The Hilltop Institute
UMBC

Risk Score Specifications and Codebook for The Hilltop Institute's Pre- Models

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Version 3

Maryland
DEPARTMENT OF HEALTH

Documentation Edit History

Version	Date	Description of Primary Change(s)
MDPCP 1	October 3, 2019	Initial Release
MDPCP 2	January 11, 2020	▪ Added clarification of time lag of estimates; consistency of risk scores over time; reasons for risk; and model performance in production ▪ Updated model coefficients and appendix table ▪ Added List of Tables and Figures
MDPCP 3	June 29, 2020	▪ Added section on nonlinear modeling tests ▪ Updated weighting methodology for environmental risk factors ▪ Added section on new risk factors as of June 2020 ▪ Updated Appendix 1 to reflect additional risk factors
Pre- Models 1	November 7, 2022	▪ Substantially restructured to accommodate new predictive models ▪ Added details about census tract-level environmental risk factors ▪ Updated Pre-AH outcome definition to reflect latest AHRQ PQI specifications
Pre- Models 1.1	April 27, 2023	▪ Updated Pre-HE Model risk score name.
Pre- Models 2	December 19, 2023	▪ Updated Pre-AH outcome definition to reflect 2022 AHRQ PQI specifications ▪ Updated CCW risk factors to reflect the CCW 30 Version (2022) ▪ Updated Appendix 1 to reflect additional risk factors
Pre- Models 3	January 2, 2025	▪ Substantially restructured to accommodate new predictive model populations and inactive models ▪ Updated variable specifications and performance metrics for existing models where necessary

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for The Hilltop Institute's Pre- Models (Version 3)

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Section 1. Introduction

In 2014, the state of Maryland partnered with the Centers for Medicare and Medicaid Services (CMS) to modernize its unique all-payer rate-setting system for hospital services to improve the overall health of Maryland residents by increasing health care quality and reducing the cost of care. In service of providing better care at lower cost, The Hilltop Institute at UMBC, in partnership with the Maryland Department of Health (the Department), has developed predictive risk stratification models to identify patients at high risk for potentially preventable health care utilization that can be used to help target care resources to the patients who need them most.

This document explains the intended use, technical implementation, and model performance of the Hilltop Pre- Models as of December 2024. The Pre- Models are a suite of prediction tools spanning the Pre-AH Model, Pre-DC Model, and Pre-HE Model, currently deployed in several populations. This document will be updated as the models are updated or when new models become operational, and significant changes will be noted in the documentation edit history table. This first section of the codebook provides a short introduction; the second section provides a general overview of data sources, training methodology, and scoring methodology; the third section provides specific details on each model within the Hilltop Pre- Models suite; and the fourth section includes an overview of Pre- Models that are active at the time of writing.

As of December 2024, the Pre- Models are operational in four distinct populations:

- Medicare beneficiaries who are attributed to practices participating in the Maryland Primary Care Program (MDPCP). MDPCP is a key element of the Total Cost of Care (TCOC) All-Payer Model, an agreement between the CMS and the state of Maryland. MDPCP is a voluntary program that provides funding and support for the delivery of advanced primary care throughout the state. It allows primary care providers to play an increased role in the prevention and management of chronic disease, as well as in the prevention of unnecessary hospital utilization. As an important part of supporting providers in their care management efforts, the MDPCP provides event risk scores to participating practices of their attributed beneficiaries according to each patient's risk of incurring a model-specific outcome. Patient-level risk scores and reasons for risk are generated for the Pre-AH, Pre-DC, and Pre-HE models for the MDPCP population. As of December 2024, this population spans approximately 350,000 beneficiaries.
- Medicaid recipients enrolled in the Maryland HealthChoice program. HealthChoice is the Medicaid managed care delivery system in Maryland, and patient-level risk scores and reasons for risk are generated for the Pre-AH and Pre-DC models for this population. As of December 2024, this population spans approximately 1.4 million individuals.
- Medicare fee-for-service (FFS) beneficiaries who live in Maryland and are not attributed to an MDPCP-participating provider. Patient-level risk scores and reasons for risk are

generated for the Pre-AH and Pre-DC models for this population. As of December 2024, this population spans approximately 350,000 individuals.

- Full-benefit, non-dual Maryland Medicaid FFS beneficiaries who are not enrolled in the HealthChoice program. Patient-level risk scores and reasons for risk are generated for the Pre-AH and Pre-DC models for this population. As of December 2024, this population spans approximately 45,000 individuals.

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Section 2. Pre- Model Overview, Data, and Methodology

Intended Use

The Hilltop Pre- Model risk scores are intended to facilitate improved efficiency in the allocation of scarce care coordination resources and each model is calibrated to predict a patient's risk of a specific health event. Theoretically, if such resources are limited and the patients in a given practice panel differ in the benefit they would obtain through care coordination, then patient outcomes are optimized by focusing those care coordination resources on the patients for whom these resources will generate the most benefit.[1] Hilltop's models are intended to be used to *rank* beneficiaries in each practice's or MCO's panel based on their risk of experiencing a health event – as opposed to classifying individuals as "high" or "low" risk - in order to assist in the identification and care coordination efforts for high-risk individuals.

Hilltop conceptualizes benefit, in this context, as the avoidance of a patient-specific adverse event. Many distinct adverse events are possible (ranging from disease onset to institutionalization to death), but for each model (i.e., the Pre-AH Model, Pre-DC Model, and Pre-HE Model), Hilltop treats these events as homogeneous and therefore focuses on patients' *probabilities* of incurring the specified outcome. This forms the theoretical foundation for the Hilltop Pre- Model framework: those individuals with the highest *probability* of incurring a given health event are likely to benefit the most from advanced primary care services with respect to that outcome. Through the dissemination of risk scores and reasons for risk, Hilltop aims to facilitate the identification of these individuals within each practice or MCO so that providers and end-users can allocate their care management resources accordingly.

It is crucial that the risk scores are as accurate as possible: ideally, the riskiest individuals as identified by the model have the highest *actual* likelihood of incurring a given health event, and the individuals identified by the model as lowest risk have the lowest actual likelihood. Due to the nature of the modeling problem—estimating the *distribution* of risk, rather than binary classification—it is not appropriate to use the traditional Receiver Operator Characteristic curve as a measure of model fit. Instead, the utility of the model is assessed using *concentration curves,* which estimate the share of all health events occurring within the riskiest patients. Concentration curves can indicate, for example, that 50% of all patients who experience an avoidable hospital event are in the top 10% riskiest patients as estimated by the Hilltop Pre-AH Model. Concentration curves are presented for all models and populations in Section 4, below.

Clinical Vignette

In order to illustrate the intended use of the Hilltop Pre- Models, we have created a hypothetical clinical vignette using the Hilltop Pre-AH Model risk scores for an MDPCP practice. For the sake

[1] There is some evidence to suggest that different patients receive different benefits from care coordination services. Researchers have found that proactive care coordination interventions for patients with a high risk of hospitalization have so far led to reductions in avoidable hospitalizations, ED utilization, and readmissions for the Medicaid population but not the Medicare population (Berkowitz et al., 2018).

of exposition, the patient panel consists of thirteen patients, each of which represents ten similar patients. Table 1 displays the patient panel, along with each patient's (hypothetical) Hilltop Pre-AH Model risk score.

Table 1. Hypothetical Patient Panel

Patient Name	Pre-AH Risk Score (%)
Patient 1	75%
Patient 2	15%
Patient 3	5%
Patient 4	4%
Patient 5	2%
Patient 6	1%
Patient 7	Less than 1%
Patient 8	Less than 1%
Patient 9	Less than 1%
Patient 10	Less than 1%
Patient 11	Less than 1%
Patient 12	Less than 1%
Patient 13	Less than 1%

Patients in this practice are listed in descending order of risk. Based on the most recently available month of risk factors spanning diagnoses, procedures, medications, utilization, demographics, and geographic information, in conjunction with risk coefficients derived from the most recent quarterly model retraining, , Patient 1 (or, equivalently, the ten patients represented by Patient 1) has a 75% chance of incurring an avoidable hospital event in the near future.[2] Patient 2 is the next riskiest and has a 15% chance of incurring an avoidable hospital event. Patient 3 is the next riskiest, with a 5% chance. The distribution of risk is highly skewed: the majority of the practice's panel has less than 1% chance of incurring an avoidable hospital event, and all but two of the patients have under a 6% event risk.

Distributing available care coordination resources equally to all 130 underlying patients would result in each patient receiving a relatively small portion of available resources. This distribution of resources may not have a significant impact on patient outcomes: the low-risk individuals would likely be low-risk even without the advanced primary care intervention, and the high-risk individuals may require more resource-intensive interventions to experience improvement in outcomes.[3] The Pre-AH Model risk scores, used in conjunction with provider clinical guidance,

[2] See below for a more detailed discussion of the Pre-AH Model training and scoring process.

[3] Liaw et al. (2015) conclude that, based on a review of four CMS-funded demonstrations involving care management fees, "to generate savings, resource allocation cannot be homogeneous. Instead, practices must focus more intensely on those at highest risk of utilization" (p. 557). Indeed, this may (partly) explain the varying effectiveness of care management, care coordination, and intensive primary care interventions as documented in the academic literature; many patients have low underlying risk of adverse outcomes, thus obviating the need for intervention, and the few high-risk patients may require significant intervention resources. For summaries of the literature on this subject, see Edwards et al. (2017) and Baker et al. (2018).

can assist practices with a more efficient and impactful allocation of their care management efforts.

Care Interventions

Hilltop remains agnostic as to the types of interventions that are best suited for the high-risk patients. Many interventions are possible, ranging from medication reconciliation to patient education to scheduling assistance, and patients are likely to respond best to different interventions based on their clinical and social needs. Interested readers should see published best practices in care coordination and care management.[4] Whatever the intervention strategy, Hilltop recommends that care managers and other users of the Hilltop Pre- Model risk scores allocate their effort first to individuals with the highest risk of incurring a given health event in the near future. This risk score is not, however, meant to override the clinical and subject matter expertise of the practice, their care transformation organization (CTO) partners, or the MCOs and should be used in conjunction with the practice's current care coordination protocols.

Risk Factor Overview

The risk factors in each of the Hilltop Pre- Models are derived from comprehensive literature reviews designed to identify risk factors that have been shown, in previously published research, to be statistically associated with the outcome of interest. Initially, Hilltop identified over 190 risk factors for the Pre-AH Model risk factor pool based on a literature review conducted in early 2019 (Pelser et al., 2019). Hilltop subsequently expanded the pool of Pre-AH Model risk factors in 2020. All Hilltop Pre- Models use the risk factor pool developed for the Pre-AH Model, as well as additional event-specific risk factors identified through targeted literature reviews.

Data Sources

Medicare Populations (MCPCP and Medicare FFS)

The administrative data used in the Pre- Models developed for the MDPCP and Medicare FFS populations are derived from the Claim and Claim Line Feed (CCLF) Medicare Parts A, B, and D claims files. Each month, Hilltop receives Part A claims, Part A revenue centers, Part A procedure codes, Part A diagnosis codes, Part B claim lines, Part B durable medical equipment claims (DME), Part D claims, and patient demographic information (which also includes eligibility information) from CMS. Additionally, Hilltop receives beneficiary attribution files and practice rosters each quarter.

Upon receipt of the monthly claims files, Hilltop first performs automated data validity checks in order to assess the integrity of the CCLF data files, followed by a data reduction step that subsets the claims files against the beneficiary attribution file. The resulting files retain the raw claims data that are inputs to the risk factor feature engineering process.

[4] See examples at Hong et al. (2014); McCarthy et al. (2015); and Anderson et al. (2015).

In addition to risk factors based on administrative claims, the models also include risk factors based on publicly available, environmental risk factors. Appendix 2 details the data sources for these risk factors.

