-level race variables measured resident’s race variability within a nursing home, and the variation of nursing home-level race variables reflected between nursing home race variability. Therefore, the coefficient of individual-level race variable $x\_{(k-1)ij}-\overbar{x}\_{(k-1)j} $reflected differences on reporting rate between race $k-1 $and the reference race, which was White in our model, within the same nursing home. The coefficient of nursing home-level race variable $\overbar{x}\_{(k-1)j}$ measured the mean difference of reporting rates between a nursing home composed entirely of race $k-1$ and of residents who are White.

We applied a similar method to pressure ulcer severity, which was also a categorical variable with $g$ categories. We derived the nursing home-level pressure ulcer severity from calculating the percentage of claims with pressure ulcers at each stage that was identified as the stage of the highest staged pressure ulcer for the claim for each nursing home each year using the hospital analytical sample. The reference stage level is Stage 1. Hence, the coefficient of individual-level stage variable was interpreted as the differences of reporting rate between a resident with ulcers at Stage $g-1$ and at Stage 1 within the same nursing home; the coefficient of nursing home-level stage variable was interpreted as the mean difference of reporting rates between a nursing home composed with residents who had pressure ulcers only at Stage $g-1$ and only at Stage 1.

Since coefficients of race and ulcer severity variables on both levels were large and significant, we added the interactions of individual-level variables of race and ulcer severity as well as interactions of nursing home-level variables of race and ulcer severity in the model.

1. **Creations of analytical sample of MedPAR hospital admission data linked to MDS for pressure ulcer items**

Appendix Figure A1 describes the population of hospital admission claims in each step where we linked claims to MDS assessments. Our analytical sample is in grey boxes. Our final analytical sample included residents who were admitted to the hospital with a present-on-admission pressure ulcer within one day of nursing home discharge and returned to the same nursing home within one day of hospital discharge.

Among primary pressure ulcer hospital claims with linked discharge assessments, 32,406 were for individuals who did not return to a nursing home within 1 day of discharge; 14,643 were for individuals who returned to a different nursing home. This amounts to 27.9% of the linked hospital claims. For secondary pressure ulcers, this number was 36.3%. Further, among these excluded hospitalizations, 14.7% and 31.9% were for individuals who did not survive to hospital discharge after primary and secondary pressure ulcer diagnoses, respectively.

1. **Creations of analytical sample of MedPAR SNF claims linked to MDS for pressure ulcer items**

Different from how we linked MDS to hospital admission data, we linked all MDS during the beneficiaries’ stay at the nursing home to SNF claims. First, SNF claims should have associated MDS assessments since Medicare reimburses nursing homes Part A services according to residents’ RUG category that is determined by MDS assessments. Second, pressure ulcer diagnosis codes on SNF claims could refer to pressure ulcer developed any time during the stay at the nursing home (the start date of the stay is admission date, and the end date is discharge date or the SNF care through date in claims). Therefore, for each SNF claim, we scanned all MDS assessments with a target date within the SNF stay and counted the pressure ulcer as being reported if any of the MDS recorded a pressure ulcer item listed in Table 1. We excluded Entry and Death in facility tracking record because neither assessment contains any pressure ulcer items. Finally, we excluded claims matched with MDS from multiple nursing homes and included only the MDS assessments submitted by the same nursing home as that of the SNF claims. Appendix Figure S2 shows the population of SNF claims in each step to create the final analytical sample.

1. **Sensitivity analysis: Reporting rates without the readmission restriction**

For the final analytical sample, we required the residents to return to the same nursing home within one day after hospitalization. In this sensitivity analysis, we calculated the reporting rates of pressure ulcer items for residents without the readmission restriction, which was the sample (1) and (2) in Appendix Figure S1 and S2. Appendix Table S3 shows the reporting rates of pressure ulcer items for residents in sample (1) and (2). There is no clear pattern of the differences between these reporting rates and those from the main analysis. Most of the differences in reporting rates are within five percentage points. We also presented in Appendix Table S4 the reporting rates of pressure ulcers from residents who did not survive hospital discharge, a subsample from those in Appendix Table S3. These reporting rates are also similar to the main reporting rates.

1. **Sensitivity analysis: Reporting rates with additional MDS assessments**

In Table 3, the percent of pressure ulcer reported for primary and secondary hospital claims was evaluated only for MDS discharge assessments, where nursing homes should report the latest pressure ulcers status of residents prior to their hospitalization. In this sensitivity analysis, in addition to discharge assessments, we included other MDS assessments within seven days of the nursing home discharge date to check whether nursing homes reported pressure ulcers in any of the linked MDS. We set the cutoff at seven days because the look back period of pressure ulcer items is seven days. Appendix Table S5 shows the reporting rate with additional MDS assessments and its difference with reporting rate that only included discharge assessments.

The percentage of claims linked to additional MDS assessments was 38.7% (44,435) for primary hospital claims and 43.5% (127,604) for secondary hospital claims. Most differences in reporting rates between sensitivity analysis and the main analysis were smaller than one percentage point, and the largest difference was for secondary pressure ulcer diagnosis hospital admission claims for short-stay residents with Stage 1 pressure ulcer (3.6, Appendix Table S5). Since more than half of the claims didn’t have additional MDS assessments within 7 days prior to nursing home discharge, and the difference between sensitivity analysis and main analysis was small, it is reasonable for us to assess reporting accuracy only using discharge assessment.

1. **Model specifications and results**

We built a multilevel logistic model with nursing home random intercepts, adjusting for individual-level variables of sex, age, disability, comorbidity score, and chronic conditions, and nursing home-level variables of nursing home ownership, size, region, and individual-level and nursing home-level variables of dual status, race and pressure ulcer severity, and interactions for race and pressure ulcer severity variables at the individual-level and nursing home-level , as well as year indicators.

