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REPORT

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Development of an HCBS Pressure Ulcer Measure, Volume 2

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EXECUTIVE SUMMARY

This is the second of two reports describing the development of a measure to assess the occurrence of inpatient hospitalizations with severe pressure ulcers among Medicaid fee-for-service (FFS) beneficiaries using home- and community-based services (HCBS). The HCBS pressure ulcer measure is intended to assess the quality of care for HCBS recipients under a shared accountability framework: the measure profiles the experience of the HCBS population and reflects care delivered by all providers (not just HCBS providers). This report describes that final risk-adjusted HCBS pressure ulcer measure.

The Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services, began the development of the HCBS pressure ulcer measure 10 years ago as directed by the Deficit Reduction Act of 2005. Through this process, AHRQ finalized a set of HCBS quality measures that included a measure of potentially avoidable hospitalizations due to pressure ulcers, which was adapted from Patient Safety Indicator 03 (PSI 03) (Schultz et al. 2012). Mathematica is tasked with updating this pressure ulcer measure definition to account for updated data sources, changes to diagnosis coding standards for pressure ulcer reporting, and current clinical practices for pressure ulcer prevention and treatment in the HCBS population.[1] In addition, Mathematica is responsible for developing an approach to risk adjusting the measure, which was recommended by the Technical Expert Panel convened to provide guidance for the measure's development. The risk adjustment process seeks to account for state-level differences in population health and case mix that may impact the occurrence of pressure ulcers in the HCBS population.

A previous report (Volume 1) summarizes: (1) Mathematica's preliminary evaluation of several options for defining the pressure ulcer measure, (2) the presentation of these preliminary analyses to the HCBS Pressure Ulcer Technical Expert Panel (TEP), and (3) final recommended measure specifications (Wysocki et al. 2015). This report (Volume 2) continues the work of developing the HCBS pressure ulcer measure by describing the recommended risk-adjustment models developed for this measure. Specifically, we summarize the data, methods, and approach to developing the risk-adjustment models (Chapter II), outline the model development process (Chapter III), and provide descriptive statistics on the HCBS user population, the prevalence of risk factors, and the incidence of HCBS pressure ulcer events (Chapters IV and V).

This report describes predictive models developed to risk adjust the HCBS pressure ulcer measure. In general, we find that:

- The prevalence of comorbidities, physical disabilities, mental health conditions, and substance use disorders widely varies across states, motivating the need for risk adjustment.

[1] Mathematica is also tasked with building risk-adjustment models for two HCBS composite measures, which were also recommended by AHRQ for the HCBS population. The final risk-adjustment models for the HCBS composite measures and associated recommendations for addressing small sample sizes and appropriate benchmarks will be published in two volumes, and are available at http://www.medicaid.gov/Medicaid-CHIP-Program-Information/By-Topics/Long-Term-Services-and-Supports/Balancing/Money-Follows-the-Person.html.

- In regression models built to predict the risk of pressure ulcers, mobility impairment, spinal cord injury, spina bifida, multiple sclerosis and transverse myelitis, and Chronic Kidney Disease are the strongest predictors of pressure ulcers.
- Risk adjustment models fit the data well overall, but like many risk-adjusted quality measures for rare events, risk is under-predicted for the lowest risk HCBS users.
- Risk adjustment does not markedly shift the ranking of state pressure ulcer rates but does highlight substantial variation in rates across states.
- Due to the small sample sizes of the MFP and non-MFP populations, we report risk-adjusted rates for these populations as a whole rather than by state.
- While issues related to statistical uncertainty and appropriate benchmarks were not specifically explored for the HCBS pressure ulcer measure, related work on the HCBS composite measures supports the use of minimum case sizes and 95 percent confidence intervals surrounding risk-adjusted rates to draw meaningful conclusions using this measure (Ross et al. 2015).

The report concludes by reporting risk-adjusted state-level HCBS pressure ulcer rates for HCBS users in 2009 and 2010 (Appendix C), and population-level results for policy-relevant subgroups of Medicaid beneficiaries who transitioned from institutional long-term care settings to HCBS.[2] In addition, detailed measure specifications and SAS programming code for producing the observed (unadjusted) and risk-adjusted pressure ulcer measures for Medicaid FFS beneficiaries using HCBS were produced to accompany this report.

The overarching goal of this work is to continue to develop quality measures that can be used to assess the care provided to Medicaid beneficiaries receiving long-term services and supports in the community. This report, as well as other reports related to the effort to develop quality measures for the HCBS population, can be found at: http://www.medicaid.gov/Medicaid-CHIP-Program-Information/By-Topics/Long-Term-Services-and-Supports/Balancing/Money-Follows-the-Person.html.

[2] The state-level results in this report are descriptive and should not be used to rank performance. Instead, these results should be used to guide states or other stakeholders to further examine quality issues. The HCBS pressure ulcer measure needs further development if it is to be used for state profiling, including reliability adjustment, establishing benchmarks, defining a statistical framework for comparison, and accounting for managed care HCBS users.

I. INTRODUCTION

The Centers for Medicare & Medicaid Services (CMS), the Agency for Healthcare Research and Quality (AHRQ), and the Office of Disability, Aging, and Long-Term Care Policy (DALTCP) in the Office of the Assistant Secretary for Planning and Evaluation (ASPE) are working to formalize a set of quality measures for Medicaid beneficiaries who use community-based long-term services and supports (LTSS). Until recently, the only quality measures available to evaluate outcomes or processes of care delivered to LTSS recipients were specific to institutional settings, such as hospitals or nursing homes. To fulfill this unmet need for those who use home- and community-based services (HCBS), Section 6086(b) of the Deficit Reduction Act of 2005 directed AHRQ to develop "program performance indicators, client function indicators, and measures of client satisfaction" for Medicaid beneficiaries receiving HCBS (109th United States Congress 2006). In response, AHRQ and its contractors developed a preliminary set of HCBS quality indicators (QIs) and in 2012 published a methodology report. The initial set of HCBS QIs included adaptations of existing AHRQ prevention quality indicators (PQIs) and patient safety indicators (PSIs) as well as newly developed measures (Schultz et al. 2012).

Through the Money Follows the Person (MFP) evaluation, CMS and its contractors enhanced these HCBS QIs by developing preliminary risk-adjustment models and a framework for state-by-state comparisons (Ross and Bohl 2013). The MFP Demonstration is a CMS initiative that allows Medicaid beneficiaries receiving LTSS in institutional settings to transition into the community and receive care through HCBS. A central question for the program is how the quality of care delivered to MFP participants compares with that of other Medicaid HCBS beneficiaries, including those receiving care through HCBS waiver programs and those who transition to HCBS from institutions without the MFP program.

One of the HCBS QIs recommended by AHRQ and its contractors was a measure of potentially preventable hospitalizations due to the development of pressure ulcers. AHRQ developed a HCBS pressure ulcer measure (Schultz et al. 2012); however, since that time significant changes occurred in both International Classification of Diseases, 9th revision (ICD-9) diagnosis codes and the availability of present-on-admission (POA) data. The original definitions were developed using 2005 Medicare- and Medicaid-paid discharges, but starting in 2008, the ICD-9 diagnosis coding standards for pressure ulcers changed. The new standards require documentation of the severity of the ulcer, which is coded as stage I, II, III, IV, or unstageable. Furthermore, starting on October 1, 2008, acute inpatient prospective payment system (IPPS) hospitals are required to report the POA indicators for all Medicare discharges, to distinguish between events occurring before or during a hospital stay. These new data elements present an opportunity to refine and improve the HCBS pressure ulcer measure to identify the most severe pressure ulcers that occur in community-based settings (that is, outside of the hospital and nursing home settings). This identification was the stated intent of the HCBS pressure ulcer measure (Schultz et al. 2012).

The first volume of this report (Volume 1) summarizes Mathematica's work updating the HCBS pressure ulcer measure using these newly available data sources (Wysocki et al. 2015). Specifically, Volume 1 details: (1) Mathematica's investigation of several different options for specifying defining the pressure ulcer measure, (2) the presentation of these preliminary analyses to the HCBS Pressure Ulcer Technical Expert Panel (TEP), and (3) final recommended measure

specifications. The report concludes by presenting observed (unadjusted) pressure ulcer hospitalization rates for four populations: (1) 2009 HCBS users, (2) 2010 HCBS users, (3) MFP participants who transitioned from 2008 to 2010, and (4) Medicaid beneficiaries who transitioned to HCBS outside of MFP from 2008 to 2010. These four populations were identified during an earlier phase of this work that focused on developing risk-adjustment methods for three PQI composite measures.

This report (Volume 2) continues the work begun in Volume 1, and describes the development of risk-adjustment models for the pressure ulcer measure. In response to the TEP's recommendation of risk adjusting the pressure ulcer measure, we built risk-adjustment models following a process similar to that proposed and used for related composite measures (Bohl et al. 2015; Bohl et al. 2015b). In this report, we summarize the data, methods, and approach to developing the risk-adjustment models (Chapter II), outline the model development process (Chapter III), and provide descriptive statistics on the HCBS user population, the prevalence of risk factors, and the incidence of HCBS pressure ulcer events (Chapters IV and V).

This report does not cover other important topics in measure development and application, such as methods to address statistical uncertainty, set appropriate benchmarks, and establish frameworks for comparison. This report is limited to the development of risk-adjustment models for the HCBS pressure ulcer measure, but concludes by offering recommendations on these key topics that were explored as part of the development of the HCBS acute and chronic composite measures, described in the *Risk Adjustment of HCBS Composite Measures, Volume 2* report (Ross et al. 2015).

II. DATA AND MEASURES

A. Analytic populations

To develop risk-adjustment models, we used the data on Medicaid beneficiaries using HCBS in 2010, the most recent year for which the required Medicare and Medicaid data are available for nearly all states. The 2010 HCBS user population includes persons enrolled in HCBS 1915(c) waiver plans or using HCBS state plan or 1915(c) waiver services at any point during 2010.[3] This population includes HCBS users who are enrolled only in Medicaid, as well as those eligible for both Medicare and Medicaid (referred to as Medicare–Medicaid eligible, or MME). In addition to the 2010 HCBS population, we use data on the 2009 HCBS user population for model validation and comparison. The data are derived from Medicare and Medicaid administrative data, including the Medicaid Analytic eXtract (MAX) Person Summary (PS), Other Services/Therapies (OT), and Long-term Care (LT), and Inpatient (IP) files, Medicare Beneficiary Summary File (MBSF), and Medicare Part A (from the Medicare Provider Analysis and Review (MedPAR) files)[4], and B claims data available on the Chronic Conditions Data Warehouse (CCW).[5]

In alignment with AHRQ's recommended specifications, we imposed several important exclusions on these populations (Schultz et al. 2012). We excluded both Medicaid managed care and Medicare Advantage enrollees, because their claims are either unavailable or incomparable to those for beneficiaries enrolled in fee-for-service programs. The population is also limited to HCBS users who are age 18 or older as of January 1, 2010. Finally, we excluded people with a record of HCBS enrollment only (that is, no observed HCBS claims) and at least one month with an institutional claim for long-term care. This step removes individuals who are enrolled in HCBS 1915(c) waivers but are only receiving institutional long-term services and supports (LTSS) during the period of interest.

B. Measure definition

The HCBS pressure ulcer measure definition was developed through an analytic process that evaluated the impact of various exclusion criteria, use of pressure ulcer stage and site codes, and present-on-admission (POA) information. This report summarizes the final recommended measure specifications used for risk-adjustment; the details of the measure development process are described in Volume 1.

[3] HCBS 1915(c) waivers include aged/disabled, aged only, disabled only, traumatic brain injury, HIV/AIDS, intellectually disabled/developmentally disabled, mental illness, technologically dependent, an unspecified waiver, or autism. HCBS 1915(c) or state plan services include personal care, at-home private duty nursing, adult day, home health of at least 90 days, residential care, at-home hospice, rehabilitation, case management, transportation, or durable medical equipment.

[4] For additional information on these data files see the Centers for Medicare & Medicaid Services (CMS) Research Data Assistance Center (ResDAC) at http://www.resdac.org/.

[5] For additional information see the Chronic Conditions Data Warehouse (CCW) at https://www.ccwdata.org/.

1. Denominator

The denominator for the HCBS pressure ulcer measure uses units of person-time. It is calculated by summing the total number of months during the period of interest when eligible Medicaid beneficiaries were either enrolled in or using HCBS 1915(c) waivers or state plan HCBS. Months of HCBS use that coincide with months when hospice care was also used are excluded from the denominator.

2. Numerator

The numerator for the pressure ulcer measure identifies whether an HCBS user was hospitalized and had a diagnosis for a severe pressure ulcer. We searched through inpatient acute care hospital admissions for a diagnosis code for a severe (Stage III, IV, or unstageable) pressure ulcer. On claims where POA information is available (i.e., those paid by Medicare), the pressure ulcer numerator is further refined to exclude pressure ulcers that are acquired during a hospital stay (POA values of N or U).

To better attribute events to the HCBS care experience, Mathematica imposed an additional restriction so that qualifying admissions are included in the numerator only if the admission date occurs during a month of HCBS use. Numerator events that occur during months when hospice care was used are also excluded.