Medicaid Populations (HealthChoice and Medicaid FFS)

The administrative data used in the Pre- Models developed for the HealthChoice and Medicaid FFS populations are derived from the Medicaid Management Information System (MMIS2) eligibility, recipient information, inpatient, outpatient, physician, and pharmacy claim files for the Medicaid beneficiaries. Each month, Hilltop receives new claim files from the Maryland Department of Health.

Upon receipt of the monthly claims files, Hilltop first performs automated data validity checks in order to assess the integrity of the MMIS2 data files, followed by a data reduction step that subsets the claims files against the MCO eligibility files. The resulting files retain the raw claims data that are inputs to the risk factor feature engineering process.

In addition to risk factors based on administrative claims, the models also include risk factors based on publicly available environmental risk factors. Appendix 2 details the data sources for these risk factors.

Condition-Based Risk Factors

A significant portion of Hilltop's risk factor pool is composed of condition-based risk factors: that is, 0/1 variables that indicate—based on an individual's claims history—whether they have been recorded as having diagnoses consistent with a given condition. These condition flags largely rely on diagnostic information from hospital, nursing home, physician, and lab claims in conjunction with Chronic Conditions Data Warehouse (CCW) coding specifications in order to generate beneficiary-level risk factors that represent underlying disease states.[5]

At the time of writing, the models use the July 2023 CCW definitions. Based on planned model updates, the July 2024 CCW definitions will be used to create scores starting in February 2025.

Utilization-Based Risk Factors

Risk factors from this category cover utilization of certain services (such as vaccinations, lab tests, or provider-administered drugs), place of service (for example, urgent care or rural health clinic), and provider specialty (for example, endocrinology or oncology). These risk factors also capture information on inpatient and outpatient hospital admissions, ED visits, and nursing home admissions over the past 12 months.

[5] Additional detail on the CCW condition flag specifications can be found here: https://www2.ccwdata.org/documents/10280/19139421/chr-chronic-condition-algorithms.pdf , https://www.ccwdata.org/documents/10280/19139421/ccw-chronic-condition-algorithms-reference-list.pdf

Prescription Drug-Related Risk Factors

Risk factors from this category index utilization of prescription drugs. The coding logic relies on first mapping drug names to National Drug Codes (NDCs) and then identifying those NDCs in pharmacy claims files. In order to capture compound drugs, which are drugs that contain multiple active ingredients, Hilltop relies largely on text-based, "contains"-type searches of the FDA's National Drug Code Directory to map drug names to NDCs.[6] We regularly update the list of NDCs to account for the addition of new NDCs.

At the time the of writing, the models use the FDA NDC database from June 2023.

Demographic Risk Factors

Risk factors from this category index cover beneficiary demographic characteristics such as age, race, and Medicare or Medicaid eligibility information. The respective beneficiary eligibility files are used to create these risk factors for all of the populations for which risk scores are deployed.

Social and Environmental Risk Factors

Social and environmental variables play an important role in health; however, many individual-level demographic and socioeconomic factors are unavailable in administrative claims data (for example, marital status). Consequently, Hilltop developed an extensive database of area risk factors from publicly available data sources (i.e., the percentage of the population aged 15+ that is currently married) that can be linked to an individual's administrative claims using their recorded address to proxy for the unobserved individual-level variables. Other environmental risk factors (e.g., area poverty rate) are intended to capture social determinants of health—the neighborhood conditions in which people live and age that may affect health outcomes. Hilltop created two versions of these variables: one that maps to an individual's ZIP code (ZCTA), and, in October 2021, more granular versions of the variables at the census tract level[7]. See Appendix 2 for more details on the risk factors and how they are linked to claims data.

General Methodology

Training

Each of the Hilltop Pre- Models is operationalized as a discrete-time survival model that uses the *current* month of risk factors in order to predict the specified outcome in the *following* month. The model uses month as a time unit—instead of, for example, weeks or years—to balance the

[6] For example, "Simcor" contains two active substances: Simvastatin and Niacin. This is flagged as a statin because one of its active ingredients is a statin. Source for the FDA NDC directory: https://www.fda.gov/drugs/drug-approvals-and-databases/national-drug-code-directory

[7] Goetschius et al., (2023) found that ZCTA and census tract level granularity social and environmental risk factors resulted in similar predictive performance. However, the more granular census tract risk factors resulted in improved model interpretation.

increased model accuracy obtained by a more granular time unit with the increased prediction error due to rare events.

The raw claims data span three years, or 36 person-months for individuals with full coverage. Since the model estimates the risk of incurring an outcome in the *next* month, however, it is not possible to use the most recently available month of risk data in the training model (since the next month's outcomes have not been realized at this point). Therefore, the training data are based on underlying data covering 35 person-months per attributed patient with full coverage. While, in general, a reduction in sample size can adversely impact the statistical precision of the risk factor estimates, lagged predictors are used for three reasons. First, several of the risk factors—such as the count of hospitalizations in the previous 12 months, or the condition flag for diabetes—overlap with the definition of the outcome variables. Consequently, including these risk factors as *contemporaneous* predictors could artificially increase the predictive power of the model. Second, Hilltop believes that using lagged predictors aids in the interpretability of the model. The goal of the Hilltop Pre- Models is to predict future events and using contemporaneous predictors to generate future risk scores requires the assumption that individuals' risk factors do not change in the future. Finally, the use of lagged predictors implies a natural "person-now" data set: the most *recent* month of risk factors, which is not included in the training data set.

The statistical model is trained on an 80% sample of our analytical person-month data set. The functional form of the statistical model is:

$$\log\left(\frac{p_i(t)}{1-p_i(t)}\right) = \varphi(t) + \beta X_i(t-1) + \Omega V_i$$

- $\varphi(t)$ is a function of time at risk
- t is duration of time at risk in months
    - counting start from the first month of available data if the patient is in coverage longer than three years, or
    - counting from the coverage start month if the patient's coverage start is within three years
- β and Ω are the vectors of model parameters to be determined by training data
- $X_i(t-1)$ is a vector of patient $i's$ time-dependent features in the previous month
- V_i is a vector of patient *i*'s time-independent features
- $p_i(t)$ is the probability of a given outcome of patient i at time t (i.e., the month following the realization of the risk factors)

The statistical model uses five types of risk factors: condition, pharmacy, utilization-based, geographic, and demographic. It is important to note that not all risk factors are available for every person-month. Hilltop uses a twelve-month lookback period for most of the time-varying risk factors, implying that an individual with, for example, five months of claims history will have

incomplete information in their risk factors: if this individual truly has glaucoma, then it is possible that they will not amass the claims history by month five that meets the qualifications required for a glaucoma flag in our model. Furthermore, while most individuals in the data have addresses that link to the environmental risk factor data set, there are individuals for whom a valid census tract cannot be identified or who have ZIP codes for which there is no equivalent ZCTA, and therefore receive no environmental risk factors.[8] Table 2 presents the risk factor availability, depending on claims history and availability of area-level (ZCTA or census tract) data.

Table 2. Risk Factors by Data Availability

		At Least 12 Months of Claims History	
		Yes	**No**
Availability of Geographic Risk Factors	**Yes**	Claims-based/Geo/Demo	Geo/Demo
	No	Claims-based/Demo	Demo

Risk factor availability is an issue for the "scoring" step, in which risk scores are assigned to every individual based on the parameter estimates derived in the training step. For example, suppose that the vector of estimated coefficients from the logistic regression is as follows in Table 3.

Table 3. Risk Factor Availability Example 1

Risk Factor	Value for individual i
Asthma Flag	.1
…	
ZIP Code Income	-.00001
…	
Age	.02

These hypothetical risk factor coefficients indicate that, as expected, if an individual meets the clinical criteria for asthma, the risk of the outcome is higher; if they live in a ZIP code with higher income, the risk is lower; and if they are older, the risk is higher. The scoring step will apply this vector of coefficients to the "person-now;" that is, the current month for each individual. Individual *i*'s predicted probability of incurring an outcome in the next month, then, will be scored as follows:

$$Risk_i = \frac{e^{.1*Asthma_i + \cdots - .00001*ZIP\ Code\ Income_i + \cdots + .02*Age_i}}{1 + e^{.1*Asthma_i + \cdots - .00001*ZIP\ Code\ Income_i + \cdots + .02*Age_i}}$$

Suppose that these variables (Asthma Flag, ZIP Code Income, and Age) are the only three risk factors in the model. Furthermore, suppose that individual *i* has the following characteristics:

[8] These individuals appear to use P.O. boxes as their mailing address, which, being point representations, do not have ZCTA areal equivalents.

Table 4. Risk Factor Availability Example 2

Risk Factor	Value for individual i
Asthma Flag	1
ZIP Code Income	$55,000
Age	66

This hypothetical individual has asthma, lives in a ZIP code in which the median income is $55,000 and is 66years old. Then, that individual's risk of an outcome event in the following month is $\frac{e^{(.1*1 - .00001*55{,}000 + .02*66)}}{1+ e^{(.1*1 - .00001*55{,}000 + .02*66)}}$ = 70.47%.

Suppose, however, that this individual is newly eligible for Medicare and does not have sufficient claims history to meet the criteria for an asthma flag (anything under 12 months). In this instance, the individual might truly have asthma as an underlying disease state, but this is not observable. The individual's risk factors, then, are:

Table 5. Risk Factor Availability Example 3

Risk Factor	Value for individual i
Asthma Flag	NOT OBSERVED
ZIP Code Income	$55,000
Age	66

If the model's coefficients are applied only to the risk factors that are *observed*, then this individual's estimated risk is 68.35%. By failing to account for the risk factors that are not present in the model, the risk of incurring the outcome is underestimated for individual *i*.

Hilltop's solution to this issue is to estimate four different regression models for a given outcome based on the risk factors that are available for each group. This allows the risk factors that are present to "compensate," to a certain extent, for the risk factors that are missing due to data availability. For example, suppose that an individual lacks sufficient claims history to generate condition risk factors but does have the following demographic risk factors: age, sex, and race. If sex is correlated with the unobserved condition factors (if, for example, female beneficiaries are more likely to experience chronic conditions than male beneficiaries), then the coefficient for the "sex" risk factor will capture this correlation, and thus represent the marginal impact of being female *and* the portion of unobserved diagnostic risk factors that is correlated with sex. Consequently, if female beneficiaries are more likely to experience chronic conditions than male beneficiaries, then the risk factor coefficient for "sex" will be larger in the models without condition risk factors than in the models with diagnostic risk factors. By allowing observed risk factors to capture some of the predictive power of unobserved risk factors, the loss in predictive power due to missing data is minimized.

The four sub-models are trained on the subset of person-months for which all risk factors are complete (that is, person-months with at least 12 months of claims history and a valid

geographic linkage), and include the following sets of risk factors (analogous to the four partitions of the person-month sample):

- Sub-Model 1: use Claims-based/Geo/Demo risk factors
- Sub-Model 2: use Geo/Demo risk factors
- Sub-Model 3: use Claims-based/Demo risk factors
- Sub-Model 4: use Demo risk factors

Variable selection can improve the performance of predictive models by reducing prediction variance and increasing generalizability (Bagherzadeh-Khiabani et al., 2016; Walter & Tiemeier, 2009). Hilltop performed this in two steps: first, the team selected initial risk factors for the Pre-AH Model based on an extensive literature review, which screened over 3,300 articles and ultimately selected 211 published, peer-reviewed papers from which to extract risk factors. This generated a baseline pool of 204 risk factors; each of the additional Pre- Models is based on its own literature which adds risk factors to this baseline pool. Additionally, in model training, Hilltop uses stepwise selection in the multivariable logistic model to remove insignificant predictors from the model before adding significant predictors.