The model specification was as the following:

where $reporting\_{ij}$ was the binary indicator of whether nursing home $j$ reported pressure ulcers of resident $i$, and $X^{'}\_{ij}$ was a vector of individual-level variables except for dual status, race and pressure ulcer severity, $Y^{'}\_{j}$ a vector of nursing home-level variables and year indicators except for dual status, race and pressure ulcer severity. $β\_{dual}$, $β\_{race} $and $β\_{stage}$ were the coefficients for individual-level dual status, race and pressure ulcer severity; $γ\_{dual}$, $γ\_{race}$ and $γ\_{stage}$ were coefficients for nursing home-level variables for dual status, race and pressure ulcer severity; $β\_{race.stage}$ were coefficients for interactions between individual-level race and severity; $γ\_{race.stage}$ were coefficients for interactions between nursing home-level race and pressure ulcer severity. We ran the model separately for long-stay and short-stay residents. Appendix Table S6 shows the regression results. Appendix Table S7 presents predictive reporting rates using the fitted parameters from the model with slightly different specifications than the Table 4.

1. **A Readme file for Coding scripts**

(link removed for blinded review)

**Document Description**

These notes describe in sequence the code files used for the analysis.

**Software**

We used Python 3.8, SAS 9.4 and Stata/MP 15.0.

**Steps**

**1. Identify MedPAR pressure ulcer claims**

We used 100% sample of Medicare fee-for-service beneficiaries during 2011 – 2017. We used hospital admission data and SNF claims from the Medicare Provider Analysis and Review (MedPAR) file and the 26 diagnosis codes and POA indicators to identify claims related to pressure ulcer and divide them into 1) primary pressure ulcer diagnosis hospital admission claims, 2) secondary pressure ulcer diagnosis hospital admission claims and 3) SNF claims. Outputs from these scripts were linked with MDS assessments on the resident-level.

| **Script Name** | **Script Description** | **Input Files** | **Output Files** |
| --- | --- | --- | --- |
| processMEDPAR.py | This script selects two types of IP claims: (1) primary pressure ulcer diagnosis hospital admission claims where the admitting, the first or the second diagnosis code is related to pressure ulcer and the corresponding POA is “Y”(2) secondary pressure ulcer diagnosis hospital admission claims where any other 23 diagnosis codes is related to pressure ulcer and the corresponding POA is “Y” | 2011 - 2017 MedPAR files | Parquet files in main\_pu\_claims\_medpar/ and secondary\_only\_pu\_claims\_medpar/ |
| processSNF.py | This script selects primary SNF claims where the admitting, the first or the second diagnosis code is related to pressure ulcer. | 2011 - 2017 MedPAR files | Parquet files in main\_pu\_claims\_snf/ |

**2. Clean MDS assessments**

We cleaned the MDS assessments, selecting useful variables such as assessment type, target date, discharge date and M0300 items. Output from these scripts was linked with MedPAR pressure ulcer claims in Step 3.

|  |  |  |  |
| --- | --- | --- | --- |
| **Script Name** | **Script Description** | **Input Files** | **Output Files** |
| processMDS.py | This script cleans up MDS assessments. | MDS from 2011 - 2017 | Parquet files in cleaned\_mds\_unique/ |

**3. Link MedPAR claims and MDS assessments**

We linked MedPAR claims and MDS assessments on the resident-level based on two criteria. For hospital claims, we required residents to have a MDS discharge assessment within one day of hospital admission and required residents to be readmitted to the same nursing home within one day of hospital discharge. We linked the MDS discharge assessment to hospital claims. For SNF claims, all MDS assessments within the patient’s stay at the facility were linked with the claim, except for Entry and Death Tracking Record because they don’t contain any pressure ulcer item. The output from this step was the denominator files including information from claims and MDS assessments. The output was then merged with MBSF and CASPER for patient- and facility-level characteristics.

|  |  |  |  |
| --- | --- | --- | --- |
| **Script Name** | **Script Description** | **Input Files** | **Output Files** |
| 2\_concat\_mds\_medpar.py | For each beneficiary, concatenate his/her pressure ulcer claims and MDS assessments and order them by hospital admission date or MDS target date. | Parquet output from processMEDPAR.py and processMDS.py | CSV files in concat\_rank/ and concat\_secondary\_only/ |
| 3\_select\_mds\_within\_snf\_stay.py | For each claim, look for its prior record to determine if the patient is admitted to hospital within one day of being discharged from the nursing home. | CSV output from 2\_concat\_rank\_mds\_medpar.py | CSV files in main\_pu\_claims\_from\_nh/ and secondary\_only\_pu\_claims\_from\_nh/ |
| 4\_select\_samenh\_medpar.py | For each claim, determine if the patient returns to the same nursing home within one day after hospitalization. | Output files from 2\_concat\_rank\_mds\_medpar.py and 3\_select\_mds\_within\_snf\_stay.py | CSV files in main\_pu\_claims\_from\_samenh/ and secondary\_only\_pu\_claims\_from\_samenh/ |
| 5\_merge\_mds\_medpar\_samenh.py | For each claim, merge it with the closest prior MDS discharge assessment for patients who have pressure ulcer during nursing home residency and return to the same nursing home within one day of hospital discharge. | Output files from 2\_concat\_rank\_mds\_medpar.py, 3\_select\_mds\_within\_snf\_stay.py and 4\_select\_samenh\_medpar.py | Parquet files in main\_merge\_samenh/ and secondary\_only\_merge\_samenh/ |
| 2\_merge\_snf\_mds.py | For each SNF pressure ulcer claim, merge it with the MDS assessments of the same beneficiary. | Output parquets from processSNF.py and processMDS.py | Parquet files in main\_merge\_snf\_mds/ |
| 3\_select\_mds\_within\_snf\_stay.py | For each SNF pressure ulcer claim, select linked MDS assessments within the resident’s stay at the nursing home. | Output from 2\_merge\_snf\_mds.py | CSV files in main\_merge\_snf\_mds\_within\_stay/ |