If an HCBS user experiences multiple qualifying hospital admissions during the period of interest, only one of these admissions is counted in the numerator. In this way, the numerator definition contrasts with the numerator of the HCBS composite measure, in which one HCBS user can contribute multiple events (Bohl et al. 2015b). In the event that an HCBS user is transferred between acute care settings, the second stay (the "transfer in") is excluded from the analysis, to align with AHRQ's specifications (Schultz et al. 2012).

3. Observed (unadjusted) rates

The observed (unadjusted) HCBS pressure ulcer rate for the time period of interest

is calculated as the number of HCBS users with at least one qualifying inpatient admissions divided by the number of months of HCBS *use, i.e.,*

$$\frac{\text{Number of HCBS users with at least 1 qualifying inpatient admission during HCBS months}}{\text{Total number of HCBS months}} = \text{Rate of 1 or more events during HCBS months.}$$

For ease of discussion, we multiply rates by 12 to generate rates in person-years. In addition, we multiply rates by 100,000 to present the HCBS pressure ulcer measure with units of events per 100,000 person-years.

C. Candidate risk factors

When building risk-adjustment models for the HCBS pressure ulcer measure, Mathematica had access to information on demographics, HCBS enrollment and use, chronic conditions, disability-related conditions, mental health conditions, substance use disorders, Medicare–

Medicaid enrollment, and waiver enrollment. We list the set of potential risk factors or stratification variables below, describing their rationale and data source.

Age and gender. These two characteristics are included in the basic risk-adjustment algorithm developed by AHRQ for the PQIs. In this work, these variables are derived from the MAX PS file.

Chronic conditions, disability-related conditions, mental health conditions, and substance use disorders. Information on these health conditions and disorders is incorporated using the algorithms developed for the CCW (Appendix B includes information on the data and methods used to define the CCW indicators). The CCW was developed as a result of the Medicare Modernization Act of 2003, which required CMS to develop a research database to facilitate research on chronic illness that could be used to improve quality of care and reduce program spending. Currently, the comorbidities defined in the CCW include 27 chronic conditions, 15 disability-related conditions, 9 mental health conditions, and 2 substance use disorders (Tables II.1-3).

Compared with other claims-based comorbidity classification schemes, the CCW comorbidities have the advantage of relative simplicity (53 conditions, compared with 189 conditions in the Hierarchical Condition Classification and 285 in the Clinical Classification Software), and the CCWs are readily available for both MME and Medicaid-only beneficiaries. The CCW algorithms search both Medicare and Medicaid inpatient and outpatient claims using a one-, two-, or three-year look-back period.

Table II.1. CCW chronic conditions

Alzheimer's disease	Chronic obstructive pulmonary disease and bronchiectasis
Alzheimer's disease and related disorders or senile dementia	Depression
Acute myocardial infarction	Diabetes
Anemia	Glaucoma
Asthma	Hip/pelvis fracture
Atrial fibrillation	Hyperlipidemia
Breast cancer	Hypertension
Colorectal cancer	Benign prostatic hyperplasia
Endometrial cancer	Acquired hypothyroidism
Lung cancer	Ischemic heart disease
Prostate cancer	Osteoporosis
Cataract	Rheumatoid arthritis/osteoarthritis
Heart failure	Stroke/transient ischemic attack
Chronic kidney disease	

Source: Chronic Conditions Data Warehouse: https://www.ccwdata.org/.

Table II.2. CCW Disability-related conditions

Autism spectrum disorders	Muscular dystrophy
Cerebral palsy	Other developmental delays
Cystic fibrosis and other metabolic developmental disorders	Sensory: deafness and hearing impairment
Epilepsy	Sensory: blindness and visual impairment
Intellectual disabilities and related conditions	Spina bifida and other congenital abnormalities of the nervous system
Learning disabilities	Spinal cord injury
Mobility impairments	Traumatic brain injury and nonpsychotic mental disorders due to brain damage
Multiple sclerosis and transverse myelitis	

Source: Chronic Conditions Data Warehouse: https://www.ccwdata.org/.

Table II.3. CCW Mental health conditions and substance use disorders

Anxiety disorders	Schizophrenia
Bipolar disorder	Schizophrenia and other psychotic disorders
Conduct disorders and hyperkinetic syndrome	Tobacco use
Depressive disorders	Alcohol use
Personality disorders	Substance abuse
Post-traumatic stress disorders	

Source: Chronic Conditions Data Warehouse: https://www.ccwdata.org/.

Note: The substance use algorithms were provided by CMS, and reflect public comments on the proposed definitions for these conditions published in April 2014.

Waiver enrollment and use. Due to the variation in implementation among 1915(c) waivers across states, a group of experts convened in 2013 cautioned against using enrollment in or use of 1915(c) waivers in risk adjustment (Ross and Bohl 2013). However, it may be useful in select cases, such as profiling specific subpopulations (for example, individuals enrolled in 1915(c) waivers for intellectual disabilities/developmental disabilities or HIV/AIDS). These data are derived from the MAX PS and OT files.

III. MODEL DEVELOPMENT PROCESS

A. Analytic approach

The model development process used the guidelines summarized in the Proposed Methods for Developing and Testing Risk- and Reliability-Adjustment Models for HCBS Composite Measures (Bohl et al. 2015) and featured the following primary components:

Definition of statistical model. Each HCBS user has a binary indicator as to whether they had at least one pressure admission during HCBS enrollment. To predict this outcome, we specified a logistic regression model.

Selection of person-level risk factors. As discussed previously, candidate risk factors included age, gender, comorbidity information from the CCW conditions, and waiver enrollment.

Consideration of HCBS "exposure" or use. Our analysis includes persons using HCBS for at least one and up to 12 months in calendar year 2010. We did not use an offset variable in the model to account for the duration of enrollment. As was discussed in a TEP for related measures, HCBS enrollment is endogenous with the outcome and is thus unfit for inclusion in the model (see Bohl et al. 2015b).

Inclusion of state effects. The focus of this work is to identify state-level differences or "effects" in the HCBS pressure ulcer measure rates, after accounting for differences in person-level risk factors, exposure time, and other influences that may affect rates but are not directly related to the quality of care. To accomplish this goal, we might include these state effects directly in the model as fixed effects, model them via random intercepts (random effects), or omit them from the model entirely.

Model diagnostics and performance. We analyzed the predictive ability of the model using the C-statistic and compared models with different sets of risk factors using Akaike Information Criterion (AIC) and scaled deviance. We also examine Hosmer-Lemeshow plots to assess model fit for different types of patients.

We described the plan for model development and rationale for each of these steps in our previous report, Proposed Methods for Developing and Testing Risk- and Reliability-Adjustment Models for HCBS Composite Measures (Bohl et al. 2015). While this report focused on the methods to develop risk-adjustment for the HCBS composite measures, similar principles are applicable to the risk-adjustment process for the pressure ulcer measure.

B. HCBS Pressure Ulcer measure TEP guidance

Mathematica recruited clinicians knowledgeable about pressure ulcers, HCBS providers, representatives from state Medicaid programs, LTSS researchers, measure experts, representatives from the disability community, and consumer advocates to provide input on the pressure ulcer measure development process. The primary focus of this discussion was how to specify the measure numerator, whether to consider POA information, and appropriate exclusions; a complete summary of this discussion can be found in Volume 1 (Wysocki et al.

2015). However, the TEP also discussed several topics that directly influence the risk-adjustment process, and provided the following recommendations to Mathematica:

Stratify by MME (dual-eligibility) status. The TEP recommended that we develop separate risk-adjustment models for HCBS users who are MME compared with those who are eligible only for Medicaid. Although there are other subgroups of interest, the MME split is the most important due to significant differences in case-mix, data availability, data standardization, and available policy levers.

Consider both clinical and statistical significance to select risk factors. As for clinically important risk factors, the TEP specifically identified chronic obstructive pulmonary disease (COPD), smoking, diabetes, and mobility impairment. They recommended that these risk factors be included in the model regardless of statistical significance within the development sample.

Use caution when modeling multiple admissions. The TEP warned against counting admissions for a single pressure ulcer as separate events even if the measure is risk-adjusted, because even with very high quality care, a pressure ulcer can take 6 to 12 months to fully heal, and some pressure ulcers become chronic. Due to the difficulty of identifying admissions for the same severe pressure ulcer using ICD-9 codes, we developed a final pressure ulcer measure that only counts one event per HCBS user. Once the ICD-10 coding scheme is introduced in October 2015, it will become easier to identify multiple admissions for the same pressure ulcer, as discussed in Volume 1 (Wysocki et al. 2015).

In addition, to ensure consistency with the HCBS composite risk-adjustment methodology, we adhered to the following guidance provided by the HCBS Composite Measures TEP:

Do not account for prior-year outcomes. TEP members agreed that because the end goal of these measures is state-to-benchmark comparisons, and not comparison within a state over time, prior-year outcomes (i.e., numerator events) should not be included in the adjusted models.

Do not adjust for waiver enrollment. The eligibility criteria for HCBS waivers vary by state. Therefore, using waiver enrollment as a proxy for identifying individuals with comorbidities (for example, intellectual or development disabilities) may lead to risk factor misspecification. Instead, the TEP recommended reporting results for waiver groups (for example, persons with traumatic brain injuries) separately.

To learn more about the HCBS composite model development process and the input from the technical expert panel, we refer the reader to the *Risk Adjustment of HCBS Composite Measures Volume 1 and Volume 2* reports (Bohl et al. 2015b; Ross et al. 2015).

IV. DESCRIPTIVE STATISTICS

A. Demographic characteristics of the 2010 HCBS population

The risk-adjustment model was developed over the 2010 HCBS user population, which included 1,834,198 Medicaid beneficiaries meeting the inclusion criteria outlined in Section II.A (Table IV.1). Data from 49 states were available at the time of this analysis, but Medicaid fee-for-service beneficiaries using HCBS in Arizona and Hawaii were excluded, because the high concentration of managed care in these states resulted in very small HCBS user populations available for modeling. California had the largest population, with 390,239 users, and all states other than Tennessee had more than 2,000 HCBS users in 2010. The age distribution varied substantially by state. Tennessee's HCBS population was most unusual, primarily consisting of younger adults between the ages of 18 to 24, compared with an overall population mean of 60. Tennessee and New Mexico are also unique because the FFS HCBS users in our analysis represent a small proportion of all HCBS users, as these states have high proportions of HCBS users in managed care. We keep these states throughout the report for illustration as to why stratified analyses are needed; because of their small and unique samples, we will withhold most of their results in the final tables.

In addition, there was substantial state-level variation in Medicare eligibility and average duration of HCBS use (Table IV.1). In all states but Tennessee and Idaho, we observe that the majority of HCBS users are MME (in Idaho, no HCBS users are MME).[6] Furthermore, in New Jersey, New Mexico, and Michigan, more than 90 percent of the HCBS population is MME. HCBS users in most states are enrolled on average for at least nine months of a calendar year. North Dakota, which has a relatively high proportion of HCBS users older than 85, has the lowest average duration of HCBS use (7.6 months). The relationship between duration of HCBS use and age is multifaceted, and is most likely related to age, mortality, or the loss of independence, which may lead to institutional care.

B. Comorbidities in the 2010 HCBS population

An analysis of comorbid conditions in the 2010 HCBS user population further helps characterize this population and emphasizes the existence of substantive case-mix differences by state and MME status. The distribution of risk-factor prevalence across states (in other words, the proportion of HCBS users with a given risk factor) was highly skewed. For most comorbid conditions, the distribution of state-level comorbidity prevalence is clustered around a value, but one or two outlier states may have exceptionally high prevalence of a condition. As an example, the overall prevalence of development disabilities is one percent across all states; however, in two states, the prevalence is 8 and 35 percent. This skewness is not captured when looking solely at the mean prevalence and suggests that states with exceptionally high or low prevalence of risk factors may warrant special considerations in final comparisons of risk-adjusted composite rates.

[6] Analyses by Mathematica indicate that the lack of 2010 HCBS users in Idaho who are MME is due to the state's transition to a new Medicaid Management Information System in 2010, not a lack of MME HCBS users (Mathematica Policy Research, 2014).