In the current version of the Hilltop Pre- Models, the risk factors typically enter the model additively: that is, if an individual has both diabetes and heart failure diagnostic flags, then their risk score will reflect the risk coefficient for the diabetes flag, plus that of the heart failure flag. It is possible, however, that there is additional risk due to the fact of the beneficiary having *both* conditions, over and above the sum of the risks of having each condition. We have included such "interaction terms" where indicated by the literature reviews. For example, in the Pre-HE Model, we include a measure of frailty, a 0/1 variable indicating a history of Alzheimer's disease or related dementia, and the interaction of the two.

Hilltop trains each of the Pre- Models on a quarterly basis unless otherwise specified. We will, however, monitor the predictive accuracy of the model and adjust the training schedule as needed.

Scoring

The four risk models above are *trained* each quarter on the subset of data with at least twelve months of claims history and full environmental data (ZIP code or census tract) data to estimate the vectors of coefficients for the risk factors in each model. Then, using the most recently available month of risk factors (that is, the "person-now" data set), individuals are scored using the model coefficients that correspond to the risk factors available in the person-now data set.

The Hilltop Pre- Models generate risk scores for the entire population cohorts, but individual practices or MCOs only receive risk scores for their specific beneficiaries. This has the consequence that, if a practice or MCO contains disproportionately high-risk patients, and another contains disproportionately low-risk patients, then the riskiest patients within each will differ in their *absolute* risk.

Hilltop scores the Pre- Models monthly. During this process, we create risk factors from raw claims data for the most recent one month of claims history and apply the most recent model coefficients to create risk scores.

Predictive Performance Metrics

Predicted Probabilities

The output for all the Pre- Models is a set of probabilities that estimate the patient-specific risk of incurring the model-specific outcome. In general, these events are rare and, consequently, the predicted probabilities are low. Hilltop does not interpret this as a limitation of the risk scores; rather, this reflects the relative rarity of the outcome events. Moreover, the *relative* risk is the key metric that should be used to allocate care resources: no matter the absolute risk of the patient panel, the efficient allocation of care resources requires the identification (and treatment) of the riskiest patients the medical practice treats.

Patient-level risk tends to persist across time: that is, higher-risk patients tend to remain at a high-risk from one month to the next, while lower-risk patients tend to remain at a lower-risk. This is likely due to two factors. First, to prevent coding idiosyncrasies from introducing noise into the predictions, the majority of risk factors are coded with at least one year of lookback. This has the consequence of making the Pre- Model risk factors relatively stable over time, and thus, smoothing out variation in the risk scores. Second, it is likely that true, underlying patient risk is also persistent: if some patients tend to have high (or low) risk for structural reasons, then the risk scores should also be relatively stable across time.

However, large month-to-month changes in risk scores can occur for two reasons. First, using a given set of risk factors coefficients, any changes in underlying risk factors will lead to changes in patients' predicted risk. For example, if an attributed beneficiary meets the conditions for heart failure beginning in July 2024, then their risk score will likely increase significantly because of that underlying change. Second, Hilltop estimates new risk factor coefficients every quarter in model retraining. As a result, the *relationship* between a given risk factor and the model-specific outcome events can also change upon retraining. To continue the previous example, if the risk factor coefficient for heart failure rises after the model is retrained, the individual's risk score would rise not only because they have a new heart failure risk factor, but also because the heart failure risk factor has risen in predictive importance based on the new coefficients.

We present the predicted probabilities separately for each model and population (if applicable).

Predictive Power

It is imperative that the accuracy of predictive models be assessed during both model development using holdout data, and in a production environment once the scores have been deployed. "Holdout data" are data that are available at the time of model training *but not used to train the models*; the Pre- Models reserve 20% of all data to use as holdout data for purposes of model assessment. Testing model performance on holdout data constitutes assessing the

predictive performance on the model on data that is new to the model (although which is technically available at the time of model training). Assessing model performance in a production environment, however, means that we check the accuracy of scores that were released to the relevant healthcare providers against events that *actually occurred* in the following month. Since this requires knowledge of the "true" events in the month after a given score release, this is only possible several months following the release of a given month of risk scores.

Typically, the discriminatory power of predictive models is summarized using the c-statistic, which is a measure of the area under the Receiver Operating Characteristic (ROC) curve (Steyerberg et al., 2010). The ROC curve plots the true positive rate against the false positive rate for binary classifiers using successive cutoff thresholds and "measures the probability that a randomly selected diseased subject has a higher predicted risk than a randomly selected non-diseased subject" (Mauguen & Begg, 2016). However, this measure is uninformative regarding model calibration, which is the degree to which estimated risk scores match underlying true risk: it is possible to have a model with strong discrimination and poor calibration (Alba et al., 2017). Moreover, the objective of the Hilltop Pre- Models is not binary classification, but instead the estimation of individual-level risks of incurring the model specific outcome event so that care managers can, by focusing on the riskiest individuals, potentially intervene. To that end, the performance of the Hilltop Pre- Models is assessed using the *concentration curve*.[9]

This measure of model accuracy estimates the cumulative share of all model-specific outcome events incurred by the riskiest patients, where the reader can determine the share of all outcome events occurring for individuals above different risk thresholds. To estimate the concentration curve, the patient cohort panel is ordered from most to least risky (in terms of predicted risk) on the X axis, and the fraction of total outcome events captured by the riskiest patients on the Y axis. We estimate the percent of outcome events incurred by the top 1% and 10% riskiest patients based on their absolute risk.

Concentration curves can be summarized by a Gini coefficient, a measure of 0 to 1, that can be interpreted as a measure of risk concentration in the population: the greater the Gini index, the more concentrated is the risk of the model-specific outcome event in a small proportion of persons (Llorca & Delgado-Rodríguez, 2002). A higher Gini coefficient indicates better model fit. To assess whether model performance is improving or declining over time, we estimate monthly concentration curves for the 20% holdout sample of the training data set.

Where possible, we assess predictive power on both holdout and production samples. We present the predictive performance metrics separately for each model and population (if applicable) for each model.

[9] This is very similar to the Lorenz curve, which "is especially useful in the context of disease prevention because it maps out what public health policy investigators need to know. That is, it tells us how much disease burden will occur in any given proportion of the population with risks above a chosen threshold" (Mauguen & Begg, 2016).

Reason for Risk

As of January 11, 2020, the Hilltop Pre- Models have—in addition to generating individual-level risk scores—also displayed the top actionable risk factors underlying each patient's risk of incurring a future model-specific outcome. The intention of this update was to further facilitate patient-specific advanced primary care by providing practices insight into why a patient received their risk score. For example, in addition to a risk score of 3.2% for a particular patient, care managers will also be able to see that the patient (for example) meets the clinical criteria for diabetes and heart failure and incurred a claim for insulin within the past year (in descending order of contribution to risk). This is particularly important as patients may have the same risk score but have different contributing risk factors.

While that patient may also have had other salient risk factors, Hilltop only displays the most predictive and intervene-able risk factors in order to allow care mangers to focus their attention on the most pressing patient needs.[10] These constitute the "reasons for risk". Based on the feedback from stakeholders, Hilltop excludes risk factors that are not potentially modifiable; that is, for which the effects cannot be meaningfully modified by clinical intervention (e.g., area income). Additionally, risk factors that are not positive and statistically significant are also excluded from the reason for risk pool.

These reasons for risk are based on the underlying risk factor coefficients, which are derived from the training phase of the model. It is important to note that these coefficients do not necessarily have a *causal* interpretation: they only capture the strength of *association* between a given risk factor and the risk of incurring a future outcome. For example, if the risk factor coefficient for diabetes is positive in a particular model, then that could mean that having diabetes *causes* an increased risk of that model's outcome; however, it could also mean that having diabetes is only *correlated* with some unobserved factor that causes an increased risk of that model's outcome. While these risk factors do not have a strictly causal interpretation, they are intended to provide care managers with a useful starting point from which to address specific patient needs.

In order to operationalize the identification of reasons for risk, the Hilltop team first re-coded select risk factors so that a higher level of a given risk factor is theoretically associated with greater risk of incurring the outcome event for each model. Consider the example of flu vaccinations: there is evidence that receiving annual influenza and/or pneumococcal vaccinations reduce the risk of hospitalization for various prevention quality indicators (PQIs) in various populations (Furumoto et al., 2008; Hedlund et al., 2003; Nichol et al., 2003). This implies that receipt of a flu vaccination should be *negatively* associated with the risk of incurring an avoidable hospital event. This risk factor, then, was re-coded to be 1 if the individual has *not* received a flu vaccination, and 0 if the individual *has* received a flu vaccination.

[10] Hilltop collected stakeholder feedback from clinical partners in order to ensure that we only displayed those risk factors over which patients, providers, and care managers can exert some control. We did not, for example, include most environmental risk factors, since providers cannot directly assist patients with the management of this factor.

Consider the following illustrative example. Suppose that the Pre-AH Model contains only three risk factors: a flag for diabetes, the number of recent avoidable hospitalizations, and a flag for heart failure. In this example, the coefficients for these three risk factors are 0.1, 0.08, and 0.07, respectively. The coefficient for diabetes represents the increase in risk of avoidable hospitalizations associated with having diabetes (relative to not having diabetes), holding all other factors constant.[11] The coefficient for the number of avoidable hospitalizations reflects the added risk associated with one additional previous avoidable hospitalization, and the coefficient for heart failure reflects the added risk associated with having heart failure (relative to not having heart failure), again holding all other factors constant.

It is important to note that these risk coefficients are marginal effects; that is, the *additional* risk due to, for example, a patient having one additional previous avoidable hospitalization. In order to translate these marginal effects to reason for risk contributions, Hilltop multiplies each marginal estimate by the *level* of that risk factor for each individual. Thus, if an individual has four previous avoidable hospitalizations (over the last 35 person-months), then the risk contribution of avoidable hospitalizations is 4*0.08 = 0.32.[12] Crucially, this risk contribution is still interpreted relative to a reference category: in this case, individuals with no history of avoidable hospitalizations. More broadly, the risk contribution should be interpreted relative to individuals *without* that particular risk factor.[13]

Suppose that, in this example, there are four patients in a given practice panel. Patient 1 has diabetes, no history of avoidable hospitalization, and heart failure. Patient 2 does not have diabetes, has no history of avoidable hospitalization, and has heart failure. Patient 3 has diabetes, four prior avoidable hospitalizations, and does not have heart failure. Finally, Patient 4 does not have diabetes, has one previous avoidable hospitalization, and has heart failure. This information is presented in Table 6, below.

Table 6. Hypothetical Reason for Risk Example

Patient ID	Diabetes	Diabetes * Coefficient	# AH	# AH * Coefficient	Heart Failure	Heart Failure * Coefficient
1	1	0.1	0	0.0	1	0.07
2	0	0.0	0	0.0	1	0.07
3	1	0.1	4	0.32	0	0.0
4	0	0.0	1	0.08	1	0.07

In this example, the top reason for risk for Patient 1 is diabetes: this risk factor yields the largest positive contribution (risk factor level * coefficient) among all the risk factors for that individual.

[11] Since our baseline model is a multivariate logistic regression, the coefficient is technically the marginal impact on log odds of incurring an avoidable hospital event. For the sake of exposition, we label this as "risk."

[12] This assumes that marginal effect is constant across units: that is, that the effect neither grows, nor shrinks, as the level of the risk factor rises. Since the vast majority of the reason for risk factors are binary variables, for which this assumption does not bind, we believe that this is a reasonable simplification.

[13] This motivates the exclusion of continuous (that is, non-binary and non-count) risk factors from the reason for risk pool: there is no natural reference group for these risk factors. For example, there is no meaningful group of people that do not have the "age" risk factor.

For Patient 2, the top reason for risk is heart failure; for Patient 3, the top reason for risk is the history of avoidable hospitalizations; and for Patient 4, the top reason for risk is the history of avoidable hospitalizations. The second reason for risk is calculated analogously: it is the second highest contribution of (risk factor level * coefficient) for each individual. All other reasons for risk are estimated in a similar fashion.