**4. Construct patient- and facility-level variables**

We used claims data, MBSF Base file and MBSF Chronic Condition file to construct patient-level variables: age, sex, dual status, short- vs long-stay, pressure ulcer severity, comorbidity score, and chronic conditions. We also merged LTCFocus and CASPER with denominator files to construct nursing home-level variables: size, region, ownership. We also created patient- and facility-level variables for dual status, pressure ulcer severity and race. Finally, we merged publicly available NHC data of star-ratings and nursing home quality measures with denominator files. The output from this step is the final sample data used to build model and to create exhibits.

|  |  |  |  |
| --- | --- | --- | --- |
| **Script Name** | **Script Description** | **Input Files** | **Output Files** |
| 6\_merge\_facility\_data.py | Merge denominator files with LCTFocus and CASPER for facility-level variables. | CASPER LTCFocus 2011 - 2017 MBSF Summary Files Output from 5\_merge\_mds\_medpar\_samenh.py and 3\_select\_mds\_within\_snf\_stay.py | CSV files in main\_merge\_samenh\_mbsf\_fac/, secondary\_only\_merge\_samenh\_mbsf\_fac/ and main\_merge\_snf\_mds\_within\_stay\_mbsf\_fac/ |
| 7\_merge\_mbsfcc.py | Merge MBSF Chronic Conditions with denominator files. | 2011 - 2017 MBSF Chronic Condition Files Output from 6\_merge\_mbsf\_and\_fac.py | Parquet files in main\_merge\_samenh\_mbsf\_cc/ and secondary\_only\_merge\_samenh\_mbsf\_cc/ |
| 8\_sl\_stay\_medpar\_mds.py | Identify long-stay and short-stay nursing home residents. For each record in denominator files, look back 100 days to find if there is a 5-day PPS assessment. If there is one, the resident is a short-stay resident. | Output from 2\_concat\_mds\_medpar.py and 7\_merge\_mbsfcc.py | CSV files: main\_merge\_samenh\_sl.csv and secondary\_only\_merge\_samenh\_sl.csv |
| 9\_merge\_star\_ratings.py | Merge NHC star-ratings, quality ratings and pressure ulcer quality measures with denominator files. Create claims-based pressure ulcer rate for each nursing home. | 2011 - 2017 NHC data main\_merge\_samenh\_sl.csv and secondary\_only\_merge\_samenh\_sl.csv | CSV files: main\_merge\_star.csv and secondary\_only\_merge\_star.csv |
| prepare\_comorb\_data.sas | Reshape denominator files from wide to long format. | main\_merge\_samenh\_sl.csv |  |
| comorbidity.sas | Create comorbidity score based on this [paper](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3100405/). |  | A CSV file: main\_comorbidity.csv |
| 10\_construct\_model\_data.py | Construct patient- and facility-level variables and output final datasets for analysis. | main\_comorbidity.csv, main\_merge\_star.csv and secondary\_only\_merge\_star.csv | main\_model\_data.csv, secondary\_only\_model\_data.csv, main\_data\_final.csv, and secondary\_only\_data\_final.csv |
| 10\_construct\_snf\_data.py | Clean the SNF denominator file for main exhibits. | CSV files in main\_merge\_snf\_mds\_within\_stay\_mbsf\_fac | main\_snf\_final\_data.csv |
| 10\_confirm\_snf\_mds\_matching.py | Include only MDS assessments that are linked to SNF claims from the same nursing home in the final MDS and SNF analytical sample data. | main\_snf\_final\_data.csv | main\_snf\_final\_data.csv |

**5. Statistical Analysis (generate exhibits)**

This section describes scripts used to generate the four exhibits in the paper. Exhibit 2 shows the demographics of primary hospital claims population. Exhibit 3 shows the national reporting rate for MDS pressure ulcer items stratified by claims type, short- vs. long-stay, and by highest pressure ulcer stage. Exhibit 4 displays the predictive reporting rates for hypothetical residents using the parameters of multilevel models. Exhibit 5 displays the relationship between primary hospital claims-based pressure ulcer rates and the NHC MDS-based pressure ulcer quality measures and ratings.

|  |  |  |  |
| --- | --- | --- | --- |
| **Script Name** | **Script Description** | **Input Files** | **Output Files** |
| exhibit2.py | Create a descriptive table of demographic information of the primary hospital claims population stratified by short- vs. long-stay and pressure ulcer severity. | main\_data\_final.csv | exhibit2\_bystay.xlsx |
| exhibit3.py | Create a table of the national reporting rate of MDS pressure ulcer items stratified by claims type, short- vs. long-stay and pressure ulcer severity. Create a table of pressure ulcer reporting rate for each nursing home that was used to calculate weighted 25th and 75th percentiles of nursing home reporting rate. | main\_model\_data.csv, secondary\_only\_model\_data.csv, main\_snf\_final\_data.csv | report\_rate\_table.xlsx, report\_rate\_nh\_table\_weight2.csv, report\_rate\_denominator\_count\_table.csv |
| exhibit3\_weighted.sas | Calculate 25th and 75th percentiles of nursing home reporting rates, weighted by the number of pressure ulcer claims. | report\_rate\_nh\_table\_weight2.csv | exhibit3\_quantile\_weight\_by\_claims.csv |
| (exhibit4) model\_final.do | Build a multilevel model with nursing home random intercepts using primary hospital claims, and calculate predictive reporting rates for various hypothetical residents with different races, different pressure ulcer severities and living in different nursing homes. | main\_model\_data.csv | Regression result tables and predictive reporting rate tables |
| exhibit5.py | Create a table of primary hospital claims-based pressure ulcer rates distribution and the NHC MDS-based ulcer measures and star-ratings, as well as correlations between claims-based and MDS-based measures for each year. | main\_data\_final.csv | main\_corr\_pu\_rate\_medicare\_and\_qm\_score\_byyear.csv, main\_pu\_rate\_medicare2011-2017\_quintile\_QM.csv |