Table IV.1. Demographics of the 2010 HCBS user population, by state

State	HCBS users (n)	Female (%)	Age (mean)	Age 18–24 (%)	Age 85+ (%)	MME (%)	Months of HCBS (mean)
ALL	1,834,198	62	60	6	12	74	10.0
Alaska	6,586	61	60	7	10	70	9.96
Alabama	16,133	64	57	6	9	64	9.96
Arkansas	19,666	67	62	5	16	76	9.58
California	390,239	62	64	5	12	71	10.29
Colorado	27,818	57	57	7	11	71	10.03
Connecticut	26,906	61	60	6	13	78	9.99
District of Columbia	8,264	59	59	3	9	59	9.23
Delaware	3,003	54	57	3	9	78	10.54
Florida	66,900	58	60	8	18	76	10.10
Georgia	38,738	63	56	6	8	64	8.00
Iowa	27,756	60	58	9	12	80	10.00
Idaho	13,463	61	57	9	12	0*	10.14
Illinois	105,593	62	60	5	9	73	10.55
Indiana	21,189	55	50	13	6	71	10.57
Kentucky	19,801	60	56	8	9	65	9.23
Louisiana	31,201	65	52	10	7	55	9.50
Massachusetts	45,122	61	60	4	11	74	9.76
Maryland	18,940	56	57	6	10	88	10.59
Michigan	51,553	66	61	3	9	92	10.06
Minnesota	40,927	52	45	13	2	63	10.06
Missouri	63,350	64	60	3	10	74	9.36
Mississippi	16,739	67	63	3	14	78	9.78
Montana	7,421	65	46	15	7	56	8.44
North Carolina	85,919	65	61	5	12	73	9.74
North Dakota	4,681	58	56	7	16	76	7.60
Nebraska	10,156	61	57	10	15	74	10.12
New Hampshire	7,637	57	52	13	9	72	10.27
New Jersey	44,741	66	69	2	19	90	9.98
New Mexico	2,092	43	43	7	0	91	11.66
Nevada	8,594	64	60	6	11	69	9.69
New York	162,775	59	60	7	14	78	10.57
Ohio	79,610	64	62	6	14	80	9.64
Oklahoma	29,524	65	60	4	9	76	9.93
Oregon	13,079	60	61	9	17	80	9.89
Pennsylvania	37,699	60	59	6	12	83	10.06
Rhode Island	5,823	64	61	2	12	78	9.89
South Carolina	22,340	58	57	6	11	74	10.41
South Dakota	4,718	56	53	12	11	76	10.43
Tennessee	234	38	20	96	0	12	8.86
Texas	111,879	62	62	6	12	79	10.04
Utah	4,432	54	50	16	12	63	9.74
Virginia	36,055	62	62	6	17	75	8.28
Vermont	6,491	60	57	11	14	72	10.11
Washington	58,650	62	60	7	12	73	10.13
Wisconsin	11,477	56	53	11	9	71	8.64
West Virginia	14,615	63	57	6	7	66	9.74
Wyoming	3,669	57	52	11	6	72	10.56

Source: Mathematica analysis of MAX 2010 PS and OT files, and MBSF.

Notes: *Analyses by Mathematica indicate that the lack of 2010 HCBS users in Idaho who are MME is due to the state's transition to a new Medicaid Management Information System in 2010, not a lack of MME HCBS users (Mathematica Policy Research, 2014).

Among the three types of comorbidities examined—chronic conditions, disabilities-related conditions, and mental health conditions—the frequency of chronic conditions was substantially higher than disabilities or mental health conditions. For example, all ten of the most common chronic conditions were more prevalent than the most frequently reported disability-related condition (intellectual disabilities, 8.1 percent) and most frequently reported mental health condition (depressive disorders, 12.3 percent) among 2010 HCBS users (Tables IV.2–IV.4). Tables IV.2–IV.4 list the mean, minimum, and maximum among states to provide a sense of the distribution of these conditions.

Table IV.2. Frequency of most common chronic comorbidities, 2010 HCBS users

Comorbidity	All states (%)	All MMEs (%)	All Medicaid-only (%)	State with highest percentage	Value of highest percentage	State with lowest percentage	Value of lowest percentage
Hypertension	37.8	40.5	30.4	Mississippi	63.7	Tennessee	7.3
Diabetes	27.7	29.5	22.9	Mississippi	40.5	Tennessee	6.0
Ischemic heart disease	20.4	23.5	11.6	Oklahoma	33.7	Tennessee	1.3
Rheumatoid arthritis/osteoarthritis	19.2	20.8	14.8	Oklahoma	40.7	Tennessee	2.6
Hyperlipidemia	15.5	14.6	17.8	Oklahoma	23.2	Utah	5.1
Anemia	14.6	14.9	13.9	North Carolina	22.7	New Mexico	5.4
Congestive heart failure	14.4	16.3	9.2	Mississippi	28.1	Tennessee	1.3
Depression	13.3	13.3	13.4	Minnesota	28.6	Tennessee	5.1
Chronic obstructive pulmonary disorder	13.0	13.6	11.3	Oklahoma	28.5	New Mexico	5.1
Chronic kidney disease	12.6	14.0	8.7	Virginia	18.8	Tennessee	3.4

Source: Mathematica analysis of MAX 2010 PS and OT Files, and MBSF.

Note: The conditions in this table were identified by applying the Chronic Conditions Warehouse (CCW) algorithms to Medicare and Medicaid claims.

Table IV.3. Frequency of most common disability-related conditions, 2010 HCBS Users

Comorbidity	All states (%)	All MMEs (%)	All Medicaid-only (%)	State with highest percentage	Value of highest percentage	State with lowest percentage	Value of lowest percentage
Intellectual disabilities	8.1	7.0	11.1	Tennessee	66.7	Washington	2.0
Epilepsy	6.4	5.2	9.9	Tennessee	21.8	North Dakota	2.8
Mobility impairments	5.6	5.7	5.6	Mississippi	12.2	New Mexico	2.7
Cerebral palsy	2.8	1.9	5.3	Tennessee	24.4	North Dakota	0.9
Sensory impairment: deafness	2.4	2.4	2.3	New York	7.3	Utah	0.7

Source: Mathematica analysis of MAX 2010 PS and OT Files, and MBSF.

Note: The conditions in this table were identified by applying the CCW algorithms to Medicare and Medicaid claims.

Chronic conditions varied markedly by state and MME status. For example, hypertension was the most common comorbidity in this population, observed in 37.8 percent of 2010 HCBS users. The prevalence of hypertension ranged from a high of 63.7 percent in Mississippi to a low of 7.3 percent in Tennessee (Table IV.2). Similarly, there was at least a 30 percentage point difference in the highest and lowest state percentages of diabetes, ischemic heart disease, and rheumatoid arthritis/osteoarthritis. We also observe that the same states tend to fall at the top or the bottom of the range for these comorbidities, with Mississippi and Oklahoma frequently having high prevalence of chronic conditions, while the HCBS users in Tennessee, New Mexico, and Utah have much lower prevalence. Chronic condition prevalence is also generally higher among HCBS users who are MME, compared with those eligible for only Medicaid. These results indicate that the MME population bears a larger burden of chronic disease than their younger, Medicaid-only counterparts.

Among HCBS users, disability-related conditions were much less prevalent than chronic conditions; nonetheless, some states do have high concentrations of HCBS users with disability-related conditions. For example, while 8.1 percent of HCBS users were observed to have intellectual disabilities overall, in Tennessee, two-thirds of HCBS users were observed to have this condition (Table IV.3). This likely is due to the fact that Tennessee transitioned most HCBS users other than persons with intellectual disabilities to managed care plans. Disability rates also differ notably between MME and Medicaid-only users, with the Medicaid-only HCBS users exhibiting a higher proportion of these disability conditions than their MME counterparts. States with specialized HCBS fee-for-service users like Tennessee merit separate consideration when assessing performance.

Although the burden of mental health conditions and substance use and abuse is also low relative to chronic conditions, state-level variation is again evident. For example, the most commonly reported mental health condition among all 2010 HCBS users was depression and related disorders (12.3 percent), with a high of 25.3 percent in Minnesota (Table IV.4). The

prevalence of mental health conditions is similar between MME and Medicaid-only HCBS populations. Although Minnesota's HCBS population is not as strikingly different as Tennessee's HCBS population, accounting for mental health and substance use conditions will still likely be important in our modeling approach.

Table IV.4. Frequency of most common mental health conditions and substance uses, 2010 HCBS users

Comorbidity	All states (%)	All MMEs (%)	All Medicaid-only (%)	State with highest percentage	Value of highest percentage	State with lowest percentage	Value of lowest percentage
Depressive disorders	12.3	13.3	11.9	Minnesota	25.3	Tennessee	5.6
Anxiety	7.5	7.1	8.8	Minnesota	16.5	California	4.2
Schizophrenia and related disorders	6.8	6.1	8.8	Minnesota	16.1	Vermont	2.5
Tobacco use	6.3	5.8	7.6	Oklahoma	14.8	New Mexico	2.0
Schizophrenia	5.0	4.3	6.9	Minnesota	12.9	Vermont	1.3

Source: Mathematica analysis of MAX 2010 PS and OT Files, and MBSF.

Note: The conditions in this table were identified by applying the CCW algorithms to Medicare and Medicaid claims.

C. Hospice enrollment

Excluding HCBS users enrolled in hospice reduced the denominator by less than 2 percent (data not shown). In Volume 1, we reported that removing pressure ulcers during hospice decreased pressure ulcer rates by 5 percent overall. More information on the hospice exclusion is available in Volume 1 (Wysocki et al. 2015).

D. Implications of demographics on modeling

The variation observed in the 2010 HCBS user population across all these characteristics—whether age, MME status, chronic conditions, disability-related condition, or mental health conditions—demonstrates the need to risk adjust quality measures for this population. However, not all of these differences can be addressed by risk adjustment, and they may require different strategies as follows:

Stratification by MME status. The differing case-mix profiles of the MME and Medicaid-only populations confirm the TEP's belief that these two groups are markedly different and supports the argument that they should be treated separately in the risk-adjustment process. Accordingly, we will build separate risk-adjustment models for the MME and Medicaid-only populations.

Treatment of unique states. These descriptive statistics suggest that certain states have very specialized HCBS populations. For example, more than 60 percent of Tennessee's HCBS users have intellectual disabilities, which is much higher than all other states. Although risk

adjustment can reconcile some of these differences, the uniqueness of such states may preclude them from comparisons to more "typical HCBS users" from other states.

V. OBSERVED (UNADJUSTED) HCBS PRESSURE ULCER RESULTS

A. Observed rates for 2010 and 2009 HCBS users

The rate of pressure ulcers is fairly stable over time at the national level (Table V.1). We used the 2010 HCBS population to develop our models, and 2009 to validate the models. Among the 2010 HCBS user population, 11,137 individuals experiencing at least one hospitalization for a severe pressure ulcer. Similar to the 2010 HCBS population, we observe 11,520 individuals experiencing at least one event, with MME HCBS users having higher rates than their Medicaid-only counterparts. The MME population experienced a higher rate of pressure ulcers than the Medicaid-only population (671 events per 100,000 person-years versus 430 events per 100,000 person years). MME rates varied 8-fold, with a low in New Mexico (211 events per 100,000 person-years) to a high of 1,681 per 100,000 person-years in South Carolina. There was large variation in Medicaid-only pressure ulcer rates as well. Five states had zero events in the Medicaid-only population, while Virginia has 1,500 pressure ulcer events per 100,000 person-years.

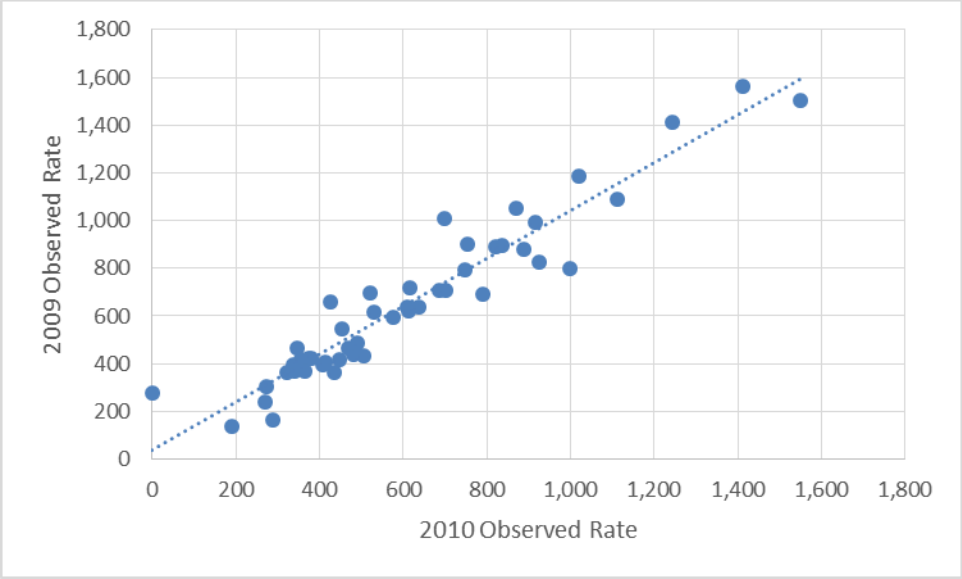
Table V.1. Pressure ulcer events and rates (per 100,000 person-years) for the 2010 HCBS user population, by state and Medicare enrollment

HCBS User Population	Number of HCBS users in numerator	Overall rate	MME rate	Medicaid-only rate
2010	11,137	609	671	430
2009	11,520	636	700	453

Source: Analytic file of 2010 Medicaid beneficiaries (MMEs and Medicaid only) who were enrolled in or used HCBS during the month of the pressure ulcer event, were at least 18 years of age, and were enrolled in fee-for-service Medicare and/or Medicaid. We also excluded HCBS use and pressure ulcer events were identified through MAX and MedPAR records.