Users can also see the contribution of each risk factor category (Condition, Demographic, Pharmacy, Utilization, and Environmental) in percentage terms for the risk models. These are intended to provide a high-level description of the contribution of various types of risk factors that are positive and significant for an individual. The contribution for a given category is calculated as the sum of (risk factor level * coefficient) for all reasons for risk in that category, divided by the sum of (risk factor level * coefficient) for all positive, statistically significant reasons for risk. It is important to note that an individual's *overall* risk is a function of *all* risk factors, including those that are not included as potential reasons for risk (e.g., median area income). The category contributions, however, are only interpretable relative to the reason for risk pool, which is restricted to the operationalizable, modifiable risk factors.[14]

Limitations

There are three main limitations of the Hilltop Pre- Models that are important to consider when implementing the models for guiding care coordination services: the timing lag, the lack of clinical risk factors, and the granularity of the environmental risk factors. These are discussed in detail below.

Timing Lag

Hilltop receives the Medicare CCLF claims with a lag of over one month. CCLF claims that arrive in late October 2024, for example, cover utilization through mid-September 2024. Hilltop uses these data to calculate risk factors based on utilization in September 2024 and then applies the risk model coefficients to estimate the risk of incurring an avoidable hospitalization in October 2024. These scores are then deployed in mid-November 2024 for use by providers and care managers. This raises two distinct, but related, issues:

- By providing the one-month predictions (in this example, predicting October 2024 events) to care managers over a two-month time horizon (here, in November 2024), the risk predictions may be "outdated" by the time they are used by care managers and providers.
- The risk predictions do not incorporate the most recent patient experience, which may degrade the quality of the risk scores.

[14] If an individual has 3.2% overall risk and the Condition category contribution is 50%, then it is not appropriate to conclude that 50% of that individual's risk is due to Condition risk factors. Instead, it is appropriate to conclude that, of the positive, statistically significant, operationalizable, modifiable risk factors for that individual, conditions represent 50% of the total (risk factor level * coefficient).

Hilltop does not believe that this issue—the possibility that the risk score quality is impaired due to either being "outdated" or missing relevant recent information—substantively impacts the utility of our risk scores, for three reasons. First, the time-variant risk factors in the predictive models are all estimated with a look-back period of at least one year. This has the consequence that risk factors tend to change slowly, meaning that the risk scores also change slowly. As a result, there is high consistency of risk scores across months: patients that have high risk scores in October 2024 will also have high risk scores in November 2024. Second, internal testing has verified that applying one-month predictions on a two-month time horizon is substantively equivalent to directly estimating two-month predictions. This, to the extent that structural factors determine the risk of incurring a given outcome, it is likely that high-risk *behavior* persists across time; that is, most individuals will not suddenly "become" high-risk in the interval between the most recent claims data and receipt of the risk scores by care managers and providers.

Clinical Data

Administrative claims data do not include information on vital statistics—for example, blood pressure or lab results—meaning that Hilltop is unable to incorporate those clinical risk factors into our predictive models. It is likely that development of clinical risk factors would improve the predictive power of the models, although researchers have documented only relatively modest improvements in model performance for claims-and-clinical models relative to claims-only prediction models for heart failure patients (Hammill et al., 2011). Hilltop hopes to include this information in future versions of the model once the level of information exchange between electronic health records allows.

Environmental Risk Factors

To control for environmental factors in the Hilltop Pre- Models, we have developed a rich set of ZIP code-level and census tract-level covariates derived from publicly available sources. These data have two main limitations:

- The data are static: the environmental risk factors for a given attributed beneficiary do not change over time. This is largely due to data availability, as the publicly available data sources are only refreshed periodically. Hilltop plans, in the future, to use the address-level information available in the CCLF claims to disaggregate (and refresh) the area-level risk factors as much, and as frequently, as possible. Additionally, if available in the future, individual-level social welfare screening data will be added to provide a more robust individual-level risk prediction.
- ZCTA-level risk factors are relatively coarse: Maryland has 468 ZCTAs, each containing, on average, roughly 13,000 Maryland residents. To the extent that risky individuals tend to live in the same ZIP codes, ZIP code-level risk factors offer little predictive power. The census tract-level of the covariates are more granular; however, they are currently only available for MDPCP beneficiaries. Hilltop plans to assess the feasibility of extending the

geocoding procedure to link individual claims and census tract-level environmental risk factors to the Medicaid population in the near future.

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Section 3. Pre- Model Specifications

Pre-AH

The Hilltop Pre-AH Model is a risk prediction model that uses a variety of risk factors derived from administrative claims and publicly available social and environmental data to estimate the probability that a given patient incurs an avoidable hospital event in the following month. It was initially developed by The Hilltop Institute, in conjunction with the Maryland Department of Health (the Department), to support the care management efforts of primary care providers enrolled in MDPCP. Given the MDPCP's emphasis on the reduction of unneeded utilization, the Hilltop Pre-AH Model focuses on *potentially avoidable* hospitalization or ED visits.[15] These events, by definition, are more likely to be prevented with targeted, outpatient care efforts than all-cause, general hospitalizations and ED visits.

The Hilltop Pre-AH Model risk scores were first deployed for the MDPCP population in October 2019. Patient-level risk scores and reasons for risk are provided to participating practices monthly for their attributed beneficiaries via the MDPCP Prediction Tools area on CRISP. These risk scores were originally referred to as the "Likelihood of Avoidable Hospital Event" (LAH) scores; at the time of this writing, they are known as the "Avoidable Hospital Events (Pre-AH)" scores. In addition to being available in the MDPCP Prediction Tools area, the Pre-AH Model risk scores are also available in the CRISP multi-payer reporting suite.

Beginning in May 2021, a second version of the Hilltop Pre-AH Model was deployed for the MCOs that are part of the Maryland Medicaid HealthChoice program. This version of the model uses the same risk factors but is trained and scored for Medicaid recipients enrolled in the HealthChoice program. These patient-level risk scores are provided to MCOs monthly for their enrollees via secure file transfer and are also available in the CRISP multi-payer reporting suite.

Beginning in January 2025, a third version of the Hilltop Pre-AH Model was deployed for two new populations: Medicare FFS beneficiaries not attributed to an MDPCP participating practice and Medicaid FFS beneficiaries. Patient-level risk scores and reasons for risk are made available via the CRISP Multi-Payer reporting suite.

Outcome: Avoidable Hospitalizations and ED Visits

The outcome measure in the Hilltop Pre-AH Model is a 0/1 indicator variable denoting whether an individual incurred an avoidable hospitalization or ED visit in a given month. To construct this measure, Hilltop relies on technical definitions provided by the Agency for Healthcare Research

[15] Potentially avoidable hospitalizations/ED visits are those incurred for medical conditions or diagnoses "for which timely and effective outpatient care can help to reduce the risks of hospitalization by either preventing the onset of an illness or condition, controlling an acute episodic illness or condition, or managing a chronic disease or condition" (Billings et al., 1993). This measure is discussed in greater detail in Section 3.2.1.

and Quality (AHRQ) as part of its PQI measures.[16] Diagnosis codes from administrative claims are used to flag the following conditions, which are the basis for the composite outcome variable:[17]

- PQI #1: Diabetes Short-Term Complications
- PQI #3: Diabetes Long-Term Complications
- PQI #5: COPD or Asthma in Older Adults
- PQI #7: Hypertension
- PQI #8: Heart Failure
- PQI #11: Community Acquired Pneumonia
- PQI #12: Urinary Tract Infection
- PQI #14: Uncontrolled diabetes
- PQI #15: Asthma in Younger Adults
- PQI #16: Lower-Extremity Amputation among Patients with Diabetes

This is implemented in the model as an indicator variable at the person-month level. If an individual incurs at least one avoidable hospitalization or ED visit in a given month, then that person receives a value of 1 for this variable—and 0 otherwise.

At the time of writing, the model uses the 2023 PQI definitions. Based on planned model updates, the 2024 PQI definitions will be used to create scores starting in February 2025.

Risk Factor Updates

As part of the ongoing development process, Hilltop makes improvements or additions to the pool of risk factors.

- June 2020: Hilltop added eight new risk factors to the model: an indicator for frailty; an indicator for original Medicare eligibility due to a non-age-related reason; an indicator for DME use within the past year; the number of ED visits in the past six months; an indicator for sickle cell anemia; area-level pollution level; area-level walkability; and area-level pharmacy density.
- October 2021: Hilltop developed an automated geocoding pipeline to identify each beneficiary's census block of residence where possible. This allowed us to use more granular versions of the environmental risk factors (census tract-level) that are posited to more accurately describe an individual's' proximal environment. The census tract

[16] For more information, see https://www.qualityindicators.ahrq.gov/modules/pqi_resources.aspx.
[17] Specifically, Hilltop defines these claims as those with a claim type of either 60 or 61 (indicating an inpatient claim) or a claim type of 40 (indicating an outpatient claim) and revenue center codes of 0450-0459 and 0981. Source: https://www.resdac.org/articles/how-identify-hospital-claims-emergency-room-visits-medicare-claims-data.

versions of the variables are currently only used for the MDPCP population (see Appendix 2 for more detail).

Pre-DC

The Hilltop Institute's Pre-DC Model is designed to facilitate the active management of type 2 diabetes by estimating individuals' risk of incurring inpatient admissions or ED visits for severe diabetes complications. For each population in which the Pre-DC model is deployed, Hilltop estimates risk scores and reasons for risk for all patients in the population every month to help care teams proactively identify high-risk individuals and thus target care management resources accordingly.

It is important to note that we do not require patients to have an active type 2 diabetes diagnosis to receive a Pre-DC score. This is intentional. Requiring an active diabetes diagnosis would exclude individuals who may have undiagnosed diabetes, or who have diagnosed diabetes, but who have not received care within the data window. Additionally, the model estimates risk for conditions that are considered severe complications for type 2 diabetes based on the Diabetes Complications Severity Index. Certain of the conditions, like "type 2 diabetes with ketoacidosis with coma," are specific to type 2 diabetes, but others, like "gas gangrene," are more general. Therefore, it is possible for a patient without type 2 diabetes to be at high risk for one (or more) of the more general complications.

This model was initially developed by The Hilltop Institute, in conjunction with the Maryland Department of Health, to support the care management efforts of primary care providers enrolled in MDPCP in alignment with the State's Statewide Integrated Health Improvement Strategy (SIHIS) goal of reducing the public health costs of diabetes.

The Hilltop Pre-DC Model risk scores were first deployed for the MDPCP population in October 2022. Patient-level risk scores are provided to participating practices monthly for their attributed beneficiaries via CRISP and are known as the "Severe Diabetes Complications (Pre-DC)" scores. In January 2025, the Pre-DC Model was deployed in three additional populations - the Maryland HealthChoice population, the Medicare FFS population and the Medicare FFS population – and are made available to end-users through the CRISP Multi-Payer Reporting Suite.