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2. Haley E. Yaremych, Kristopher J. Preacher, Donald Hedeker. Centering categorical predictors in multilevel models: Best practices and interpretation. *Psychol Methods*. Published online 2021. http://quantpsy.org/pubs/yaremych\_preacher\_hedeker\_(in.press).pdf

|  |
| --- |
| **Appendix Table S1.** Pressure ulcer stage definitions in MDS RAI, NPUAP and corresponding ICD-9CM and ICD-10CM diagnosis codes  |
| **Pressure Ulcer Stage** | **NAUAP Definition** |  | **MDS RAI Definitions** |  | **ICD9-CM** | **ICD10-CM (L89.000 - L89.96)** |
|  |  |  |  |  |  | **(elbow, back, hip, buttock, ankle, heel, other)**  |  | **unspecified, contig. back, buttocks, hip** |
|  |  |  |  |  |  |  |  |  |
| Unspecified |  |  |  |  | 707.20 | ending in 9 |  | ending in 0 |
| Stage 1 | Non-blanchable erythema of intact skin |  | Intact skin with non-blanchable redness of a localized area usually over a bony prominence. Darkly pigmented skin may not have a visible blanching; in dark skin tones only it may appear with persistent blue or purple hues. (M0300A1) |  | 707.21 | ending in 1  |  | ending in 1  |
| Stage 2 | Partial-thickness skin loss with exposed dermis |  | Partial thickness loss of dermis presenting as a shallow open ulcer with a red or pink wound bed, without slough. May also present as an intact or open/ruptured blister. (M0300B1) |  | 707.22 | ending in 2  |  | ending in 2  |
| Stage 3 | Full-thickness skin loss |  | Full thickness tissue loss. Subcutaneous fat may be visible but bone, tendon or muscle is not exposed. Slough may be present but does not obscure the depth of tissue loss. May include undermining and tunneling. (M0300C1) |  | 707.23 | ending in 3  |  | ending in 3  |
| Stage 4 | Full-thickness skin and tissue loss |  | Full thickness tissue loss with exposed bone, tendon or muscle. Slough or eschar may be present on some parts of the wound bed. Often includes undermining and tunneling. (M0300D1) |  | 707.24 | ending in 4  |  | ending in 4  |
| Unstageable | Obscured full-thickness skin and tissue loss |  | Non-removable dressing: Known but not stageable due to non-removable dressing/device. (M0300E1) |  | 707.25 | ending in 0 |  | ending in 5 |
|  | Slough and/or eschar: Known but not stageable due to coverage of wound bed by slough and/or eschar. (M0300F1) |  |  |
| Deep Tissue Pressure Injury | Persistent non-blanchable deep red, maroon or purple discoloration |   | Deep tissue: Suspected deep tissue injury in evolution. (M0300G1) |   | - | ending in 6 |   | ending in 6 |

| **Appendix Table S2** Complete MDS 3.0 Section M items |
| --- |
| **Section/item description** |  | **Item** | **Question** |  | **Possible responses** | **Used in MDS-based pressure ulcer quality measure** |
|  |  |  |  |  |  |  |
| Determination of Pressure Ulcer Risk |  | M0100A | Resident has a stage 1 or greater, a scar over bony prominence, or a non-removable dressing/device |  | Checked if applies | - |
|  | M0100B | Formal assessment instrument/tool (e.g., Braden, Norton, or other) |  | Checked if applies | - |
|  | M0100C | Clinical assessment |  | Checked if applies | - |
|  | M0100Z | None of the above |  | Checked if applies | - |
| Risk of Pressure Ulcers |  | M0150 | Is this resident at risk of developing pressure ulcers? |  | 0 if No; 1 otherwise | - |
| Unhealed Pressure Ulcer(s) |  | M0210 | Does this resident have one or more unhealed pressure ulcer(s) at Stage 1 or higher? |  | 0 if No; 1 otherwise | - |
| Current Number of Unhealed Pressure Ulcers at Each Stage |  | M0300A | Number of Stage 1 pressure ulcers |  | Enter number | - |
|  | M0300B1 | Number of Stage 2 pressure ulcers  |  | Long-stay and short-stay |
|  | M0300B2 | Number of these Stage 2 pressure ulcers that were present upon admission/reentry |  | - |
|  | M0300B3 | Date of oldest Stage 2 pressure ulcer |  | Enter Month - Day - Year | - |
|  | M0300C1 | Number of Stage 3 pressure ulcers  |  | Enter number | Long-stay and short-stay |
|  | M0300C2 | Number of these Stage 3 pressure ulcers that were present upon admission/reentry |  | - |
|  | M0300D1 | Number of Stage 4 pressure ulcers  |  | Long-stay and short-stay |
|  | M0300D2 | Number of these Stage 4 pressure ulcers that were present upon admission/reentry  |  | - |
|  | M0300E1 | Number of unstageable pressure ulcers due to non-removable dressing/device |  | - |
|  | M0300E2 | Number of these unstageable pressure ulcers that were present upon admission/reentry  |  | - |
|  | M0300F1 | Number of unstageable pressure ulcers due to coverage of wound bed by slough and/or eschar  |  | - |
|  | M0300F2 | Number of these unstageable pressure ulcers that were present upon admission/reentry |  | - |
|  | M0300G1 | Number of unstageable pressure ulcers with suspected deep tissue injury in evolution  |  | - |
|  | M0300G2 | Number of these unstageable pressure ulcers that were present upon admission/reentry |  | - |
|  |  |  |  |
| **Section/item description** |  | **Item** | **Question** |  | **Possible responses** | **Used in MDS-based pressure ulcer quality measure** |
|  |  |  |  |  |  |  |
| Dimensions of Unhealed Stage 3 or 4 Pressure Ulcers or Eschar |  | M0610A | Pressure ulcer length |  | Enter number in cm | - |
|  |  | Pressure ulcer width |  | - |
|  |  | Pressure ulcer depth |  | - |
| Most Severe Tissue Type for Any Pressure Ulcer |  | M0700 | Select the best description of the most severe type of tissue present in any pressure ulcer bed.1. Epithelial tissue - new skin growing in superficial ulcer. It can be light pink and shiny, even in persons with darkly pigmented skin. 2. Granulation tissue - pink or red tissue with shiny, moist, granular appearance.3. Slough - yellow or white tissue that adheres to the ulcer bed in strings or thick clumps, or is mucinous.4. Necrotic tissue (Eschar) - black, brown, or tan tissue that adheres firmly to the wound bed or ulcer edges, may be softer or harder than surrounding skin |  | Check the number 1-4 | - |
| Worsening in Pressure Ulcer Status Since Prior Assessment (OBRA, PPS, or Discharge). |  | M0800A | Stage 2 |  | Enter number | Short-stay |
|  | M0800B | Stage 3 |  | Short-stay |
|  | M0800C | Stage 4 |  | Short-stay |
| Healed Pressure Ulcers |  | M0900A | Were pressure ulcers present on the prior assessment (OBRA, PPS, or Discharge)? |  | 0 if No; 1 otherwise | - |
|  | M0900B | Stage 2 |  | Enter number | - |
|  | M0900C | Stage 3 |  | - |
|   | M0900D | Stage 4 |   | - |