At the state level, unadjusted pressure ulcer rates are highly correlated between 2009 and 2010 (Figure V.1). There are roughly 2.2 million unique HCBS users in 2009 and 2010, and 1.44 million (65 percent) are HCBS users in both 2009 and 2010. The spearman rank correlation between the 2009 and 2010 rates is 0.95. Considering that the HCBS user populations overlap by 65 percent in these years, the high correlation in state rates is expected.

Figure V.1. State pressure ulcer rates for 2009 and 2010 HCBS populations using Definition 2 (per 100,000 HCBS users)



Source: Analytic files of 2010 and 2009 Medicaid beneficiaries (MMEs and Medicaid only) who were enrolled in or used HCBS during the month of the pressure ulcer event, were at least 18 years of age, and were enrolled in fee-for-service Medicare and/or Medicaid. Pressure ulcer events were identified through MAX and MedPAR records.

VI. MODEL RESULTS

Model selection used a combination of 2009 and 2010 data, but the final coefficients and model are based on the 2010 HCBS population. Early in the process, we established the model structure. In this section we specify the risk-adjustment model, describe our process for model selection, report the final model (with coefficients), and report validation statistics.

Of note, we decided up front not to include state effects or account for HCBS directly in the risk-adjustment model. We do not include state effects in the risk-adjustment model because we intend to apply the models to subpopulations, and the state effect may vary by subpopulation; however, we do not that models fit with state fixed effects on the overall 2010 population had a better fit compared to the model without. As we explain in Section III.B, the duration of HCBS use cannot be included in the model because of endogeneity. Over 93 percent of our sample continuously used HCBS. We include those who are continuous users as well as those with breaks in HCBS enrollment because both groups are of interest to policy makers.

A. Analytic sample and model specification

We modeled the probability of having at least one pressure ulcer using logistic regression model. The unit of analysis is the HCBS user, and the outcome is whether this user had at least one pressure ulcer hospitalization in 2010. We fit the model using the entire 2010 population from all states. State fixed or random effects were not included in the model.

Logistic regression models the logit of having at least one pressure ulcer as a function of risk factors. Let Y be an indicator as to whether an HCBS user had at least one pressure ulcer event and assume the probability of being 1, that is, at least one pressure ulcer event follows the equation below.

$$\text{Logit}(P(Y=1 \mid X,Z))=\alpha_0+\sum_{i=1}^{n}\beta_i X_i+\sum_{j=1}^{m}\gamma_j Z_j$$

Here X_i, i=1,…,n, are health status covariates such as chronic conditions, physical disabilities, mental health conditions, and substance use disorders and Z_j, j=1,…,m, are demographic covariates such as age and gender.

B. Selecting risk factors

We select covariates in the risk-adjustment model using a backwards selection process. We began with all risk factors available in the Chronic Conditions Warehouse or clinically important for pressure ulcers. Clinically important risk factors were defined as those conditions cited by the TEP as being associated with the development of pressure ulcers. After starting with a broad set of candidate risk factors, we refit models several times, removing insignificant risk factors that were not clinically relevant to pressure ulcers. The threshold for statistical significance was a p-value less than 0.3. Once a risk factor was removed, it was never again considered in the model. Clinically important risk factors regardless of their statistical significance.

Based on the TEP's recommendation, we fit separate models based on MME status. This decision was further supported by a likelihood ratio test, showing that a model with interactions between MME and all covariates was significantly different from a model with covariates and MME status (chi-square statistic = 282, degrees of freedom = 34). In addition, the models also incorporated age and gender flags regardless of statistical significance. Age and gender are used by AHRQ to risk adjust the original PQI measures. We used wide age groups (18–24, 25–44, 45–64,75–84, and 85+, with 65–74 as the referent), because more narrow definitions did not significantly improve model fit.

C. Final risk factors

The final set of risk factors with coefficients and p-values are found in Appendix A. The final model for MME included more risk factors (42) than the Medicaid-only model (39). In the MME model, higher age is associated with greater pressure ulcer risk, but age above 65 was associated with lower risk in the Medicaid-only model. This discrepancy is most likely due to the fact that there are few Medicaid-only HCBS users over the age of 65, making them a select group.

The risk factors with the largest effect on pressure ulcer risk are the same in the Medicaid-only and MME models (Table VI.1). Spinal cord injury, Spina Bifida, multiple sclerosis, mobility impairments, and chronic kidney disease have the largest odds ratios for the Medicaid-only and MME models; all of these risk factors have a p-value less than 0.0001. The similar list of important risk factors gives face validity to these models; in addition, the different odds ratios for the same risk factor further motivate the stratification of models by MME status.

Table VI.1. Five strongest predictors of a pressure ulcer event

Medicaid-Only		MME	
Risk Factor	**Odds Ratio**	**Risk Factor**	**Odds Ratio**
Mobility impairments	10.78	Spinal cord injury	8.51
Spinal cord injury	6.10	Spina bifida and other congenital abnormalities of the nervous system	5.40
Spina bifida and other congenital abnormalities of the nervous system	3.96	Mobility impairments	5.35
Multiple sclerosis and transverse myelitis	3.36	Multiple sclerosis and transverse myelitis	4.79
Chronic Kidney Disease	2.43	Chronic Kidney Disease	1.97

Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

In general, we found that physical disabilities and chronic conditions are associated with greater pressure ulcer risk, but mental health conditions are associated with lower risk. In both the MME and Medicaid-only models, autism and other developmental delays were associated with lower pressure ulcer risk. We hypothesize that mental health conditions are associated with lower risk because HCBS users with these conditions are typically younger and are not as physically limited as other HCBS users with physical impairments.

D. Model validation and sensitivity

When developing our model, we selected risk factors based on significance and performance on the full 2010 HCBS user population. To ensure the final set of risk factors performs well on other HCBS populations, we validated our model using multiple approaches.

1. Assessing overall model fit

The overall fit of the pressure ulcer risk-adjustment model was strong for the Medicaid-only and MME models (Table VI.2). The C-statistic indicated strong predictive ability of the models, with the Medicaid-only model having slightly better performance. Compared to the initial model that considered all possible risk factors, the final model had slightly better performance, with lower AIC and scaled deviance and similar C-statistic. Given that a small subset of insignificant risk factors were removed to form the final model, we expect that the fit would be similar between the initial and final models.

Table VI.2. Model fit for initial and final pressure ulcer model

.	Medicaid-only		MME	
Statistic	Initial	Final	Initial	Final
C-statistic	0.86	0.86	0.79	0.79
AIC (smaller is better)	20,528	20,518	94,817	94,811
Scaled Deviance	21,027	20,950	95,362	95,320

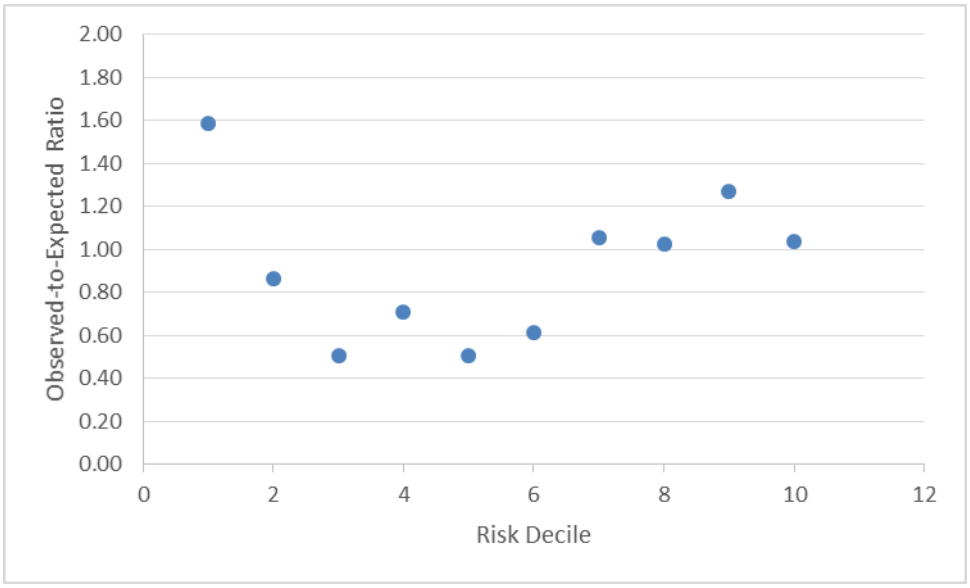
Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

Note: All results from logistic models. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; MME = Medicare–Medicaid eligible; Sample 1 and 2 = random split samples of the 2010 HCBS user population.

Although the overall fit statistics are promising, the Hosmer-Lemeshow plots show that fit is less than optimal for certain HCBS users (Figures VI.1 and VI.2). Hosmer-Lemeshow plots compare the observed-to-expected ratios for deciles of risk. In these plots, risk (number of predicted events) increases as the axis moves to the right, and a point above one indicates that, for this decile, the observed number of events is greater than the expected number of events. Ideally, all points would be at 1.0.

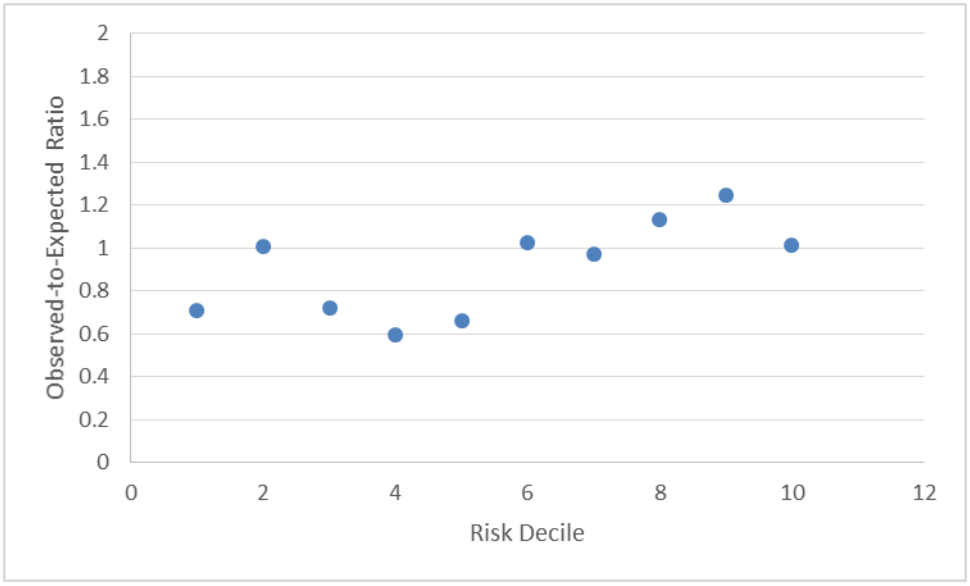
The plots show that the risk-adjustment models under-predicts for Medicaid-only HCBS users with lowest pressure ulcer risk, but over-predicts for most (Figure VI.1). The model also under-predicts for low-risk MME HCBS users (Figure VI.2). This is a common problem with risk-adjustment models, especially for relatively infrequent events like severe pressure ulcers. One factor driving the under-prediction of risk is the distribution of patient risk factors: a few HCBS users have many high-risk conditions, creating a highly-skewed distribution of predicted risk. Future work improve the model fit may include interaction terms, further stratifying HCBS users into subgroups with similar risk, or excluding the highest-risk HCBS users from the pressure ulcer denominator altogether.

Figure VI.1. Hosmer-Lemeshow plot for final pressure ulcer model fit on the 2010 Medicaid-only HCBS population



Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

Figure VI.2. Hosmer-Lemeshow plot for final pressure ulcer model fit on the 2010 MME HCBS population



Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

2. Split-sample validation

We split the 2010 sample evenly and refit the logistic model using the same risk factors to assess fit (Table VI.3). When fit on these independent samples, the C-statistic and likelihood-based indicators of fit showed similar performance for nearly all models. For Medicaid-only HCBS users, the five risk factors with the largest coefficients were the same in each sample (not shown); in addition, they were the same five risk factors with the largest coefficients in the 2010 model. For MME HCBS users, the same five risk factors had the largest coefficients (not shown). Compared to the model fit on the 2010 overall model, Alzheimer's and senile dementia replaced chronic kidney disease in the top five (Alzheimer's and dementia had the sixth largest coefficient in the 2010 overall model). The stability of the coefficients suggests that the model can predict out of sample well and is not strongly affected by overfitting.

Table VI.3. Split-sample validation fit statistics

	Medicaid-only		MME	
Statistic	Sample 1	Sample 2	Sample 1	Sample 2
C-Statistic	0.85	0.86	0.79	0.79
AIC (smaller is better)	10,737	10,391	48,768	49,983
Scaled deviance	11,141	10,795	49,248	50,462

Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

Note: All results from logistic models. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; MME = Medicare–Medicaid eligible; Sample 1 and 2 = random split samples of the 2010 HCBS user population.

3. Cross-year validation

We also refit the logistic models using the same risk factors on the 2009 HCBS user population. Although nearly two-thirds of HCBS users are in the 2009 and 2010 populations, this test gives us a chance to validate the stability of the risk factors and model performance. As previously shown in Table V.1 and Figure V.1, the national and state-level observed rates of pressure ulcer events are strongly correlated between 2009 and 2010.