Finally, is it important to note that while the Pre-AH Model and the Pre-DC Model both include diabetes complications in the outcome that is predicted, the predicted outcome differs significantly across the two models, and the resulting risk scores are statistically distinct.[18]

Outcome: Severe Type 2 Diabetes Complication

Severe complication of type 2 diabetes (1/0) is defined as an inpatient hospitalization or ED visit in a person-month with one or more of the following ICD-10 diagnosis codes (in any position on

[18] For additional information see https://health.maryland.gov/mdpcp/Documents/PreDC_PreAH_Outcome_Distinction_Final.pdf

the claim) associated with severe complications of diabetes as defined by the Diabetes Complication Severity Index (DCSI):[19]

Retinopathy

Retinal detachments and breaks: H33.x
Type 2 diabetes mellitus with severe non-proliferative diabetic retinopathy: E11.34xx
Type 2 diabetes mellitus with proliferative diabetic retinopathy: E11.35xx
Blindness and low vision: H54.x
Vitreous hemorrhage: H43.1x

Nephropathy

Type 2 diabetes mellitus with chronic kidney disease (stage 4 or 5): E11.22, N18.4, N18.5
Type 2 diabetes mellitus with end stage renal disease: E11.22, N18.6
Unspecified kidney failure: N19

Cerebrovascular Complications

Nontraumatic intracerebral hemorrhage: I61.x
Cerebral infarction: I63.x
Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction: I65.x
Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction: I66.x
Acute cerebrovascular insufficiency: I67.81

Cardiovascular Complications

Acute myocardial infarction (STEMI, NSTEMI): I21.x
Subsequent acute myocardial infarction (STEMI, NSTEMI): I22.x
Complications from acute myocardial infarction (STEMI, NSTEMI): I23.x
Old myocardial infarction: I25.2
Atrial fibrillation and flutter: I48.x
Cardiac arrest: I46.x
Paroxysmal tachycardia: I47.x
Other cardiac arrythmia: I49.x
Heart failures: I50x
Atherosclerosis of native arteries of the extremities with ulceration/gangrene: I70.25x, I70.26x
Aortic aneurysm/dissection: I71.x

Peripheral Vascular Disease

Gas gangrene: A48.0
Embolism and thrombosis of arteries of the lower extremities: I74.3
Non-pressure chronic ulcer of limb, not elsewhere classified: L97.x
Type 2 diabetes with diabetic peripheral angiopathy, with gangrene: E11.52
Gangrene, not elsewhere classified: I.96

Metabolic Complications

Type 2 diabetes mellitus with hyperosmolarity, with coma: E1101

[19] Centers for Disease Control and Prevention, 2020; Chang et al., 2012; Glasheen et al., 2017

Type 2 diabetes mellitus with ketoacidosis, with coma: E1111
Type 2 diabetes mellitus with hypoglycemia, with coma: E11641

The DSCI scores complications from 0 (no abnormality) to 2 (severe abnormality). Only complications with a score of 2 are included in the event definition for "severe complications of type 2 diabetes" (Young et al., 2008).

Risk Factors

The Pre-DC Model is built on the Hilltop Pre-AH Model and thus uses all the risk factors from the Pre-AH Model. There are 18 additional risk factors created from facility-related claims, provider-related claims, and prescription drug-related claims. See the Literature Review section below for details on the identification of these additional risk factors. While some of these risk factors are eliminated in the variable selection step, this process is data-driven, and all risk factors are included in the pool of *potential* risk factors to be used in the model. A high-level description of risk factors, as well as the process for identifying them, is provided in the sections below. For a description of each risk factor, along with data source and sample statistics, see Appendix 1.

Focused Literature Review

As part of the development process for its type 2 diabetes complications predictive model, Hilltop conducted a literature review to identify potential risk factors for inclusion in the model. This is a crucial element of model development: including high-quality risk factors as predictors can improve model performance, transparency, and interpretability. The review was intended to survey the existing literature and locate risk factors for which there is statistical evidence of association with type 2 diabetes complications. In early 2022, the research team searched PubMed to identify published literature that identifies risk factors for hospitalization for type 2 diabetes complications.[20] This review proceeded in three phases: a title screen, an abstract screen, and a full-text review. All records were reviewed by two independent reviewers on the research team. Any disagreements were reconciled through additional reviewer discussion.

We identified 107 articles that met the search criteria and conducted title and abstract screens on this pool of results. This process yielded 35 papers for full-text review. In the risk factor extraction process, we excluded as candidate risk factors those that were similar in substance to those already in the Pre-AH risk factor library. We then grouped similar remaining risk factors. The risk factor extraction yielded 18 unduplicated risk factors that have been shown to be highly predictive of type 2 diabetes complications.

[20] We used the following search strings: "(Diabetes Mellitus, Type 2/complications*) AND (Machine Learning)"; "(Diabetes Mellitus, Type 2/complications*) AND (Predict*) AND (Administrative data)"

Pre-HE

The Hilltop Institute's Pre-HE Model is designed to support proactive advanced care planning discussions by estimating a patient's risk of death within the next six months. Every month, Hilltop estimates risk scores and reasons for risk for all attributed patients of MDPCP-participating practices with the goal of identifying patients who are potentially suitable for hospice care and providing care teams with information that can guide the sensitive and difficult conversations about end-of-life care with patients and their families. It was initially developed by The Hilltop Institute, in conjunction with the Maryland Department of Health, to support the care management efforts of primary care providers enrolled in MDPCP.

The Hilltop Pre-HE Model risk scores were first deployed for the MDPCP population in October 2022. Patient-level risk scores are provided to participating practices monthly for their attributed beneficiaries via CRISP and are known as the "Hospice Eligibility and Advanced Care Planning (Pre-HE)" scores. These scores are only available for patients attributed to MDPCP-participating providers.

Outcome: Death within Six Months

Death within six months (1/0) is defined at the person-month level as the presence of a date of death for a beneficiary in the Beneficiary Demographics file that is within six months of the last day of each person-month. This means that for each beneficiary who has died, the flag for this event will be a 1 for the month of their death and for the five months prior to their death.

Table 7. Example Scenario for Modeling Death within 6 Months

	Jun 2024	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024
Presence of a Date of Death	-	-	-	-	-	-	X
Death within 6 Months Flag	0	1	1	1	1	1	1

Risk Factors

Because the Pre-HE Model is built on the Hilltop Pre-AH Model, it uses all the risk factors from the Pre-AH Model, in addition to 18 other risk factors created from facility-related claims, provider-related claims, and prescription drug-related claims. While some of these risk factors are eliminated in the variable selection step, this process is data-driven, and all risk factors are included in the pool of *potential* risk factors to be used in the model. A high-level description of risk factors, as well as the process for identifying them, is provided in the sections below. For a description of each risk factor, along with data source and sample statistics, see Appendix 1.

Literature Review

As part of the development process for this model, Hilltop conducted a literature review in order to identify potential risk factors for inclusion in the model. This is a crucial element of model development: including high-quality risk factors as predictors can improve model performance, transparency, and interpretability. The review was intended to survey the existing literature and locate risk factors for which there is statistical evidence of association with mortality within a short or moderate time horizon. In early 2022, the research team searched PubMed to identify published literature that identifies risk factors for mortality.[21] This review proceeded in three phases: a title screen, an abstract screen, and a full-text review. All records were reviewed by two independent reviewers on the research team, and any disagreements were reconciled through additional reviewer discussion.

We identified 80 articles that met the search criteria and conducted title and abstract screens on this pool of results. This process yielded 22 papers for full-text review. In the risk factor extraction process, we excluded as candidate risk factors those that were similar in substance to those already in the Pre-AH risk factor library, and then grouped similar remaining risk factors. The risk factor extraction yielded 18 unduplicated risk factors that have been shown to be highly predictive of mortality within a short or moderate time horizon.

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[21] We used the following search strings: "(mortality/frailty) AND (predict*) AND Medicare*"; "(mortality) AND (machine learning) AND Medicare*"

Section 4: Pre- Model Operations & Performance

This section provides an overview of how each Pre- Model operates and performs in each population. We present three sets of information for all nine model-population combinations – Pre-AH, Pre-DC, Pre-HE Models for the MDPCP population and Pre-AH and Pre-DC Models for the non-MDPCP Medicare FFS, Medicaid HealthChoice, and Medicaid FFS populations:

- Risk factor coefficients: Coefficient estimates for all risk factors retained in Model 1, which includes all six categories of risk factors: diagnostic, pharmacy, procedural, utilization-based, geographic, and demographic. The risk factor coefficients in each table are presented as odds ratios[22]. Note that risk factor coefficient estimates will change as the model is re-trained. Updated risk factor coefficients are available upon request.

- Predicted probability: A summary of the set of predicted probabilities that estimate the patient-specific risk of incurring the model-specific outcome for each population. In general, these events are rare and, consequently, the predicted probabilities are low. Hilltop does not interpret this as a limitation of the risk scores; rather, this reflects the relative rarity of the outcome events. Moreover, the relative risk is the key metric that should be used to allocate care resources: no matter the absolute risk of the patient panel, the efficient allocation of care resources requires the identification (and treatment) of the riskiest patients.

- Predictive performance: A summary of how well the Pre- Model risk scores predict the specified outcome in holdout data (20%), which occurs during the model training process, and, where possible, how they predict the model-specific outcome events in temporally distinct production data. See Section 2 for more detailed information on the predictive performance metrics.

Pre-AH

MC-PCP

Table 8 presents the risk factor coefficient estimates for Model 1 for the Pre-AH Model trained in the MDPCP-attributed Medicare FFS (MC-PCP) population in September 2024.

Table 8. Pre-AH MC-PCP Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Prior hospitalization discharge status - other	2
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.519
CCW indicator for heart failure and non-ischemic heart disease	1.481

[22] Odds ratios can be interpreted in terms of a multiplicative impact. For example, an odds ratio of 1.05 indicates that if that risk factor were to increase by one unit, then the risk of incurring an avoidable hospitalization would increase by 5%.

Risk Factor	Odds Ratio
CCW indicator for hypertension	1.438
Beneficiary race - Black	1.393
Indicator for retinopathy	1.386
CCW indicator for autism spectrum disorders	1.385
Number of avoidable hospitalizations	1.385
Indicator for original Medicare eligibility for a non-age related cause	1.38
CCW indicator for intellectual disabilities and related conditions	1.36
Prior hospitalization admission type - emergency	1.347
CCW indicator for cerebral palsy	1.347
Indicator for urinary tract infection	1.334
Indicator for insulin use	1.287
Indicator for hospice enrollment	1.277
CCW indicator for tobacco use	1.274
Indicator for previous conservative diabetic wound procedure	1.269
Beneficiary race - Hispanic	1.26
Located in partial county primary care shortage area	1.214
CCW indicator for lung cancer	1.212
Prior hospitalization discharge status - home	1.208
Indicator for problems with care provider dependency	1.206
Indicator for durable medical equipment (DME) use	1.199
Indicator for arrhythmia	1.188
Prior hospitalization admission type - urgent	1.18
Indicator for oral corticosteroid use	1.161
Indicator for fluid and electrolyte imbalance	1.158
CCW indicator for chronic kidney disease	1.157
CCW indicator for asthma	1.156
CCW indicator for diabetes	1.156
Indicator for dual eligibility with Medicaid	1.148
Indicator for frailty	1.13
CCW indicator for Parkinson's Disease or Secondary Parkinsonism	1.129
Indicator for diabetes with complications	1.128
CCW indicator for ischemic heart disease	1.123
Indicator for oral antibiotic use	1.123
Beneficiary race - White	1.115
CCW indicator for atrial fibrillation and flutter	1.112
Indicator for pneumonia	1.106
Number of emergency department visits within the past 6 months	1.097
CCW indicator for pressure and chronic ulcers	1.092
Located in whole county mental health care shortage area	1.092
CCW indicator for peripheral vascular disease	1.091
Indicator for albuminuria	1.085
Beneficiary sex - female	1.08
CCW indicator for anemia	1.073
CCW indicator for anxiety disorders	1.067
Number of urgent care visits	1.067

Risk Factor	Odds Ratio
Indicator for pulmonary circulatory disorder	1.065
Indicator for neuropathy	1.063
Indicator for respiratory infection	1.062
Indicator for beta blocker use	1.06
CCW indicator for depression, bipolar, and other depressive mood disorders	1.056
Indicator for no vaccination (flu or pneumonia)	1.053
Indicator for provider administered drug	1.048
Number of home health visits	1.032
Age	1.024
Number of outpatient visits	1.003
Median household income	1
Physician diversity	1
Number of medications	.998
Continuity of primary care - Duration	.998
Percent live alone, ages 65+	.998
Number of primary care visits	.997
Number of lab tests	.979
Indicator for losartan use	.954
Indicator for solid tumor without metastasis	.951
CCW indicator for osteoporosis with or without pathological fracture	.942
CCW indicator for hyperlipidemia	.939
Indicator for anti-diabetes medication use	.935
CCW indicator for glaucoma	.933
Indicator for mental health use	.93
Indicator for sepsis	.923
Indicator for rivaroxaban use	.919
CCW indicator for rheumatoid arthritis/osteoarthritis	.913
Indicator for prior surgery	.905
CCW indicator for cataracts	.901
Indicator for protein-calorie malnutrition	.868
Indicator for statin use	.854