**Appendix Figure S1.** Analytical sample flowchart of MedPAR hospital admission claims linked to pressure ulcer related MDS items

Linked with MDS Discharge Assessments

# of claims for patients who are not NH residents

113,630

Final sample size, excluding MDS with all pressure ulcer items coded as “-”, and with missing values

**114,729**

# of claims for NH residents long before/discharged before pressure ulcer

203,856

# of claims for patients who have been NH residents

483,261

Returned to a different NH (2)

14,643

# of claims for NH residents during pressure ulcer who returned to NH within 1 day

**135,840**

# of claims for NH residents returning to the same NH within 1 day after hospitalization

**121,197**

Did not return to NH or returned more than 1 day after hospitalization (1)

32,406

# of claims for NH residents during pressure ulcer with discharge assessments

**168,824**

# of claims for NH residents during pressure ulcer with no discharge assessment

7,897

# of claims for NH residents after pressure ulcer

102,684

Admissions with pressure ulcer as primary, admitting or the second diagnosis and the corresponding POA indicator is equal to Y

**596,891**

All Medicare short/long-stay hospital claims

**125,019,398**

**Appendix Figure** **S1** (Continued)

All Medicare short/long-stay claims

**125,019,398**

Admissions with pressure ulcer as any secondary diagnoses only

**1,744,803**

# of claims for NH residents during pressure ulcer with discharge assessments

**574,331**

# of claims for patients returned to the same NH after hospitalizations

**363,861**

# of claims for NH residents during pressure ulcer with no discharge assessments

495,810

# of claims for NH residents after pressure ulcer and other

282,529

Did not return to NH or returned more than 1 day after hospitalization (1)

165,547

Returned to a different NH after hospitalization (2)

42,923

# of claims for NH residents long before/discharged before pressure ulcer

21,966

Final sample size, excluding MDS with all pressure ulcer items coded as “-”, and with missing values

**293,617**

# of claims for patients who have been NH residents

1,374,636

# of claims for patients who are not NH residents

370,167

# of claims for NH residents during pressure ulcer who returned to NH

**406,784**

Linked with MDS Discharge Assessments

**Appendix Figure S2.** Analytical sample flowchart of MedPAR SNF claims linked to pressure ulcer related MDS items

All Medicare MedPAR SNF claims

19,265,327

Admissions with pressure ulcer as primary, admitting or the second diagnosis

138,780

# of claims linked with an MDS

134,793

Linked with MDS Assessments

# of claims linked with an MDS (except entry/death record) within the SNF stay

110,134

Final sample size, excluding observations with missing values

60,203

**Appendix Figure S3.** Distribution of nursing home reporting rates of primary pressure ulcer diagnosis hospital admission claims



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| **Appendix Table S3.** Sensitivity analysis: Reporting rates of MDS pressure ulcer items without the readmission restriction (%) |
|  |  | **Long-stay** |  | **Short-stay** |
| **Claims type** | **Pressure ulcer severity on claim**b | **N** | **Percent of claims with any pressure ulcer reported on MDS**  | **Percent of claims with any pressure ulcer reported on MDS within 1 stage of claim severity**  |  | **N** | **Percent of claims with any pressure ulcer reported on MDS**  | **Percent of claims with any pressure ulcer reported on MDS within 1 stage of claim severity**  |
|  |  |  | **Sensitivity analysis** | **Difference**c | **Sensitivity analysis** | **Difference**c |  |  | **Sensitivity analysis** | **Difference**c | **Sensitivity analysis** | **Difference**c |
| **Primary pressure ulcer diagnosis**a **hospital admission claims** | Stage 1 | 208 | 14.9 | 2.0 | 7.7 | 0.7 |  | 631 | 27.1 | -1.0 | 18.7 | 0.7 |
| Stage 2 | 627 | 41.1 | 7.8 | 30.9 | 5.5 |  | 2150 | 55.0 | 2.2 | 44.3 | 3.3 |
| Stage 3 | 3453 | 67.2 | 0.4 | 63.7 | -0.4 |  | 10658 | 77.0 | -0.7 | 72.4 | -1.3 |
| Stage 4 | 6779 | 86.6 | -0.6 | 79.3 | -2.6 |  | 15584 | 91.3 | -0.2 | 84.3 | -1.3 |
| Unstageable | 1179 | 81.6 | 3.7 | 74.2 | 4.3 |  | 3609 | 87.1 | 0.4 | 80.1 | 0.9 |
| **Secondary pressure ulcer diagnosis**a **hospital admission claims** | Stage 1 | 4860 | 15.5 | 1.5 | 8.6 | 0.8 |  | 13756 | 29.6 | 1.8 | 20.0 | 2.2 |
| Stage 2 | 14536 | 35.4 | 1.8 | 27.6 | 1.7 |  | 48772 | 52.8 | 0.7 | 42.0 | 1.0 |
| Stage 3 | 7364 | 62.8 | -2.3 | 60.0 | -2.8 |  | 22028 | 74.1 | -1.8 | 69.6 | -2.4 |
| Stage 4 | 9866 | 87.0 | -1.0 | 80.8 | -2.5 |  | 21300 | 90.6 | -1.5 | 82.6 | -3.5 |
| Unstageable | 5882 | 59.4 | 2.7 | 50.0 | 3.5 |   | 20202 | 73.2 | 0.2 | 59.6 | -0.9 |
| aPrimary pressure ulcer diagnosis claims had a pressure ulcer in the admitting, first or second diagnosis code. Secondary pressure ulcer diagnosis claims had a pressure ulcer in a field after the second diagnosis.bSeverity for a claim was assigned based on the stage of the highest-staged pressure ulcer on the claims.cThe difference is calculated as the reporting rate of sensitivity analysis minus the corresponding reporting rate in Table 3. |