Whether fitting the model on the 2009 or 2010 HCBS user population, the model fit is similar (Table VI.4). The similarity in model fit between 2009 and 2010 is intuitive: the HCBS user population and state-level observed rates are correlated between 2009 and 2010; therefore, it is likely that the relationship between risk factors and pressure ulcer risk is stable over time.

The 2009 model fit is slightly worse than the 2010 model, but this is also expected. The set of risk factors included in the model are based on the 2010 population, and therefore, we expect that the model is "over fit" to capture the relationship between the risk factors and outcome in the 2010 population. Had we selected coefficients based on the 2009 data, the model fit of the model on 2009 data would improve. Some of the risk factors that are included in the 2010 model would have been excluded had the model been fit on the 2009 data (not shown). These risk factors, however, have coefficients close to null in the 2009 and 2010 models. The risk factors with the largest coefficients are the same in the 2009 and 2010 models.

Table VI.4. Fit statistics for model fit on 2009 vs. 2010 HCBS user population

	Medicaid-only		MME	
Statistic	2009	2010	2009	2010
C-statistic	0.85	0.86	0.79	0.79
AIC (smaller is better)	21,085	20,518	98,717	94,811
Scaled Deviance	21,516	20,950	99,225	95,320

Source: Mathematica analysis of 2009 and 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

Note: All results from logistic models. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; MME = Medicare–Medicaid eligible; Sample 1 and 2 = random split samples of the 2010 HCBS user population.

VII. STATE-LEVEL RESULTS

Using the finalized risk-adjustment models, we produced risk-adjusted HCBS pressure ulcer rates for each state. The final risk-adjusted rates are indirectly standardized by dividing the observed number of pressure ulcer events divided by the model-predicted number of events, creating an observed-to-expected rate (O/E) ratio. The process for this calculation was:

1. For each state, sum the observed number of pressure ulcers across MME or Medicaid-only HCBS users.
2. For each state, sum the predicted number of pressure ulcer events across MME or Medicaid-only HCBS users. Predicted events are estimated from the risk-adjustment model.
3. For each state, divide the total number of observed and expected events calculated in steps 1 and 2 above.

Instead of transforming the O/E ratio into an indirectly-standardized rate, we can use the O/E ratio directly to assess state performance. An O/E ratio below 1.0 indicates that a state is performing better than average, and a ratio above 1.0 indicates worse-than-average performance.

A. 2010 HCBS user population

Risk adjustment subtly shifts the ranking of state pressure ulcer performance for the 2010 HCBS user population (Table VII.1). When calculating rates for all HCBS users in a state, we observe substantial variation across states, but some of this variation appears to be due to differing HCBS populations by state. For example, New Mexico's overall observed rate is one-third lower than the rate in Utah, but Utah's ratio of observed-to-expected pressure ulcers is lower. Thus, ranking on observed rates alone may lead to inaccurate conclusions about the quality of care within the HCBS population.

Risk-adjusted HCBS pressure ulcer rates (as depicted by O/E ratios) are highly correlated with observed rates, and few states move ranking after risk-adjustment (Table VII.1). For example, South Carolina has the highest observed rate among states and the highest observed-to-expected ratio (1.85). Across states, observed and expected rates were highly correlated (rho = 0.96). Despite the strong correlation of observed and expected rates, performance did vary across states, with O/E ratios ranging from 0.45 to 1.85.

Although the majority of HCBS users are MME, state-level overall and MME ratios are only moderately correlated (Table VII.1). In general, states with O/E ratios above 1.0 for the overall HCBS user population also have O/E ratios above 1.0 for the MME population. However, the ranking of states changes depending on what population is used. Ranking is not the purpose of these measures, but comparing the ranking for different populations is useful when validating the risk-adjustment models.

Table VII.1. 2010 Observed and risk-adjusted pressure ulcer rates, by state

	Overall		MME	
State	Observed rate[a]	O/E ratio	Observed rate	O/E ratio
National	609	1.00	672	1.00
Alaska	365	0.63	437	0.65
Alabama	615	0.94	864	1.19
Arkansas	754	1.06	854	1.08
California	407	0.89	481	0.95
Colorado	414	0.60	426	0.55
Connecticut	491	0.88	537	0.89
District of Columbia	871	1.14	803	0.98
Delaware	1,000	1.25	1,152	1.27
Florida	687	1.17	892	1.34
Georgia	700	1.04	803	1.10
Iowa	272	0.48	246	0.40
Idaho	0	0.00	0	0.00
Illinois	820	1.15	776	1.01
Indiana	925	1.27	1,022	1.30
Kentucky	531	0.78	711	0.93
Louisiana	1,021	1.40	1,244	1.34
Massachusetts	382	0.74	411	0.71
Maryland	338	0.59	281	0.51
Michigan	887	1.30	888	1.27
Minnesota	323	0.54	338	0.49
Missouri	453	0.71	458	0.65
Mississippi	1,244	1.20	1,237	1.19
Montana	346	0.59	382	0.54
North Carolina	614	0.93	586	0.83
North Dakota	289	0.61	253	0.49
Nebraska	375	0.65	423	0.63
New Hampshire	637	1.10	640	0.95
New Jersey	791	1.25	778	1.20
New Mexico	191	0.54	211	0.58
Nevada	838	1.18	897	1.16
New York	703	1.25	787	1.25
Ohio	522	0.66	655	0.77
Oklahoma	749	1.01	767	0.94
Oregon	482	0.76	522	0.77
Pennsylvania	1,112	1.63	1,288	1.77
Rhode Island	447	0.85	572	0.98
South Carolina	1,550	1.85	1,681	1.87
South Dakota	340	0.77	307	0.67
Tennessee	427	2.45	NR	NR
Texas	575	0.90	621	0.89
Utah	271	0.47	287	0.40
Virginia	1,412	1.50	1,379	1.30
Vermont	469	0.78	533	0.79
Washington	355	0.64	339	0.58
Wisconsin	506	0.82	553	0.79
West Virginia	917	1.54	970	1.47
Wyoming	436	0.75	453	0.68

Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

Notes: Observed rate is presented as number of HCBS users with pressure ulcer events per 100,000 HCBS users. MME and Medicaid-only beneficiaries are combined for each state. Idaho and Tennessee rates are withheld due to small and unique samples.

[a] This reporting of observed rates uses the number of HCBS users in the denominator, which is different from early tables. We report observed rates with this denominator because the O/E ratio does not account for months of HCBS use.

O/E ratio = observed-to-expected ratio. NR = Not reported, denominator did not meet minimum case size of 1,200.

These results also show the relationship between outlier performance and the size of the state's HCBS population. Idaho, for example, has a small HCBS fee-for-service user population, and its results are substantially lower than the national average. We withheld its rate because of this small sample size. Many states with smaller HCBS populations have noticeably different performance than average, which points to the potential importance of reliability adjustment to facilitate fair comparisons of the HCBS composites.

B. 2009 HCBS user population

We then applied the 2010 model coefficients to the 2009 HCBS user population, which allows us to compare performance over time. Because most HCBS users are found in both the 2009 and 2010 populations, O/E ratios for each state are strongly correlated (overall rho = 0.86, MME rho = 0.94). In addition, because disability and health status generally worsen over time, we found that expected rates are slightly lower in 2009 compared with 2010—in other words, risk is increasing over time. Entry and exit of HCBS users may also impact results—presumably, those who exit have the greatest risk, while those who enter have lower risk.

Applying these models to the 2009 data yielded similar ranking of state performance in 2009 and 2010 (Table VII.2). As hypothesized, the national O/E ratio in 2009 is greater than 1.0, and because the observed rate is similar between years, the 2009 population has a lower expected rate compared with 2010. We hypothesize that this is due to a combination of factors: improvements in care over time, poorer model fit in 2009, and select states moving certain HCBS population to managed care. States that make large changes over time are often smaller (for example, the Delaware) or have implemented large changes to their Medicaid programs between 2009 and 2010 (for example, Georgia and Tennessee). The jump in rates between states further motivates reliability adjustment.

Table VII.2. O/E ratios for 2009 and 2010 populations

	Overall		MME	
State	2009	2010	2009	2010
National	1.08	1.00	1.08	1.00
Alaska	0.65	0.63	0.73	0.65
Alabama	1.08	0.94	1.34	1.19
Arkansas	1.28	1.06	1.37	1.08
California	0.90	0.89	0.95	0.95
Colorado	0.61	0.60	0.56	0.55
Connecticut	0.90	0.88	0.86	0.89
District of Columbia	1.35	1.14	1.32	0.98
Delaware	1.01	1.25	1.03	1.27
Florida	1.32	1.17	1.53	1.34
Georgia	1.40	1.04	1.20	1.10
Iowa	0.55	0.48	0.50	0.40
Idaho	0.52	Withheld	0.58	Withheld
Illinois	1.32	1.15	1.17	1.01
Indiana	1.11	1.27	1.19	1.30
Kansas	1.10	Not available	1.16	Not available
Kentucky	0.88	0.78	1.07	0.93
Louisiana	1.60	1.40	1.61	1.34
Massachusetts	0.80	0.74	0.78	0.71
Maryland	0.72	0.59	0.59	0.51
Michigan	1.34	1.30	1.31	1.27
Minnesota	0.62	0.54	0.50	0.49
Missouri	0.89	0.71	0.80	0.65
Mississippi	1.43	1.20	1.37	1.19
Montana	0.77	0.59	0.71	0.54
North Carolina	0.97	0.93	0.95	0.83
North Dakota	0.34	0.61	0.29	0.49
Nebraska	0.72	0.65	0.67	0.63
New Hampshire	1.11	1.10	1.00	0.95
New Jersey	1.16	1.25	1.15	1.20
New Mexico	0.39	0.54	0.42	0.58
Nevada	1.33	1.18	1.29	1.16
New York	1.31	1.25	1.34	1.25
Ohio	0.90	0.66	1.04	0.77
Oklahoma	1.10	1.01	0.97	0.94
Oregon	0.73	0.76	0.73	0.77
Pennsylvania	1.62	1.63	1.78	1.77
Rhode Island	0.84	0.85	1.03	0.98
South Carolina	1.83	1.85	1.78	1.87
South Dakota	0.83	0.77	0.63	0.67
Tennessee	1.44	2.45	1.59	Withheld
Texas	1.00	0.90	0.97	0.89
Utah	0.45	0.47	0.52	0.40
Virginia	1.70	1.50	1.56	1.30
Vermont	0.84	0.78	0.75	0.79
Washington	0.79	0.64	0.80	0.58
Wisconsin	0.73	0.82	0.61	0.79
West Virginia	1.70	1.54	1.61	1.47
Wyoming	0.62	0.75	0.57	0.68

Source: Mathematica analysis of 2009 and 2010 HCBS users. Data sources included the 2009 and 2010 MAX PS, OT, and IP files, MedPAR file, and MBSF.

Notes: Data are unavailable for Kansas in 2010. Rates are withheld from Idaho and Tennessee due to small and unique sample sizes.

O/E ratio = observed-to-expected rate ratio.

C. MFP and non-MFP populations

Two primary subgroups of interest in this analysis are the HCBS transitioner populations: individuals leaving institutional care with the assistance of the Money Follows the Person (MFP) demonstration, and a comparison group of those who transitioned from institutional care without MFP (non-MFP). These subpopulations are generally small, making their state-level and MME-subgroup risk-adjusted rates unstable.

Across all transitioners with matched risk factors, the MFP O/E ratio is 1.7, and the non-MFP O/E ratio is 1.4. These ratios indicate that pressure ulcer rates are higher than expected compared to the average risk in the 2010 population. We propose two possible explanations as to why transitioners have higher-than-expected pressure ulcer rates. First, pressure ulcer rates high because those leaving institutional LTSS settings are undergoing a vulnerable transition and may have gaps in care coordination. Second, the expected rates are based on the 2010 population, the pre-2010 transitioners have higher-than-expected rates similar to what was found for the 2009 HCBS user population as a whole.

In addition, we note that the MFP transitioners have higher pressure ulcer rates compared with non-MFP transitioners, but it's not clear if this is statistically significant. For those transitioners with matched risk factors, the MFP participants' observed pressure ulcer rate was 44 percent higher than for non-MFP transitioners (2,017 and 1,401 per 100,000 person-years, respectively). Risk adjustment closed the relative difference in pressure ulcer rates for MFP and non-MFP participants (21 percent difference). We expected that risk adjustment would change the relative difference between the pressure ulcer rates for the MFP and non-MFP populations, because, on average, MFP participants typically having lower care needs than those who transition outside of MFP (Ross and Simon 2012). These results, however, cannot be used to determine the effect of the MFP program on pressure ulcers—a more controlled analysis is needed to account for additional factors and statistical uncertainty.

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VIII. CONCLUSION AND TECHNICAL RESOURCES

We fit risk-adjustment models for the HCBS pressure ulcer measure, using the 2010 HCBS user population as our development sample. The final logistic regression models were fit separately for MME and Medicaid-only beneficiaries, accounting for chronic health conditions, mental health conditions, mobility limitations, substance use disorders, and demographics. In general, we find that chronic conditions and physical disabilities are associated with higher risk for pressure ulcers, and mental health conditions were associated with lower risk. Overall, the risk-adjustment models had good overall fit on the 2010 data (C-statistics of 0.79 and 0.86 for MME and Medicaid-only, respectively), but the Hosmer-Lemeshow plots showed that the models under-predicted for HCBS users with lower pressure ulcer risk. The C-statistics, AIC, and scaled deviance were very similar when fit on split-sample, external-sample, and subsamples, but because it was used to select the set of risk factors included in the model, the final model based on the entire 2010 HCBS user population had the best fit. The next step is to improve prediction for low- and high-risk HCBS users, possibly by using interaction terms.