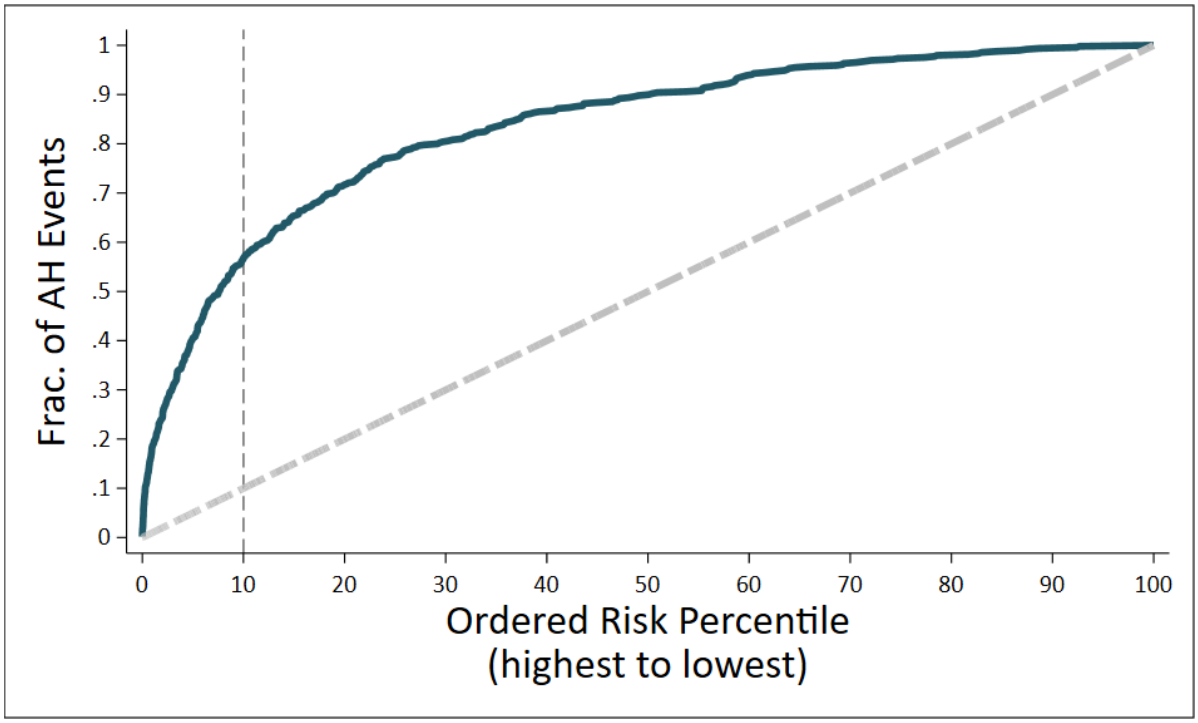
Table 9 presents summary statistics from a recent month of Pre-AH Model risk scores in the MC-PCP patient population.

Table 9. Summary Statistics for Pre-AH Scores in the MC-PCP Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	346,083	.0043	25,436	.9727

Figure 1 shows the concentration curve for the Pre-AH scores in one month of the holdout data. This curve shows how well the risks cores predict AH events in the following month. We find that the top 10% riskiest patients account for approximately 56% of all avoidable hospital events in the following month.

Figure 1. Pre-AH Concentration Curve as of August 2024 in the MC-PCP Population



Post-deployment model evaluation is a crucial component of the predictive model lifecycle. The first Pre-AH risk scores were released for the MC-PCP population in November 2019 and have since been regularly updated. Hilltop monitors the accuracy of the Pre-AH Model predictions in a production environment by comparing the risk scores released in a given month with the true outcomes that occur in the following month. Table 10 shows the percentage of all AH events incurred by patients with the top 1% and top 10% of Pre-AH scores in the month following the score release for six sets of risk scores.

Table 10. Production Predictive Performance of the MC-PCP Pre-AH Scores by Month

Model Version	Score Release Date	Top 1% of Patients	Top 10% of Patients
y5q4m12	03/08/2024	12.78%	47.49%
y5q4m12	04/12/2024	13.60%	45.80%
y6q1m03	05/10/2024	13.30%	46.45%
y6q1m03	06/07/2024	12.14%	47.60%
y6q1m03	07/12/2024	14.45%	49.46%
y6q2m06	08/09/2024	12.75%	46.93%

Note: The evaluation period is for 1 month following the score release date.

MC-FFS

Table 11 presents the risk factor coefficient estimates for Model 1 for the Pre-AH Model trained in the remaining, non-MDPCP-attributed Medicare FFS (MC-FFS) population in September 2024.

Table 11. Pre-AH MC-FFS Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Prior hospitalization discharge status - other	2.515
Beneficiary race - Black	1.576
Discontinuity of primary care - Index	1.524
CCW indicator for hypertension	1.522
Number of avoidable hospitalizations	1.489
Indicator for retinopathy	1.48
CCW indicator for heart failure and non-ischemic heart disease	1.434
Beneficiary race - Hispanic	1.433
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.423
CCW indicator for cerebral palsy	1.407
Indicator for original Medicare eligibility for a non-age related cause	1.371
Indicator for urinary tract infection	1.348
Indicator for previous conservative diabetic wound procedure	1.327
Prior hospitalization admission type - emergency	1.308
Indicator for problems with care provider dependency	1.275
Indicator for insulin use	1.247
CCW indicator for tobacco use	1.24
Indicator for arrhythmia	1.22
Prior hospitalization discharge status - home	1.213
Beneficiary race - White	1.204
Prior hospitalization admission type - urgent	1.202
CCW indicator for chronic kidney disease	1.202
Indicator for diabetes with complications	1.192
CCW indicator for asthma	1.179
Indicator for durable medical equipment (DME) use	1.168
Indicator for oral corticosteroid use	1.16
Indicator for oral antibiotic use	1.152
CCW indicator for diabetes	1.148
Indicator for fluid and electrolyte imbalance	1.139
Indicator for frailty	1.129
Indicator for dual eligibility with Medicaid	1.121
CCW indicator for anxiety disorders	1.113
Indicator for pneumonia	1.101
Indicator for respiratory infection	1.098
CCW indicator for ischemic heart disease	1.095
Indicator for neuropathy	1.086
CCW indicator for peripheral vascular disease	1.086
Beneficiary sex - female	1.083
Indicator for beta blocker use	1.078
CCW indicator for anemia	1.067
Indicator for provider administered drug	1.065
Number of urgent care visits	1.065
Number of emergency department visits within the past 6 months	1.06
Number of home health visits	1.044

Risk Factor	Odds Ratio
Age	1.014
Number of outpatient visits	1.003
Percent single mothers	1.002
Median household income	1
Population	1
Number of primary care visits	.996
Number of prior admissions	.978
Number of HbA1c tests	.977
CCW indicator for rheumatoid arthritis/osteoarthritis	.937
Indicator for protein-calorie malnutrition	.917
Indicator for prior surgery	.905
CCW indicator for cataracts	.868
Indicator for statin use	.845
Discontinuity of primary care - Proportion	.836

Table 12 presents summary statistics from a recent month of Pre-AH Model risk scores in the MC-FFS patient population.

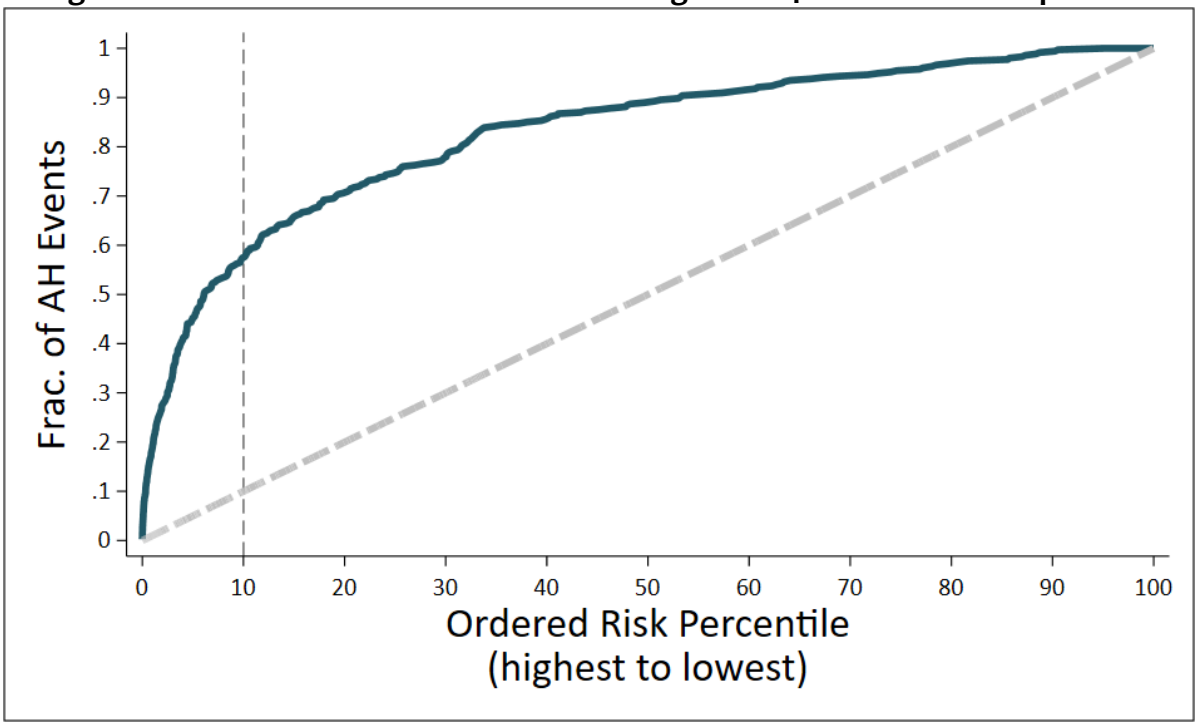
Table 12. Summary Statistics for Pre-AH Scores in the MC-FFS Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	369,608	.0049	34,300	NA*

*Multiple months of production scores were not yet available at the time of writing

Figure 2 shows the concentration curve for the Pre-AH scores in one month of the holdout data. This curve shows how well the risk scores predict AH events in the following month. We find that the top 10% riskiest patients account for approximately 57% of all avoidable hospital events in the following month.

Figure 2. Pre-AH Concentration Curve as of August 2024 in the MC-FFS Population



The first Pre-AH risk scores were released for the MC-FFS population in January 2025, and as of the time of writing, data are not yet available to assess their predictive power in the production environment.

MA_MCO

Table 13 presents the risk factor coefficient estimates for Model 1 for the Pre-AH Model trained in the Medicaid HealthChoice (MA-MCO) population in September 2024.