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| **Appendix Table S4**. Sensitivity analysis: Reporting rate for residents who died upon discharge from pressure ulcer hospital admission, 2011 - 2017 (%) |
|  |  | **Long-stay** |   | **Short-stay** |
| **Claims type**  | **Pressure ulcer severity on claimb** | **N** | **Percent of claims with any pressure ulcer reported on MDS** | **Percent of claims with any pressure ulcer reported on MDS within 1 stage of claim severity** |   | **N** | **Percent of claims with any pressure ulcer reported on MDS** | **Percent of claims with any pressure ulcer reported on MDS within 1 stage of claim severity**  |
|  |  |  | **Sensitivity analysis** | **Difference**c | **Sensitivity analysis** | **Difference**c |   |  | **Sensitivity analysis** | **Difference**c | **Sensitivity analysis** | **Difference**c |
| **Primary pressure ulcer diagnosisa hospital admission claims** | Stage 1 | 31 | 16.1 | 3.2 | 9.7 | 2.7 |  | 55 | 21.8 | -6.3 | 18.2 | 0.2 |
| Stage 2 | 80 | 40.0 | 6.7 | 28.8 | 3.4 |  | 186 | 58.1 | 5.3 | 47.8 | 6.8 |
| Stage 3 | 659 | 66.3 | -0.5 | 61.6 | -2.5 |  | 1603 | 79.6 | 1.9 | 74.5 | 0.7 |
| Stage 4 | 1090 | 88.1 | 0.9 | 79.8 | -2.1 |  | 2255 | 92.9 | 1.4 | 85.7 | 0.1 |
| Unstageable | 209 | 78.9 | 1.0 | 72.2 | 2.2 |  | 480 | 89.4 | 2.7 | 83.8 | 4.6 |
| **Secondary pressure ulcer diagnosisa hospital admission claims**  | Stage 1 | 1728 | 15.2 | 1.2 | 9.1 | 1.3 |  | 3540 | 29.8 | 2.0 | 20.6 | 2.7 |
| Stage 2 | 4877 | 36.4 | 2.8 | 28.8 | 2.9 |  | 13636 | 54.8 | 2.7 | 44.2 | 3.2 |
| Stage 3 | 2708 | 62.4 | -2.8 | 59.9 | -2.9 |  | 7584 | 75.6 | -0.3 | 71.2 | -0.8 |
| Stage 4 | 3664 | 87.2 | -0.8 | 81.1 | -2.2 |  | 7367 | 91.7 | -0.4 | 84.0 | -2.1 |
| Unstageable | 2041 | 59.4 | 2.7 | 49.9 | 3.5 |   | 5945 | 75.3 | 2.3 | 61.3 | 0.8 |
| aPrimary pressure ulcer diagnosis claims had a pressure ulcer in the admitting, first or second diagnosis code. Secondary pressure ulcer diagnosis claims had a pressure ulcer in a field after the second diagnosis.bSeverity for a claim was assigned based on the stage of the highest-staged pressure ulcer on the claims.cThe difference is calculated as the reporting rate of sensitivity analysis minus the corresponding reporting rate in Table 3. |

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| **Appendix Table S5.** Sensitivity analysis: Reporting rates of MDS pressure ulcer items if including additional MDS assessments prior to nursing home discharge (%) |
|  |  | **Long-stay** |  |  |  |  | **Short-stay** |  |  |  |
| **Claims type** | **Pressure ulcer severity on claim**a | **Percent of claims with any pressure ulcer reported on MDS**  | **Percent of claims with any pressure ulcer reported on MDS within 1 stage of claim severity**  |  | **Percent of claims with any pressure ulcer reported on MDS**  | **Percent of claims with any pressure ulcer reported on MDS within 1 stage of claim severity**  |
|  |  | **Sensitivity analysis** | **Difference**b | **Sensitivity analysis** | **Difference**b |  | **Sensitivity analysis** | **Difference**b | **Sensitivity analysis** | **Difference**b |
| **Primary pressure ulcer diagnosis hospital admission claims** | stage 1 | 13.4 | 0.5 | 7.4 | 0.5 |  | 30.7 | 2.6 | 21.1 | 3.2 |
| stage 2 | 33.7 | 0.3 | 25.8 | 0.4 |  | 55.6 | 2.8 | 44.4 | 3.5 |
| stage 3 | 67.1 | 0.3 | 64.4 | 0.3 |  | 79.3 | 1.6 | 75.2 | 1.4 |
| stage 4 | 87.4 | 0.2 | 82.2 | 0.2 |  | 92.3 | 0.8 | 86.5 | 0.9 |
| unstageable | 78.1 | 0.1 | 70.1 | 0.2 |  | 88.0 | 1.2 | 80.1 | 0.9 |
| **Secondary pressure ulcer diagnosis hospital admission claims** | stage 1 | 14.3 | 0.3 | 8.1 | 0.3 |  | 31.2 | 3.4 | 21.5 | 3.6 |
| stage 2 | 33.9 | 0.4 | 26.3 | 0.4 |  | 54.7 | 2.5 | 44.0 | 3.1 |
| stage 3 | 65.4 | 0.3 | 63.0 | 0.2 |  | 77.6 | 1.7 | 73.3 | 1.3 |
| stage 4 | 88.2 | 0.2 | 83.5 | 0.2 |  | 92.9 | 0.8 | 86.9 | 0.8 |
| unstageable | 57.1 | 0.4 | 46.7 | 0.3 |   | 75.0 | 2.0 | 61.8 | 1.3 |
| aSeverity for a claim was assigned based on the stage of the highest-staged pressure ulcer on the claims.bThe difference is calculated as the reporting rate of sensitivity analysis minus the corresponding reporting rate in Table 3. |