Observed and risk-adjusted pressure ulcer rates were highly correlated. In general, each state's risk-adjusted HCBS pressure ulcer rate was similar in 2009 and 2010, with the largest differences occurring in smaller states where rates may be unreliable. Risk-adjusted rates for the MFP and non-MFP populations were challenged by matching risk factors and the small samples of these populations.

These models can be used to help answer policy-specific research questions and inform quality improvement efforts. Specifically, research is needed to explain the variation in state-level pressure ulcer rates; risk adjustment had a relatively small impact on this variation, and it's unclear whether this variation is due to policy, quality of care, the omission or misspecification of important risk factors, or the reliability of the risk-adjustment models. In addition, these models may be used to compare state-level performance over time, or get estimates for policy-relevant subgroups such as those transitioning through the MFP program.

This report shows that risk adjustment has an impact on state HCBS pressure ulcer rates, but more work is needed if these methods are to be used by states and stakeholders, namely:

Strategies to improve reliability of estimates. Although state rates represent information on all HCBS users enrolled in fee-for-service Medicaid and Medicare, some states have variable estimates because of their small populations. One approach for addressing this issue is reliability adjustment, which can reduce this variation by shrinking state rates toward the national rate. Reliability-adjusted rates are ideal for comparisons to a benchmark, but some states may not be comparable to others (discussed in detail under peer grouping below). Moreover, some uses of these models in comparisons may require state fixed or random effects, which will provide a more stable estimate of state-level variation after accounting for case mix. A second option is the employment of minimum case sizes. Under this approach, results are not reported for states that do not have sufficient numbers of HCBS users to generate reliable estimates. For example, a power calculation can be used to determine the sample size needed to detect a 10 percent difference with 95 percent confidence. While these topics were not explored in depth for the HCBS pressure ulcer measure, use of minimum case sizes is the recommended approach for the HCBS composite measures (Ross et al. 2015).

Setting the benchmark. The goal of the HCBS pressure ulcer rate is to allow states to compare their rates with a meaningful benchmark. Such benchmarks may include national rates, peer group rates, or an achievement-oriented benchmark such as the mean among the top five states. The stability of the pressure ulcer rates suggest that historical benchmarks might be appropriate to track improvement. Tracking progress can be achieved by setting an absolute benchmark based on the historical distribution of rates, or a relative benchmark, to assess change in performance over time. By making this comparison, states can assess their performance and determine whether intervention is needed. Our analyses revealed that some states have unique HCBS populations and therefore may not be comparable to others. In such cases, it may be necessary to establish benchmarks that are relevant to the state based on their HCBS population's characteristics. Feedback from the HCBS Composite Measures TEP suggests that states prefer to identify their own peers due to the large variation in state characteristics and policies.

Peer grouping. Descriptive statistics on HCBS population demographics and comorbidities identified a handful of unique states that may not be comparable to all other states. Tennessee, for example, emerged as a state where most HCBS users had intellectual disabilities, an uncommon prevalence compared with all other states. When developing reliability-adjustment models, the comparison framework, or benchmarks, it may be necessary to create peer groups based on HCBS populations as opposed to comparing all states to a single national benchmark. More research is needed to understand whether certain states are not comparable to others because of their unique HCBS populations.

Comparison framework. HCBS pressure ulcer rates are estimates subject to statistical uncertainty. Thus, when comparing rates against a benchmark, it is important to incorporate uncertainty to determine whether differences are statistically meaningful. For example, Delaware's risk-adjusted MME pressure ulcer rate is almost 2-times the national MME pressure ulcer rate, but given that that Delaware is a relatively small state, it's unclear whether this difference is statistically significant. Going beyond simple ranking, frequentist or Bayesian methods are available for comparisons. The use of 95 percent confidence intervals around risk-adjusted rates provide a familiar, flexible approach for identifying when significant differences are likely to exist.

Display and use. Quality measures are intended to assist stakeholders in making decisions on how to improve quality. The HCBS composites are useful for assessing the quality of care experienced by the HCBS population, but these tools must be carefully used to improve quality.

Additional refinement. To keep pace with changing data, policies, statistical practices, and epidemiological and clinical knowledge, quality measure specifications need maintenance and refinement over time. The greatest need for the HCBS pressure ulcer, in the short-term, is to incorporate information on Medicaid managed care recipients, who represent a large and growing proportion of the HCBS population. In addition to the areas described above, other ideas for future work include stratifying the denominator further by subpopulation or pressure ulcer risk, adapting measure specifications to ICD-10 standards, or incorporating information from patient assessments.

State and national-level HCBS pressure ulcer observed and risk-adjusted results are included in Appendix C for the following populations:

- 2010 Medicaid-only HCBS users
- 2010 MME HCBS users
- 2009 Medicaid-only HCBS users
- 2009 MME HCBS users

Risk-adjusted rates are accompanied by 95 percent confidence intervals and contextual information on expected rates, proportion of Medicaid MCO enrollees, and per person spending on HCBS services. In alignment with the recommendations for the HCBS composite measures, results are not reported when the denominator is less than 1,200.

For those interested in replicating our results or calculating the risk-adjusted HCBS pressure ulcer measure, we have created a measure calculation package. This package includes information on how we identified our 2010 HCBS user population, and SAS programs that calculate pressure ulcer denominator, numerator, observed rate, and risk-adjusted rates according to the measure specifications. The measure calculation package for the HCBS pressure ulcer measure and acute and chronic composites (Bohl et al. 2015b) is available at http://www.medicaid.gov/medicaid-chip-program-information/by-topics/long-term-services-and-supports/balancing/money-follows-the-person.html.

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APPENDIX A

MODEL COEFFICIENTS AND P-VALUES

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Table A.1. Pressure ulcer Medicaid-Only model coefficients and p-values

Risk Factor	Coefficient	P-Value	Odds Ratio
Female	-0.44	<.0001	0.65
Ages 18 to 24	0.20	0.26	1.23
Ages 25 to 44	0.52	0.00	1.69
Ages 45 to 64	0.47	0.01	1.60
Ages 75 to 84	-0.65	0.04	0.52
Age 85 and older	-0.10	0.76	0.91
Conduct disorders and hyperkinetic syndrome	-0.36	0.09	0.70
Alcohol use	-0.24	0.02	0.78
Alzheimer's Disease and Related Disorders or Senile Dementia	0.18	0.10	1.19
Anxiety disorders	-0.24	0.00	0.78
Autism spectrum disorders	-0.69	0.04	0.50
Bipolar disorder	-0.24	0.05	0.78
Sensory: blindness and visual impairment	0.24	0.28	1.28
Cystic fibrosis and other metabolic developmental disorders	-0.44	0.26	0.64
Heart Failure	0.43	<.0001	1.53
Chronic Kidney Disease	0.89	<.0001	2.43
Chronic Obstructive Pulmonary Disease and Bronchiectasis	0.07	0.30	1.07
Colorectal Cancer	0.47	0.06	1.59
Sensory: deafness and hearing impairment	-0.70	0.00	0.49
Depressive disorders	0.11	0.08	1.12
Diabetes	0.26	<.0001	1.30
Endometrial Cancer	-1.16	0.25	0.31
Epilepsy	-0.12	0.12	0.89
Hip/Pelvis Fracture	0.44	0.08	1.55
Benign Prostatic Hyperplasia	-0.56	0.02	0.57
Hypertension	0.00	0.95	1.00
Intellectual disabilities and related conditions	-0.65	<.0001	0.52
Mobility impairments	2.38	<.0001	10.78
Multiple sclerosis and transverse myelitis	1.21	<.0001	3.36
Other developmental delays	-0.28	0.30	0.76
Personality disorders	-0.45	0.09	0.64
Schizophrenia and other psychotic disorders	-0.40	0.00	0.67
Spinal cord injury	1.81	<.0001	6.10
Spina bifida and other congenital abnormalities of the nervous system	1.38	<.0001	3.96
Stroke/Transient Ischemic Attack	-0.79	<.0001	0.45
Substance abuse	0.34	<.0001	1.41
Traumatic brain injury and nonpsychotic mental disorders due to brain damage	-0.57	0.00	0.56
Tobacco use disorders	0.33	<.0001	1.39
Intercept	-6.59	<.0001	0.00

Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, MBSF, and CCW flags.

Note: Odds ratios are the exponentiated coefficient. Numbers above 1.0 indicate greater risk associated with a risk factor.

Table A.2. Pressure ulcer MME model coefficients and p-values

Risk Factor	Coefficient	P-Value	Odds Ratio
Female	-0.13	<.0001	0.88
Ages 18 to 24	-0.02	0.86	0.98
Ages 25 to 44	0.31	<.0001	1.36
Ages 45 to 64	0.23	<.0001	1.26
Ages 75 to 84	0.21	<.0001	1.23
Age 85 and older	0.52	<.0001	1.69
Conduct disorders and hyperkinetic syndrome	-0.50	0.00	0.60
Alcohol use	-0.23	0.00	0.80
Alzheimer's Disease and Related Disorders or Senile Dementia	0.63	<.0001	1.88
Anxiety disorders	-0.13	0.00	0.88
Asthma	-0.05	0.26	0.95
Autism spectrum disorders	-0.65	0.03	0.52
Bipolar disorder	-0.35	<.0001	0.70
Sensory: blindness and visual impairment	0.07	0.22	1.07
Cystic fibrosis and other metabolic developmental disorders	0.05	0.79	1.05
Heart Failure	0.28	<.0001	1.33
Chronic Kidney Disease	0.68	<.0001	1.97
Chronic Obstructive Pulmonary Disease and Bronchiectasis	0.09	0.00	1.09
Cerebral palsy	0.38	<.0001	1.47
Sensory: deafness and hearing impairment	-0.45	<.0001	0.63
Depressive disorders	0.05	0.07	1.06
Diabetes	0.31	<.0001	1.37
Endometrial Cancer	0.45	0.04	1.58
Epilepsy	-0.09	0.06	0.92
Hip/Pelvis Fracture	0.36	<.0001	1.43
Benign Prostatic Hyperplasia	-0.13	0.05	0.88
Hypertension	0.08	0.00	1.08
Intellectual disabilities and related conditions	-0.44	<.0001	0.64
Learning disabilities	-0.50	0.14	0.61
Mobility impairments	1.68	<.0001	5.35
Multiple sclerosis and transverse myelitis	1.57	<.0001	4.79
Other developmental delays	-1.07	<.0001	0.34
Personality disorders	-0.24	0.10	0.79
Post-traumatic stress disorders	-0.32	0.10	0.73
Schizophrenia and other psychotic disorders	-0.35	<.0001	0.70
Spinal cord injury	2.14	<.0001	8.51
Spina bifida and other congenital abnormalities of the nervous system	1.69	<.0001	5.40
Stroke/Transient Ischemic Attack	-0.08	0.03	0.92
Substance abuse	0.25	<.0001	1.28
Traumatic brain injury and nonpsychotic mental disorders due to brain damage	-0.41	0.00	0.66
Tobacco use disorders	0.17	<.0001	1.19
Intercept	-6.04	<.0001	0.00

Source: Mathematica analysis of 2010 HCBS users. Data sources included the 2010 MAX PS, OT, and IP files, MedPAR file, MBSF, and CCW flags.

Note: Odds ratios are the exponentiated coefficient. Numbers above 1.0 indicate greater risk associated with a risk factor.

APPENDIX B

CHRONIC CONDITIONS WAREHOUSE INDICATORS

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We applied the Chronic Conditions Warehouse (CCW) algorithms for chronic conditions, disability-related conditions, mental health conditions, and substance use disorders in Tables B.1 through B.3 below. With the exception of the substance use disorders, these CCW algorithms were taken from the CCW website (https://www.ccwdata.org) on September 2014. The substance use algorithms were provided by CMS, and reflect public comments on the proposed definitions for these conditions published in April 2014. The CCW algorithms were developed for use with Medicare and Medicaid administrative data using International Classification of Disease, 9th revision, Clinical Modification (ICD-9) codes. Each CCW indicator has a look-back period and rules specifying the number and types of claims and ICD-9 codes that indicate a condition. Future analysis using ICD-10 data will need to apply a revised set of definitions. In our work, we identify HCBS users who met each CCW indicator definition at any point before the beginning of the calendar year, or for the transitioner populations, before the date of transition.