Table 13. Pre-AH MA-MCO Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
CCW indicator for asthma	2.792
Indicator for insulin use	1.725
Indicator for urinary tract infection	1.614
CCW indicator for diabetes	1.571
Indicator for diabetes with complications	1.564
Number of avoidable hospitalizations	1.56
Indicator for dual eligibility with Medicaid	1.502
Indicator for oral corticosteroid use	1.45
CCW indicator for pressure and chronic ulcers	1.412
CCW indicator for heart failure and non-ischemic heart disease	1.4
Discontinuity of primary care - Index	1.379
CCW indicator for hypertension	1.364
CCW indicator for tobacco use	1.355
Indicator for fluid and electrolyte imbalance	1.355

Risk Factor	Odds Ratio
Beneficiary race - Black	1.346
Indicator for respiratory infection	1.321
Indicator for previous conservative diabetic wound procedure	1.283
CCW indicator for learning disabilities	1.281
CCW indicator for spina bifida and other congenital anomalies of the nervous system	1.279
Indicator for pneumonia	1.262
Indicator for arrhythmia	1.247
Beneficiary race - Unknown	1.208
CCW indicator for drug use disorders	1.19
Indicator for leukotriene receptor modifier use	1.186
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.185
CCW indicator for benign prostatic hyperplasia	1.166
Indicator for provider administered drug	1.164
CCW indicator for chronic kidney disease	1.159
Indicator for gastroparesis	1.147
Beneficiary race - Hispanic	1.143
Indicator for oral antibiotic use	1.143
Beneficiary sex - female	1.135
CCW indicator for mobility impairments	1.129
CCW indicator for peripheral vascular disease	1.122
CCW indicator for atrial fibrillation and flutter	1.112
Indicator for no vaccination (flu or pneumonia)	1.093
Indicator for beta blocker use	1.079
Number of emergency department visits within the past 6 months	1.042
Number of medications	1.006
Percent with less than high school education, ages 65+	1.003
Percent in poverty age 65+	1.003
Age	1.002
National ranking of deprivation	1.002
Population density	1
Continuity of primary care - Duration	.999
Percent married	.996
Percent speak Spanish, aged 65+	.992
Number of primary care visits	.992
Percent foreign born	.974
CCW indicator for anxiety disorders	.964
Indicator for no federally qualified health center	.95
CCW indicator for fibromyalgia, chronic pain and fatigue	.947
CCW indicator for anemia	.942
Indicator for gastroesophageal reflux disease	.941
Indicator for sleep apnea	.936
Indicator for lifestyle problems	.931
CCW indicator for ADHD, conduct disorders, and hyperkinetic syndrome	.928
Number of HbA1c tests	.926
CCW indicator for migraine and chronic headache	.923

Risk Factor	Odds Ratio
Number of prior admissions	.922
Indicator for rheumatoid arthritis/collagen vascular disease	.91
CCW indicator for obesity	.9
CCW indicator for HIV/AIDS	.89
Indicator for neuropathy	.889
Indicator for oncologist visit	.883
Indicator for protein-calorie malnutrition	.879
CCW indicator for epilepsy	.872
CCW indicator for glaucoma	.871
CCW indicator for hyperlipidemia	.86
CCW indicator for rheumatoid arthritis/osteoarthritis	.859
Discontinuity of primary care - Proportion	.852
Number of lab tests	.84
Indicator for problems with employment and unemployment	.827
CCW indicator for other developmental delays	.826
Prior hospitalization discharge status - transferred to post-acute care	.81
Indicator for anti-diabetes medication use	.801
Prior hospitalization admission type - urgent	.764
Prior hospitalization admission type - elective	.7
Prior hospitalization admission type - none	.641
Indicator for sickle cell anemia	.621

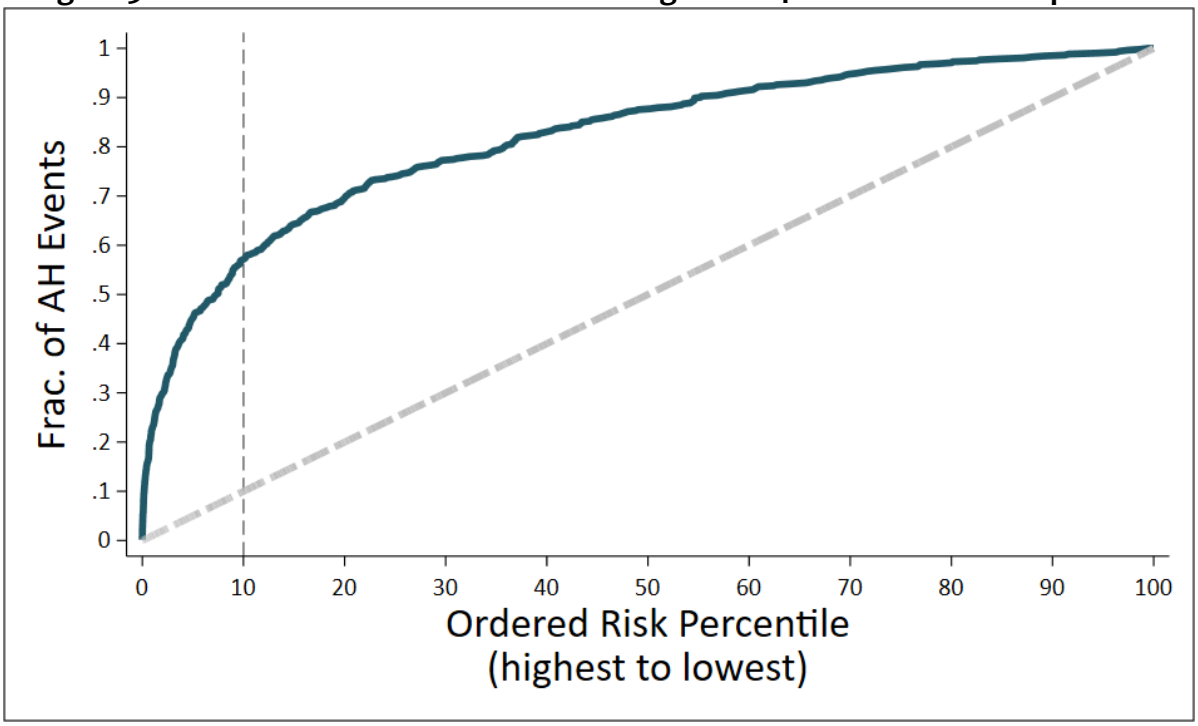
Table 14 presents summary statistics from a recent month of Pre-AH Model risk scores in the MA-MCO patient population.

Table 14. Summary Statistics for Pre-AH Scores in the MA-MCO Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	1,400,946	.0021	26,229	.9682

Figure 3 shows the concentration curve for the Pre-AH scores in one month of the holdout data. This curve shows how well the risk scores predict AH events in the following month. We find that the top 10% riskiest patients account for approximately 57% of all avoidable hospital events in the following month.

Figure 3. Pre-AH Concentration Curve as of August 2024 in the MA-MCO Population



The first Pre-AH risk scores were released for the MA-MCO population in May 2021 and have since been regularly updated. Hilltop monitors the accuracy of the Pre-AH Model predictions in a production environment by comparing the risk scores released in a given month with the true outcomes that occur in the following month. Table 15 shows the percentage of all AH events incurred by patients with the top 1% and top 10% of Pre-AH scores in the month following the score release for six sets of risk scores.

Table 15. Production Predictive Performance of the MA-MCO Pre-AH Scores by Month

Model Version	Score Release Date	Top 1% of Patients	Top 10% of Patients
y23m08	10/11/2023	21.73%	56.01%
y23m08	11/10/2023	21.74%	55.37%
y23m08	12/08/2023	23.92%	56.69%
y23m11	01/09/2024	24.42%	56.04%
y23m11	02/14/2024	23.29%	56.36%
y23m11	03/13/2024	22.78%	55.20%

Note: The evaluation period is for 1 month following the score release date.

MA-FFS

Table 16 presents the risk factor coefficient estimates for Model 1 for the Pre-AH Model trained in the Medicaid FFS (MA-FFS) population in September 2024.

Table 16. Pre-AH MA-FFS Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Discontinuity of primary care - Index	1.788
Indicator for insulin use	1.672
Prior hospitalization discharge status - transferred to inpatient care	1.613
CCW indicator for hypertension	1.495
CCW indicator for heart failure and non-ischemic heart disease	1.467
Indicator for diabetes with complications	1.431
CCW indicator for spinal cord injury	1.427
CCW indicator for asthma	1.421
Indicator for oral corticosteroid use	1.414
Indicator for fluid and electrolyte imbalance	1.388
Number of avoidable hospitalizations	1.374
Indicator for urinary tract infection	1.351
CCW indicator for migraine and chronic headache	1.265
CCW indicator for chronic kidney disease	1.264
CCW indicator for tobacco use	1.259
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.259
Beneficiary race - Black	1.243
CCW indicator for drug use disorders	1.232
Prior hospitalization admission type - emergency	1.231
Indicator for arrhythmia	1.226
Indicator for oral antibiotic use	1.223
CCW indicator for pressure and chronic ulcers	1.206
Indicator for pneumonia	1.145
Indicator for durable medical equipment (DME) use	1.134
Number of emergency department visits within the past 6 months	1.022
Age	1.01
Percent live alone, ages 65+	1.007
Social workers per 1000 residents	1.003
Number of outpatient visits	1.002
Continuity of primary care - Duration	.999
Number of primary care visits	.997
Indicator for cerebrovascular disease	.865
CCW indicator for epilepsy	.858
CCW indicator for viral hepatitis	.854
Indicator for protein-calorie malnutrition	.839
CCW indicator for hypothyroidism	.823
Indicator for solid tumor without metastasis	.792
Prior hospitalization discharge status - transferred to post-acute care	.786
Indicator for prior nursing home stay	.782
CCW indicator for ADHD, conduct disorders, and hyperkinetic syndrome	.781
Prior hospitalization admission type - elective	.722
Indicator for problems with employment and unemployment	.709
Prior hospitalization admission type - none	.653
Prior hospitalization discharge status - other	.645
Discontinuity of primary care - Proportion	.522

Table 17 presents summary statistics from a recent month of Pre-AH Model risk scores in the MA-FFS patient population.

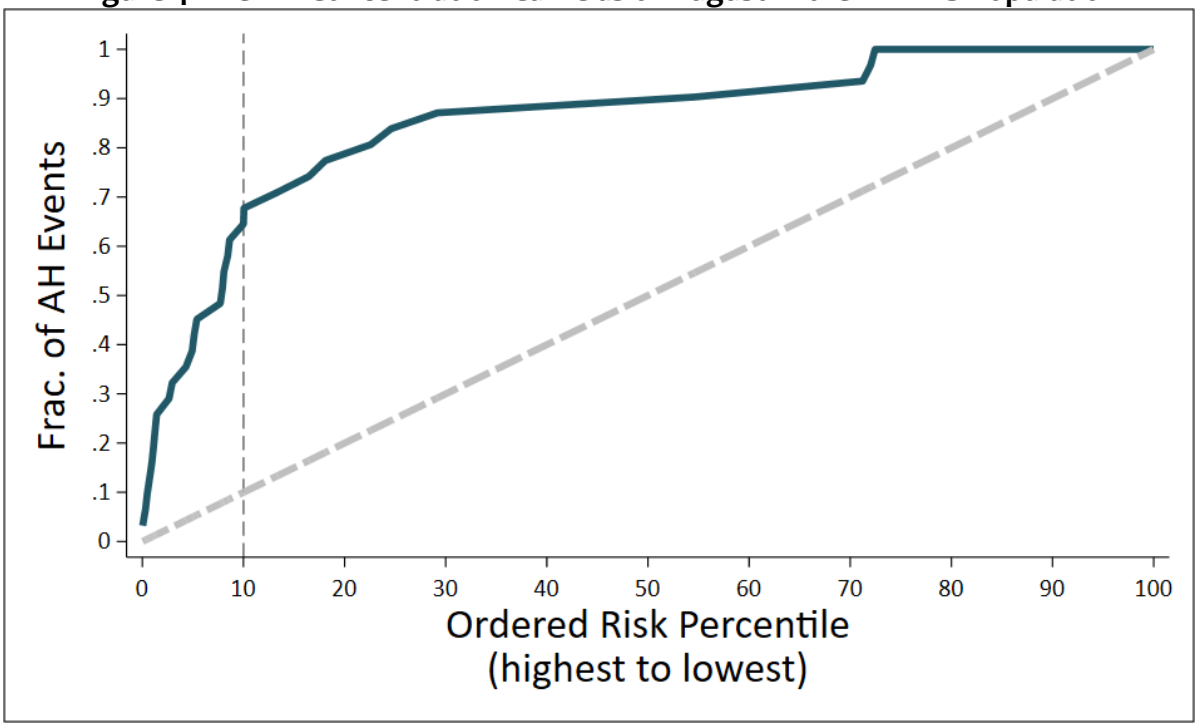
Table 17. Summary Statistics for Pre-AH Scores in the MA-FFS Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	47,784	.0043	3,293	NA*

*Multiple months of production scores were not yet available at the time of writing

Figure 4 shows the concentration curve for the Pre-AH scores in one month of the holdout data. This curve shows how well the risk scores predict AH events in the following month. We find that the top 10% riskiest patients account for approximately 61% of all avoidable hospital events in the following month.