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| Appendix Table S6. Logistic regression results of reporting of MDS pressure ulcer items |
| Variables | **Long-stay** | **Short-stay** |
| Race (individual level) |  |  |
|  | White (Ref) |  |  |
|  | American Indian | -0.115 | 0.0807 |
|  | Asian | 0.147 | 0.155 |
|  | Black | 0.216\*\*\* | 0.284\*\*\* |
|  | Hispanic | 0.0717 | 0.0358 |
|  | Other | 0.287 | 0.121 |
| Race (nursing home level) |  |  |
|  | White (Ref) |  |  |
|  | American Indian | 14.32 | 7.025 |
|  | Asian | -5.242 | 4.01 |
|  | Black | -0.836 | -1.913 |
|  | Hispanic | 3.987 | 0.474 |
|  | Other | 18.00 | 18.31 |
| Pressure ulcer severity (individual level) |  |  |
|  | Stage 1 (Ref) |  |  |
|  | Stage 2 | 1.218\*\*\* | 1.017\*\*\* |
|  | Stage 3 | 2.680\*\*\* | 2.197\*\*\* |
|  | Stage 4 | 3.872\*\*\* | 3.324\*\*\* |
|  | Unstageable | 3.288\*\*\* | 2.839\*\*\* |
| Pressure ulcer severity (nursing home level) |  |  |
|  | Stage 1 (Ref) |  |  |
|  | Stage 2 | 1.711\*\*\* | 1.538\*\*\* |
|  | Stage 3 | 3.081\*\*\* | 2.642\*\*\* |
|  | Stage 4 | 4.582\*\*\* | 3.997\*\*\* |
|  | Unstageable | 3.645\*\*\* | 3.169\*\*\* |
| Race and pressure ulcer severity interactions (individual level) |  |  |
|  | American Indian # Stage 2 | -0.401 | -1.262 |
|  | American Indian # Stage 3 | -0.522 | -1.239 |
|  | American Indian # Stage 4 | 0.0604 | -0.794 |
|  | American Indian # Unstageable | 0.253 | -1.903 |
|  | Asian # Stage 2 | -1.036 | 0.408 |
|  | Asian # Stage 3 | -1.435\* | 0.722 |
|  | Asian # Stage 4 | -1.042 | 0.911 |
|  | Asian # Unstageable | -1.347 | 0.658 |
|  | Black # Stage 2 | -0.265 | -0.613\* |
|  | Black # Stage 3 | -0.142 | -0.603\*\* |
|  | Black # Stage 4 | -0.00379 | -0.448 |
|  | Black # Unstageable | 0.0577 | -0.374 |
|  | Hispanic # Stage 2 | 0.55 | 0.399 |
|  | Hispanic # Stage 3 | 0.0966 | 0.497 |
|  | Hispanic # Stage 4 | 0.28 | 0.555 |
|  | Hispanic # Unstageable | 0.202 | 0.4 |
|  | Other # Stage 2 | -0.36 | 0.255 |
|  | Other # Stage 3 | -0.441 | 0.0636 |
|  | Other # Stage 4 | 0.135 | 0.225 |
|  | Other # Unstageable | 0.599 | -0.677 |
| Race and pressure ulcer severity interactions (nursing home level) |  |  |
|  | American Indian # Stage 2 | -13.44 | -4.022 |
|  | American Indian # Stage 3 | -13.53 | -4.937 |
|  | American Indian # Stage 4 | -14.59 | -9.342 |
|  | American Indian # Unstageable | -15.25 | -9.838 |
|  | Asian # Stage 2 | 5.538 | -4.357 |
|  | Asian # Stage 3 | 6.537 | -4.292 |
|  | Asian # Stage 4 | 5.527 | -2.476 |
|  | Asian # Unstageable | 5.408 | -2.37 |
|  | Black # Stage 2 | 1.167 | 1.818 |
|  | Black # Stage 3 | 1.504 | 2.12 |
|  | Black # Stage 4 | 1.058 | 2.308 |
|  | Black # Unstageable | 1.264 | 2.498 |
|  | Hispanic # Stage 2 | -3.628 | -1.39 |
|  | Hispanic # Stage 3 | -3.734 | 0.411 |
|  | Hispanic # Stage 4 | -4.029 | -0.362 |
|  | Hispanic # Unstageable | -2.416 | 0.306 |
|  | Other # Stage 2 | -33.67 | -7.062 |
|  | Other # Stage 3 | -21.08 | -8.452 |
|  | Other # Stage 4 | -6.632 | -22.64 |
|  | Other # Unstageable | -11.96 | -13.79 |
| Age |  |  |
|  | >=85 (Ref) |  |  |
|  | 68\_76 | 0.287\*\*\* | 0.064 |
|  | 77\_85 | 0.181\*\*\* | 0.0627\* |
|  | <68 | 0.307\*\*\* | -0.00553 |
| Female | 0.129\*\*\* | 0.035 |
| Disability | 0.125\* | 0.0642 |
| Dual (individual level) | -0.319\*\*\* | -0.164\*\*\* |
| Dual (nursing home level) | -0.428\*\*\* | -0.169\* |
| Comorbidity score | -0.0101 | -0.00809 |
| Year |  |  |
|  | 2011 (Ref) |  |  |
|  | 2012 | -0.0904\* | -0.0263 |
|  | 2013 | -0.161\*\*\* | -0.106\* |
|  | 2014 | -0.260\*\*\* | -0.172\*\*\* |
|  | 2015 | -0.275\*\*\* | -0.187\*\*\* |
|  | 2016 | -0.291\*\*\* | -0.202\*\*\* |
|  | 2017 | -0.304\*\*\* | -0.238\*\*\* |
| Chronic conditions |  |  |
|  | AMI | 0.0131 | 0.0810\* |
|  | ALZH | 0.00679 | 0.0214 |
|  | ALZH\_DEMEN | 0.0296 | 0.101\*\*\* |
|  | ATRIAL\_FIB | 0.0921\*\*\* | -0.00453 |
|  | CATARACT | -0.189\*\*\* | -0.131\*\*\* |
|  | CHRONICKIDNEY | 0.193\*\*\* | 0.179\*\*\* |
|  | COPD | -0.0105 | -0.00963 |
|  | CHF | -0.0406 | 0.0054 |
|  | DIABETES | 0.013 | -0.0573\* |
|  | GLAUCOMA | -0.0397 | -0.0283 |
|  | HIP\_FRACTURE | 0.063 | 0.0941\*\* |
|  | ISCHEMICHEART | -0.0297 | -0.00119 |
|  | DEPRESSION | -0.106\*\*\* | -0.0973\*\*\* |
|  | OSTEOPOROSIS | -0.000922 | -0.0182 |
|  | RA\_OA | -0.0149 | -0.0643\* |
|  | STROKE\_TIA | -0.0139 | -0.000385 |
|  | CANCER\_BREAST | 0.0645 | 0.0108 |
|  | CANCER\_COLORECTAL | -0.110\* | 0.0362 |
|  | CANCER\_PROSTATE | 0.136\* | 0.0497 |
|  | CANCER\_LUNG | 0.105 | 0.0121 |
|  | CANCER\_ENDOMETRIAL | 0.0134 | 0.0428 |
|  | ANEMIA | 0.180\*\* | 0.129\* |
|  | ASTHMA | 0.0268 | -0.0752\* |
|  | HYPERL | -0.0681\* | -0.0891\* |
|  | HYPERP | 0.0766\* | 0.0269 |
|  | HYPERT | -0.196\*\* | -0.247\*\*\* |
|  | HYPOTH | -0.0232 | -0.016 |
| Ownership |  |  |
|  | For-profit (Ref) |  |  |
|  | Government | 0.0874 | 0.00881 |
|  | Non-profit | 0.121\*\* | 0.0772\* |
|  | Other | -0.0689 | -0.155 |
| Region |  |  |
|  | Midwest (Ref) |  |  |
|  | Northeast | 0.234\*\*\* | 0.220\*\*\* |
|  | South | 0.0908\* | 0.170\*\*\* |
|  | West | -0.0883 | 0.0249 |
| Size |  |  |
|  | Large (Ref) |  |  |
|  | Medium | -0.0873\* | -0.0237 |
|  | Small | 0.0339 | -0.0903\* |
| Constant | -2.251\*\*\* | -1.176\*\*\* |
| var(intercept) | 0.437\*\*\* | 0.319\*\*\* |
| Observations | 51869 | 62860 |