The original CCW algorithm was expanded to consider diagnostic information contained in Medicaid claims for the following types of services: transportation services, personal care services, targeted case management, rehabilitation services, PT, OT, speech, hearing services, hospice benefits, nurse midwife services, nurse practitioner services, private duty nursing, non-waiver personal care, non-waiver private duty nursing, non-waiver adult day, non-waiver home health, non-waiver residential care, non-waiver rehab for aged/disabled, non-waiver targeted case management, non-waiver transportation, non-waiver hospice, non-waiver DME, waiver any other service, waiver personal care, waiver private duty nursing, waiver adult day, waiver home health, waiver residential care, waiver rehab, waiver targeted case management, waiver transportation, waiver hospice, or waiver DME. Inclusion of these claim types was judged to be particularly important for the HCBS population, increasing the prevalence of conditions by up to 10 percent. For persons with Medicare and Medicaid eligibility, we used the Medicare claims sources listed in Tables C1 to C.3. The indicators did not use information on Medicare assessments.

All CCW algorithms use mutually exclusive sets of ICD-9 codes to identify conditions or disorders, with the exception of two sets of indicators with overlapping definitions: Alzheimer's and depression. In our models, we used the more inclusive definitions that consider a broader set of ICD-9 codes, meaning that we used the Alzheimer's disease and related disorders or senile dementia and depression indicators listed under Chronic Conditions (Table B.1).

Table B.1. Chronic Condition Algorithms

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify[b]	Exclusions
Acquired Hypothyroidism	1 year	DX 244.0, 244.1, 244.2, 244.3, 244.8, 244.9, (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	.
Acute Myocardial Infarction	1 year	DX 410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, 410.91 (ONLY first or second DX on the claim)	At least 1 inpatient claim with DX codes during the 1-yr period	.
Alzheimer's Disease	3 years	DX 331.0 (any DX on the claim)	At least 1 inpatient, SNF, HHA, HOP or Carrier claim with DX codes during the 3-yr period	.
Alzheimer's Disease and Related Disorders or Senile Dementia	3 years	DX 331.0, 331.11, 331.19, 331.2, 331.7, 290.0, 290.10, 290.11, 290.12, 290.13, 290.20, 290.21, 290.3, 290.40, 290.41, 290.42, 290.43, 294.0, 294.10, 294.11, 294.20, 294.21, 294.8, 797 (any DX on the claim)	At least 1 inpatient, SNF, HHA, HOP or Carrier claim with DX codes during the 3-yr period	.
Anemia	1 year	DX 280.0, 280.1, 280.8, 280.9, 281.0, 281.1, 281.2, 281.3, 281.4, 281.8, 281.9, 282.0, 282.1, 282.2, 282.3, 282.40, 282.41, 282.42, 282.43, 282.44, 282.45, 282.46, 282.47, 282.49, 282.5, 282.60, 282.61, 282.62, 282.63, 282.64, 282.68, 282.69, 282.7, 282.8, 282.9, 283.0, 283.10, 283.11, 283.19, 283.2, 283.9, 284.01, 284.09, 284.11, 284.12, 284.19, 284.2, 284.81, 284.89, 284.9, 285.0, 285.1, 285.21, 285.22, 285.29, 285.3, 285.8, 285.9 (any DX on the claim)	At least 1 inpatient, SNF, HHA, OP or Carrier claim from any source (inpatient, home health, skilled nursing facility, outpatient or Part B with DX codes during the 1-year time period	.
Asthma	1 year	DX 493.00, 493.01, 493.02, 493.10, 493.11, 493.12, 493.20, 493.21, 493.22,493.81, 493.82, 493.90, 493.91, 493.92, (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	.
Atrial Fibrillation	1 year	DX 427.31 (ONLY first or second DX on the claim)	At least 1 inpatient claim or 2 HOP or Carrier claims with DX code during the 1-yr period	.
Benign Prostatic Hyperplasia	1 year	DX 600.00, 600.01, 600.10, 600.11, 600.20, 600.21, 600.3, 600.90, 600.91 (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	If any of the qualifying claims also have a diagnosis of 222.2, then EXCLUDE
Cataract	1 year	DX 366.01, 366.02, 366.03, 366.04, 366.09, 366.10, 366.12, 366.13, 366.14, 366.15, 366.16, 366.17, 366.18, 366.19, 366.20, 366.21, 366.22, 366.23, 366.30, 366.45, 366.46, 366.50, 366.51, 366.52, 366.53, 366.8, 366.9, 379.26, 379.31,379.39, 743.30, 743.31, 743.32, 743.33, V43.1, (ONLY principal DX on the claim)	At least 1 HOP or Carrier claim with DX codes during the I-yr period	

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify[b]	Exclusions
Chronic Kidney Disease	2 years	DX 016.00, 016.01, 016.02, 016.03, 016.04, 016.05, 016.06, 095.4, 189.0, 189.9, 223.0, 236.91, 249.40, 249.41, 250.40, 250.41, 250.42, 250.43, 271.4, 274.10, 283.11, 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 440.1, 442.1, 572.4, 580.0, 580.4, 580.81, 580.89, 580.9, 581.0, 581.1, 581.2, 581.3, 581.81, 581.89, 581.9, 582.0, 582.1, 582.2, 582.4, 582.81, 582.89, 582.9, 583.0, 583.1, 583.2, 583.4, 583.6, 583.7, 583.81, 583.89, 583.9, 584.5, 584.6, 584.7, 584.8, 584.9, 585, 585.1, 585.2, 585.3, 585.4, 585.5, 585.6, 585.9, 586, 587, 588.0, 588.1, 588.81, 588.89, 588.9, 591, 753.12, 753.13, 753.14, 753.15, 753.16, 753.17, 753.19, 753.20, 753.21, 753.22, 753.23, 753.29, 794.4 (any DX on the claim)	At least 1 inpatient, SNF or HHA claim or 2 HOP or Carrier claims with DX codes during the 2-yr period	
Chronic Obstructive Pulmonary Disease and Bronchiectasis	1 year	DX 490, 491.0, 491.1, 491.8, 491.9, 492.0, 492.8, 491.20, 491.21, 491.22, 494.0, 494.1, 496 (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	
Depression	1 year	DX 296.20, 296.21, 296.22, 296.23, 296.24, 296.25, 296.26, 296.30, 296.31, 296.32, 296.33, 296.34, 296.35, 296.36, 296.51, 296.52, 296.53, 296.54, 296.55, 296.56, 296.60, 296.61, 296.62, 296.63, 296.64, 296.65, 296.66, 296.89, 298.0, 300.4, 309.1, 311 (any DX on the claim)	At least 1 inpatient, SNF, HHA, HOP or Carrier claim with DX codes during the 1-yr period	
Diabetes	2 years	DX 249.00, 249.01, 249.10, 249.11, 249.20, 249.21, 249.30, 249.31, 249.40, 249.41, 249.50, 249.51, 249.60, 249.61, 249.70, 249.71, 249.80, 249.81, 249.90, 249.91, 250.00, 250.01, 250.02, 250.03, 250.10, 250.11, 250.12, 250.13, 250.20, 250.21, 250.22, 250.23, 250.30, 250.31, 250.32, 250.33, 250.40, 250.41, 250.42, 250.43, 250.50, 250.51, 250.52, 250.53, 250.60, 250.61, 250.62, 250.63, 250.70, 250.71, 250.72, 250.73, 250.80, 250.81, 250.82, 250.83, 250.90, 250.91, 250.92, 250.93, 357.2, 362.01, 362.02, 362.03, 362.04, 362.05, 362.06, 366.41 (any DX on the claim)	At least 1 inpatient, SNF or HHA claim or 2 HOP or Carrier claims with DX codes during the 2-yr period	
Glaucoma	1 year	DX 362.85, 365.00, 365.01, 365.02, 365.03, 365.04, 365.10, 365.11, 365.12, 365.13, 365.15, 365.20, 365.21, 365.22, 365.23, 365.24, 365.31, 365.32, 365.41, 365.42, 365.43, 365.51, 365.52, 365.59, 365.60, 365.61, 365.62, 365.63, 365.64, 365.65, 365.81, 365.82, 365.83, 365.89, 365.9, 377.14 (ONLY principal DX on the claim)	At least 1 Carrier claim with DX codes during the 1-yr period	
Heart Failure	2 years	DX 398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32,428.33, 428.40, 428.41, 428.42, 428.43, 428.9 (any DX on the claim)	At least 1 inpatient, HOP or Carrier claim with DX codes during the 2-yr period	

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify[b]	Exclusions
Hip/Pelvic Fracture	1 year	DX 733.14, 733.15, 733.96, 733.97, 733.98, 808.0, 808.1, 808.2, 808.3, 808.41, 808.42, 808.43, 808.44, 808.49, 808.51, 808.52, 808.53, 808.54, 808.59, 808.8, 808.9, 820.00, 820.01, 820.02, 820.03, 820.09, 820.10, 820.11, 820.12, 820.13, 820.19, 820.20, 820.21, 820.22, 820.30, 820.31, 820.32, 820.8, 820.9 (any DX on the claim)	At least 1 inpatient or SNF claim with DX code during the 1-yr period	
Hyperlipidemia	1 year	DX 272.0, 272.1, 272.2, 272.3, 272.4 (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	
Hypertension	1 year	DX 362.11, 401.0, 401.1, 401.9, 402.00, 402.01, 402.10, 402.11, 402.90, 402.91, 403.00, 403.01, 403.10, 403.11, 403.90, 403.91, 404.00, 404.01, 404.02, 404.03, 404.10, 404.11, 404.12, 404.13, 404.90, 404.91, 404.92, 404.93, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99, 437.2 (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	
Ischemic Heart Disease	2 years	DX 410.00, 410.01, 410.02, 410.10, 410.11, 410.12, 410.20, 410.21, 410.22, 410.30, 410.31, 410.32, 410.40, 410.41, 410.42, 410.50, 410.51, 410.52, 410.60, 410.61, 410.62, 410.70, 410.71, 410.72, 410.80, 410.81, 410.82, 410.90, 410.91, 410.92, 411.0, 411.1, 411.81, 411.89, 412, 413.0, 413.1, 413.9, 414.00, 414.01, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 414.12, 414.2, 414.3, 414.4, 414.8, 414.9 (any DX on the claim)	At least 1 inpatient, SNF, HHA, HOP or Carrier claim with DX codes during the 2-yr period	
Osteoporosis	1 year	DX 733.00, 733.01, 733.02, 733.03, 733.09 (any DX on the claim)	At least 1 inpatient, SNF, HHA or 2 HOP or Carrier claims with DX codes during the 1-yr period	
RA/OA (Rheumatoid Arthritis/ Osteoarthritis)	2 years	DX 714.0, 714.1, 714.2, 714.30, 714.31, 714.32, 714.33, 715.00, 715.04, 715.09, 715.10, 715.11, 715.12, 715.13, 715.14, 715.15, 715.16, 715.17, 715.18, 715.20, 715.21, 715.22, 715.23, 715.24, 715.25, 715.26, 715.27, 715.28, 715.30, 715.31, 715.32, 715.33, 715.34, 715.35, 715.36, 715.37, 715.38, 715.80, 715.89, 715.90, 715.91, 715.92, 715.93, 715.94, 715.95, 715.96, 715.97, 715.98, 720.0, 721.0, 721.1, 721.2, 721.3, 721.90, 721.91 (any DX on the claim)	At least 2 inpatient, SNF, HHA, HOP or Carrier claim with DX codes during the 2-yr period. Any combination of claims at least one day apart.	
Stroke / Transient Ischemic Attack	1 year	DX 430, 431, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.00, 434.01, 434.10, 434.11, 434.90, 434.91, 435.0, 435.1, 435.3, 435.8, 435.9, 436, 997.02 (any DX on the claim)	At least 1 inpatient claim or 2 HOP or Carrier claims with DX codes during the 1-yr period	If any of the qualifying claims have: 800 <= DX Code <= 804.9, 850 <= DX Code <= 854.1 in any DX position OR DX V57xx as the principal DX code, then EXCLUDE.

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify[b]	Exclusions
Female/Male Breast Cancer	1 year	DX 174.0, 174.1, 174.2, 174.3, 174.4, 174.5, 174.6, 174.8, 174.9, 175.0, 175.9, 233.0, V10.3 (any DX on the claim)	At least 1 inpatient, SNF or 2 HOP or Carrier claims with DX codes during the 1-year time period (Any combination of 2 HOP/Carrier claims at least one day apart)	
Colorectal Cancer	1 year	DX 153.0, 153.1, 153.2, 153.3, 153.4, 153.5, 153.6, 153.7, 153.8, 153.9,154.0,154.1, 230.3, 230.4, V10.05, V10.06 (any DX on the claim)	At least 1 inpatient, SNF or 2 HOP or Carrier claims with DX codes during the 1-year time period (Any combination of 2 HOP/Carrier claims at least one day apart)	
Prostate Cancer	1 year	DX 185, 233.4, V10.46 (any DX on the claim)	At least 1 inpatient, SNF or 2 HOP or Carrier claims with DX codes during the 1-year time period (Any combination of 2 HOP/Carrier claims at least one day apart)	
Lung Cancer	1 year	DX 162.2, 162.3, 162.4, 162.5, 162.8, 162.9, 231.2, V10.11 (any DX on the claim)	At least 1 inpatient, SNF or 2 HOP or Carrier claims with DX codes during the 1-year time period (Any combination of 2 HOP/Carrier claims at least one day apart)	
Endometrial Cancer	1 year	DX 182.0, 233.2, V10.42 (any DX on the claim)	At least 1 inpatient, SNF or 2 HOP or Carrier claims with DX codes during the 1-year time period (Any combination of 2 HOP/Carrier claims at least one day apart)	

[a]Effective dates of these codes vary. Researchers may be interested in confirming the code(s) of interest in accompanying claims or assessment data files.