 \*P< .05, \*\*P<.01, \*\*\*P<.001 at 5% significance level.

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| **Appendix Table S7.** Adjusted differences in reporting rates by pressure ulcer severity, race, and nursing home race mix for short- and long-stay residents |
|  |  | **Adjusted mean**a,b | **Difference (p value)** |
| **Percentage of Black residents** | **Pressure ulcer severity**c | **White** | **Black** | **White - Black** |
| **Long-stay** |
| 10% | Stage 2 | 32.7 | 33.9 | -1.2 (0.521) |
|  | Stage 3 | 64.7 | 68.4 | -3.7 (0.007) |
|  | Stage 4 | 84.5 | 88.1 | -3.6 (<0.001) |
| 70% | Stage 2 | 35.7 | 37.0 | -1.2 (0.517) |
|  | Stage 3 | 66.2 | 69.8 | -3.6 (0.009) |
|  | Stage 4 | 84.4 | 88.0 | -3.6 (<0.001) |
| **Short-stay** |
| 10% | Stage 2 | 51.0 | 55.0 | -4.0 (0.031) |
|  | Stage 3 | 75.8 | 78.9 | -3.0 (0.005) |
|  | Stage 4 | 90.1 | 92.7 | -2.6 (<0.001) |
| 70% | Stage 2 | 50.0 | 54.1 | -4.0 (0.032) |
|  | Stage 3 | 75.0 | 78.1 | -3.1 (0.008) |
|   | Stage 4 | 88.8 | 91.7 | -2.9 (<0.001) |
| aThe reporting rates for long-stay and short-stay residents were separately modeled using logistic multilevel models with nursing home random intercepts. The model adjusted for individual-level variables of age, sex, race, pressure ulcer severity, comorbidity score, disability status, and chronic conditions, nursing home-level variables of size, region, ownership type, and both individual-level and nursing home-level variables of Medicaid-Medicare dual status, pressure ulcer severity, and race. Interactions for pressure ulcer severity and race were also included at both levels. Only primary pressure ulcer diagnosis claims were used.bThe adjusted reporting rates were predicted using the fitted parameters of the logistic multilevel model with fixed values for the percentage of Stage 1 pressure ulcer (5%), the percentage of Stage 2 pressure ulcer (30%), the percentage of Stage 3 pressure ulcer (20%), and the percentage of Stage 4 pressure ulcer (40%), and the percentage of Unstageable pressure ulcer (5%). The percentage of Hispanic residents was set to one. The percentage of White residents was one minus the percentage of Black and Hispanic residents. All other variables were set at the sample mean.cSeverity for a claim was assigned based on the stage of the highest-staged pressure ulcer on the claims. |