[b]Carrier claims refers to RIC "O" claims (not DMERC RIC "M" claims), and excludes any claims for which line item Berenson-Eggers Type of Service [BETOS] variable equals D1A, D1B, D1C, D1D, D1E, D1F, D1G, or O1A. The categories with D1 in the first two positions are DME categories. The O1A category includes ambulance services. The intent of the algorithm is to exclude claims where the services do not require a licensed health care professional. SNF refers to skilled nursing facility; HHA refers to home health agency; HOP refers to hospital outpatient.

Table B.2. Disability-Related Condition Algorithms

Algorithms	Reference Time Period (# of years)	Valid ICD-9 Codes[a]	Number/Type of Claims to Qualify	Exclusions
Autism Spectrum Disorders	2 years	299.0, 299.00, 299.01, 299.1, 299.11, 299.8, 299.80, 299.81, 299.9, 299.90, 299.91	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Cerebral Palsy	2 years	333.71, 343, 343.0, 343.1, 343.2, 343.3, 343.4, 343.8, 343.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Cystic Fibrosis and Other Metabolic Developmental Disorders	2 years	243, 255.2, 269.2, 270.1, 270.2, 270.3, 270.4, 270.6, 270.7, 271.1, 277.0, 277.00, 277.01, 277.02, 277.03, 277.09, 277.81, 277.85, 277.6	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Epilepsy	2 years	345, 345.0, 345.00, 345.01, 345.1, 345.10, 345.11, 345.2, 345.3, 345.4, 345.40, 345.41, 345.5, 345.50, 345.51, 345.6, 345.60, 345.61, 345.7, 345.70, 345.71, 345.8, 345.80, 345.81, 345.9, 345.90, 345.91	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Intellectual Disabilities and Related Conditions	2 years	317, 318, 318.0, 318.1, 318.2, 319, 758, 758.0, 758.1, 758.2, 758.3, 758.31, 758.32, 758.33, 758.39, 758.5, 759.7, 759.81, 759.83, 759.89, 760.71	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Learning Disabilities	2 years	315, 315.01, 315.02, 315.09, 315.1, 315.2, 315.31, 315.32, 315.34, 315.35, 315.39, 315.4,	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Mobility Impairments	2 years	334.1, 342.00, 342.01, 342.02, 342.10, 342.11, 342.12, 342.80, 342.81, 342.82, 342.90, 342.91, 342.92, 344, 344.0, 344.00, 344.01, 344.02, 344.03, 344.04, 344.09, 344.1, 344.2, 344.3, 344.30, 344.31, 344.32, 344.4, 344.40, 344.41, 344.42, 344.5, 344.6, 344.60, 344.61, 344.8, 344.81, 344.89, 344.9, 438.20, 438.21, 438.22, 438.30, 438.31, 438.32, 438.40, 438.41, 438.42, 438.50, 438.51, 438.52, 438.53	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Multiple Sclerosis and Transverse Myelitis	2 years	340, 341, 341.0, 341.2, 341.20, 341.21, 341.22, 341.8, 341.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Muscular Dystrophy	2 years	359, 359.0, 359.1	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Other Developmental Delays	2 years	315.5, 315.8, 315.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None

Algorithms	Reference Time Period (# of years)	Valid ICD-9 Codes[a]	Number/Type of Claims to Qualify	Exclusions
Sensory – Deafness and Hearing Impairment	2 years	389, 389.1, 389.10, 389.11, 389.12, 389.13, 389.14, 389.15, 389.16, 389.17, 389.18, 389.2, 389.20, 389.21, 389.22, 389.7, 389.8, 389.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Sensory - Blindness and Visual Impairment	2 years	369, 369.0, 369.00, 369.01, 369.02, 369.03, 369.04, 369.05, 369.06, 369.07, 369.08, 369.1, 369.10, 369.11, 369.12, 369.13, 369.14, 369.15, 369.16, 369.17, 369.18, 369.2, 369.20, 369.21, 369.22, 369.23, 369.24, 369.25, 369.3, 369.4	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Spina Bifida and Other Congenital Anomalies of the Nervous System	2 years	740.0, 740.1, 740.2, 741, 741.0, 741.00. 741.01, 741.02, 741.03, 741.9, 741.90, 741.91. 741.92, 741.93, 742.0, 742.1, 742.2, 742.3, 742.4, 742.5, 742.51, 742.53, 742.59, 742.8, 742.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Spinal Cord Injury	2 years	349.39, 806.00. 806.01, 806.02, 806.03, 806.04, 806.05, 806.06, 806.07, 806.08, 806.09, 806.10, 806.11, 806.12, 806.13, 806.14, 806.15, 806.16, 806.17, 806.18, 806.19, 806.20, 806.21, 806.22, 806.23, 806.24, 806.25, 806.26, 806.27, 806.28, 806.29, 806.30, 806.31, 806.32, 806.33, 806.34, 806.35, 806.36, 806.37, 806.38, 806.39, 806.4, 806.5, 806.60, 806.61, 806.62, 806.69, 806.70, 806.71, 806.72, 806.79, 806.8, 806.9, 907.2, 952.00, 952.01, 952.02, 952.03, 952.04, 952.05, 952.06, 952.07, 952.08, 952.09, 952.10, 952.11, 952.12, 952.13, 952.14, 952,15, 952.16, 952.17, 952.18, 952.19, 952.2, 952.3, 952.4, 952.8, 952.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Traumatic Brain Injury and Nonpsychotic Mental Disorders due to Brain Damage	2 years	310, 310.0, 310.1, 310.2, 310.8, 310.81, 310.89, 907, 907.0, 907.1	At least one inpatient claim *OR* two other non-drug claims of any service type	None

[a] Effective dates of these codes vary. Researchers may be interested in confirming the code(s) of interest in accompanying claims or assessment data files.

Table B.3. Mental health conditions and Substance Use Disorder Algorithms

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify	Exclusions
Anxiety Disorders	2 years	293.84, 300.00, 300.01, 300.02, 300.09, 300.10, 300.20, 300.21, 300.22, 300.23, 300.29, 300.3, 300.5, 300.89, 300.9, 308.0, 308.1, 308.2, 308.3, 308.4, 308.9, 309.81, 313.0, 313.1, 313.21, 313.22, 313.3, 313.82, 313.83	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Bipolar Disorder	2 years	296.00, 296.01, 296.02, 296.03, 296.04, 296.05, 296.06, 296.10, 296.11, 296.12, 296.13, 296.14, 296.15, 296.16, 296.40, 296.41, 296.42, 296.43, 296.44, 296.45, 296.46, 296.50, 296.51, 296.52, 296.53, 296.54, 296.55, 296.56, 296.60, 296.61, 296.62, 296.63, 296.64, 296.65, 296.66, 296.7, 296.80, 296.81, 296.82, 296.89, 296.90, 296.99	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Conduct Disorders and Hyperkinetic Syndrome	2 years	312.00, 312.01, 312.02, 312.03, 312.10, 312.11, 312.12, 312.13, 312.20, 312.21, 312.22, 312.23, 312.30, 312.31, 312.32, 312.33, 312.34, 312.35, 312.39, 312.4, 312.81, 312.82, 312.89, 312.9, 314.00, 314.01, 314.1, 314.2, 314.8, 314.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Depressive Disorders	2 years	296.20, 296.21, 296.22, 296.23, 296.24, 296.25, 296.26, 296.30, 296.31, 296.32, 296.33, 296.34, 296.35, 296.36, 300.4, 311, V79.0	At least one inpatient claim *OR* two other non-drug claims of any service type AND There must be at least one qualifying claim without a screening code (i.e.,V79.0)	None
Personality Disorders	2 years	301.0, 301.10, 301.11, 301.12, 301.13, 301.20, 301.21, 301.22, 301.3, 301.4, 301.50, 301.51, 301.59, 301.6, 301.7, 301.81, 301.82, 301.83, 301.84, 301.89, 301.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Post-Traumatic Stress Disorder (PTSD)	2 years	309.81	At least one inpatient claim *OR* two other non-drug claims of any service type	None

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify	Exclusions
Schizophrenia	2 years	295.00, 295.01, 295.02, 295.03, 295.04, 295.05, 295.10, 295.11, 295.12, 295.13, 295.14, 295.15, 295.20, 295.21, 295.22, 295.23, 295.24, 295.25, 295.30, 295.31, 295.32, 295.33, 295.34, 295.35, 295.40, 295.41, 295.42, 295.43, 295.44, 295.45, 295.50, 295.51, 295.52, 295.53, 295.54, 295.55, 295.60, 295.61, 295.62, 295.63, 295.64, 295.65, 295.70, 295.71, 295.72, 295.73, 295.74, 295.75, 295.80, 295.81, 295.82, 295.83, 295.84, 295.85, 295.90, 295.91, 295.92, 295.93, 295.94, 295.95	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Schizophrenia and Other Psychotic Disorders	2 years	293.81, 293.82, 295.00, 295.01, 295.02, 295.03, 295.04, 295.05, 295.10, 295.11, 295.12, 295.13, 295.14, 295.15, 295.20, 295.21, 295.22, 295.23, 295.24, 295.25, 295.30, 295.31, 295.32, 295.33, 295.34, 295.35, 295.40, 295.41, 295.42, 295.43, 295.44, 295.45, 295.50, 295.51, 295.52, 295.53, 295.54, 295.55, 295.60, 295.61, 295.62, 295.63, 295.64, 295.65, 295.70, 295.71, 295.72, 295.73, 295.74, 295.75, 295.80, 295.81, 295.82, 295.83, 295.84, 295.85, 295.90, 295.91, 295.92, 295.93, 295.94, 295.95, 297.0, 297.1, 297.2, 297.3, 297.8, 297.9, 298.0, 298.1, 298.2, 298.3, 298.4, 298.8, 298.9	At least one inpatient claim *OR* two other non-drug claims of any service type	None
Tobacco Use	2 years	305.1, 649.00, 649.01, 649.02, 649.03, 649.04, 989.84, 99406, 99407	At least one inpatient claim *OR* two other non-drug claims of any service type *OR* one procedure code claim of any type (i.e., 99406, 99407)	None

Algorithms	Reference Time Period (# of years)	Valid ICD-9/CPT4/HCPCS Codes[a]	Number/Type of Claims to Qualify	Exclusions
Substance abuse	2 years	292, 292.0, 292.11, 292.12, 292.2, 292.8, 292.81, 292.82, 292.83, 292.84, 292.85, 292.89, 292.9, 304, 304.0 304.01, 304.02, 304.1, 304.11, 304.12, 304.2, 3042.0, 304.21, 304.22, 304.3, 304.30, 304.31, 304.32, 304.4, 304.40, 304.41, 304.42 , 304.5, 304.50, 304.51, 304.52, 304.6, 304.60, 304.61, 304.62, 304.7, 304.70, 304.71, 304.72, 304.8, 304.80, 304.81, 304.82, 304.9, 304.90, 304.91, 304.92, 305, 305.2, 305.20, 305.21, 305.22, 305.3, 305.30, 305.31, 305.32, 305.4, 305.40, 305.41, 305.42, 305.5, 305.50, 305.51, 305.52, 305.6, 305.60, 305.61, 305.62, 305.7, 305.70, 3057.1, 305.72 305.8, 305.80, 305.81, 305.82, 305.9, 305.90, 305.91 305.92, 648.3, 648.30, 648.31, 648.32, 648.33, 648.34, 655.5, 655.50, 655.51, 655.53, 760.72, 760.73, 760.75, 779.5, 965.0, 965.00, 965.01, 965.02, 965.09, V6542, 946, 946.4, 946.5, 946.6, 946.7, 946.8, 946.9, E850.0, E850.1, E850.2, E854.1, E935.0, E935.1	At least one inpatient claim *OR* two other non-drug claims of any service type *OR* one procedure code claim of any type (i.e., 946, 946.4, 946.5, 946.6, 946.7, 946.8, 946.9)	
Alcohol abuse	2 years	291, 291.0, 291.1, 291.2, 291.3, 291.4, 291.5, 291.8, 291.81, 291.82, 291.89, 291.9, 303.0, 303.00, 303.01, 303.02, 303.9, 303.90, 303.91, 303.92, 305, 305.0, 305.00, 305.01, 305.02, 357.5, 425.5, 535.3, 535.30, 535.31, 571, 571.0, 571.1, 571.2, 571.3, 760.71 ,980, 980.0, V6542, V791, 946, 946.1, 946.2, 946.3, 946.7, 946.8, 946.9, E860.0	At least one inpatient claim *OR* two other non-drug claims of any service type *OR* one procedure code claim of any type (i.e., 946, 946.4, 946.5, 946.6, 946.7, 946.8, 946.9)	

[a] Effective dates of these codes vary. Researchers may be interested in confirming the code(s) of interest in accompanying claims or assessment data files.

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