Figure 4. Pre-AH Concentration Curve as of August in the MA-FFS Population



The first Pre-AH risk scores were released for the MA-FFS population in January 2025, and as of the time of writing, data are not yet available to assess their predictive power in the production environment.

Pre-DC

MC-PCP

Table 18 presents the risk factor coefficient estimates for Model 1 for the Pre-DC Model trained in the MDPCP-attributed Medicare FFS (MC-PCP) population in September 2024.

Table 18. Pre-DC MC-PCP Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Prior hospitalization discharge status - other	4.797
Prior hospitalization discharge status - transferred to inpatient care	2.312
Indicator for hospice enrollment	2.118
Indicator for sickle cell anemia	1.881
DCSI Score – Cardiovascular	1.734
CCW indicator for atrial fibrillation and flutter	1.701
CCW indicator for heart failure and non-ischemic heart disease	1.5
CCW indicator for hypertension	1.397
Indicator for no rural health clinic	1.375
CCW indicator for sensory (blindness and visual) impairment	1.295
CCW indicator for intellectual disabilities and related conditions	1.294
Prior hospitalization admission type - emergency	1.294
Indicator for original Medicare eligibility for a non-age related cause	1.284
Prior hospitalization discharge status - transferred to post-acute care	1.218
Number of Previous Severe Type 2 Diabetes Complications	1.202
CCW indicator for lung cancer	1.193
Indicator for metastatic cancer	1.187
Prior hospitalization admission type - urgent	1.186
Indicator for insulin use	1.181
Discontinuity of primary care - Index	1.176
Beneficiary race - Black	1.159
CCW indicator for anemia	1.149
Indicator for fluid and electrolyte imbalance	1.148
Indicator for frailty	1.147
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.147
DCSI Score – Nephropathy	1.146
CCW indicator for leukemias and lymphomas	1.139
Indicator for arrhythmia	1.127
Indicator for beta blocker use	1.12
Indicator for other problems with primary support group	1.113
CCW indicator for tobacco use	1.107
Beneficiary race - White	1.107
DCSI Score - Peripheral Vascular Disease	1.097
Indicator for warfarin use	1.096
CCW indicator for Parkinson's Disease or Secondary Parkinsonism	1.089
Indicator for oral corticosteroid use	1.087
Number of emergency department visits within the past 6 months	1.083

Risk Factor	Odds Ratio
Indicator for previous conservative diabetic wound procedure	1.081
Indicator for problems with care provider dependency	1.076
Indicator for use of Anticoagulants	1.075
Indicator for albuminuria	1.073
Indicator for cerebrovascular disease	1.067
Indicator for rivaroxaban use	1.064
Indicator for oncologist visit	1.063
CCW indicator for chronic kidney disease	1.062
CCW indicator for diabetes	1.062
CCW indicator for epilepsy	1.061
Indicator for provider administered drug	1.059
Indicator for pancreatitis	1.058
CCW indicator for depression, bipolar, and other depressive mood disorders	1.057
CCW indicator for pressure and chronic ulcers	1.057
Indicator for dual eligibility with Medicaid	1.056
Indicator for durable medical equipment (DME) use	1.055
DCSI Score – Neuropathy	1.052
DCSI Score – Retinopathy	1.052
Located in partial county primary care shortage area	1.051
Number of avoidable hospitalizations	1.047
Indicator for no vaccination (flu or pneumonia)	1.045
CCW indicator for ischemic heart disease	1.044
Indicator for urinary tract infection	1.044
CCW indicator for obesity	1.041
DCSI Score – Cerebrovascular	1.04
Number of urgent care visits	1.033
CCW indicator for fibromyalgia, chronic pain and fatigue	1.03
Age	1.023
Prior admission length of stay	1.007
Number of outpatient visits	1.003
National ranking of deprivation	1.003
Percent Native American	1.001
Diabetes Duration	1.001
Number of specialist visits	1.001
Part D OOP spending	1
Total health spending	1
Continuity of primary care - Duration	.999
Number of primary care visits	.998
Percent aged 65 and over	.998
Number of medications	.998
Number of HbA1c tests	.973
CCW indicator for sensory (deafness and hearing) impairment	.964
CCW indicator for rheumatoid arthritis/osteoarthritis	.963
Indicator for prior surgery	.96
Indicator for losartan use	.958

Risk Factor	Odds Ratio
CCW indicator for glaucoma	.955
Indicator for anti-diabetes medication use	.953
CCW indicator for benign prostatic hyperplasia	.947
Number of prior admissions	.946
CCW indicator for prostate cancer	.939
Number of heart-related procedures	.938
Indicator for Use of Insulin AND Another Glucose-Lowering Medication	.923
CCW indicator for hip/pelvic fracture	.922
Beneficiary sex - female	.918
Discontinuity of primary care - Proportion	.911
CCW indicator for cataracts	.906
CCW indicator for hyperlipidemia	.903
Indicator for statin use	.888
Indicator for prior nursing home stay	.82

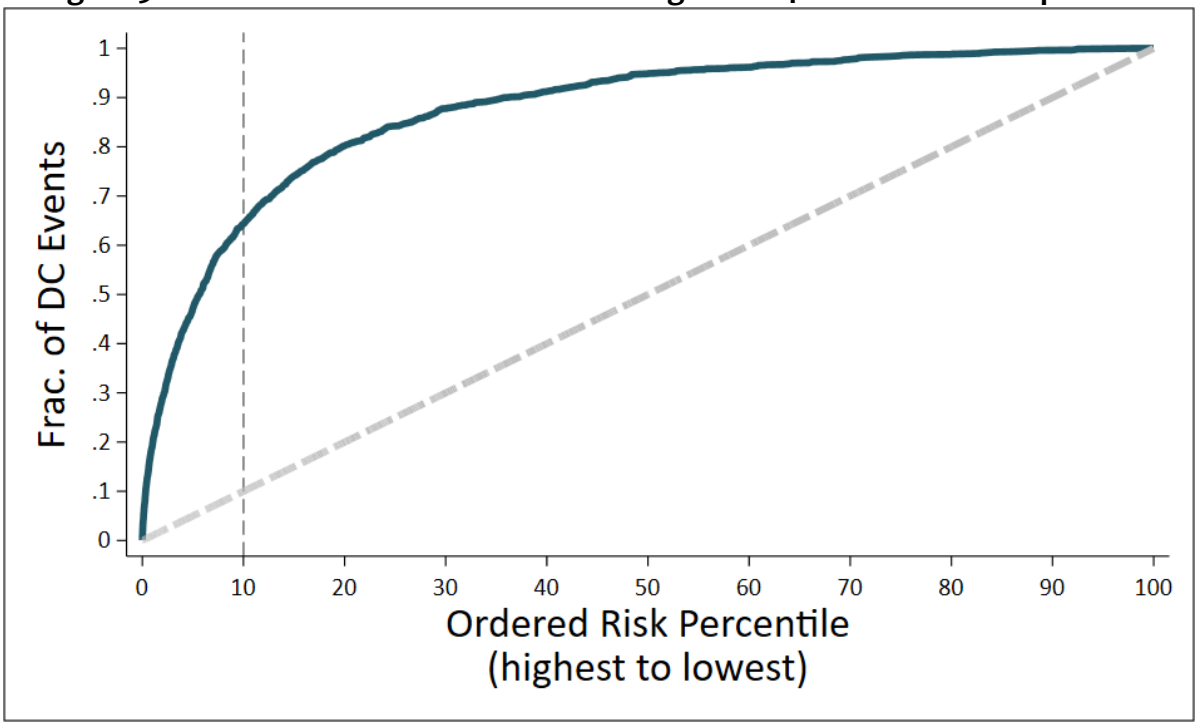
Table 19 presents summary statistics from a recent month of Pre-DC Model risk scores in the MC-PCP patient population.

Table 19. Summary Statistics for Pre-DC Scores in the MC-PCP Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	346,083	.0126	84,397	.9586

Figure 5 shows the concentration curve for the Pre-DC scores in one month of the holdout data. This curve shows how well the risk scores predict DC events in the following month. We find that the top 10% riskiest patients account for approximately 64% of all severe type 2 diabetes complication events in the following month.

Figure 5. Pre-DC Concentration Curve as of August 2024 in the MC-PCP Population



The first Pre-DC risk scores were released for the MC-PCP population in October 2022 and have since been regularly updated. Hilltop monitors the accuracy of the Pre-DC Model predictions in a production environment by comparing the risk scores released in a given month with the true outcomes that occur in the following month. Table 20 shows the percentage of all DC events incurred by patients with the top 1% and top 10% of Pre-DC scores in the month following the score release for six sets of risk scores.

Table 20. Production Predictive Performance of the MC-PCP Pre-DC Scores by Month

Model Version	Score Release Date	Top 1% of Patients	Top 10% of Patients
y5q4m12	03/08/2024	13.98%	57.11%
y5q4m12	04/12/2024	13.59%	56.45%
y6q1m03	05/10/2024	13.78%	56.54%
y6q1m03	06/07/2024	12.30%	56.89%
y6q1m03	07/12/2024	13.00%	55.32%
y6q2m06	08/09/2024	12.56%	56.10%

Note: The evaluation period is for 1 month following the score release date.

MC-FFS

Table 21 presents the risk factor coefficient estimates for Model 1 for the Pre-DC Model trained in the remaining, non-MDPCP-attributed Medicare FFS (MC-FFS) population in September 2024.

Table 21. Pre-DC MC-FFS Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Prior hospitalization discharge status - other	6.88
Prior hospitalization discharge status - transferred to inpatient care	2.011
Indicator for sickle cell anemia	1.906
DCSI Score – Cardiovascular	1.678
CCW indicator for atrial fibrillation and flutter	1.613
CCW indicator for hypertension	1.562
CCW indicator for heart failure and non-ischemic heart disease	1.362
Discontinuity of primary care - Index	1.324
Indicator for original Medicare eligibility for a non-age related cause	1.313
Prior hospitalization admission type - emergency	1.275
CCW indicator for sensory (blindness and visual) impairment	1.243
Number of Previous Severe Type 2 Diabetes Complications	1.233
Beneficiary race - Black	1.233
DCSI Score – Nephropathy	1.203
CCW indicator for anemia	1.189
Indicator for metastatic cancer	1.158
Indicator for beta blocker use	1.158
Prior hospitalization discharge status - transferred to post-acute care	1.154
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.153
Indicator for arrhythmia	1.146
Prior hospitalization admission type - urgent	1.146
Indicator for fluid and electrolyte imbalance	1.142
Indicator for use of Anticoagulants	1.137
Beneficiary race - Hispanic	1.137
Indicator for other problems with primary support group	1.131
Beneficiary race - White	1.126
Indicator for insulin use	1.123
CCW indicator for lung cancer	1.112
CCW indicator for chronic kidney disease	1.104
Indicator for frailty	1.101
CCW indicator for tobacco use	1.1
CCW indicator for leukemias and lymphomas	1.092
DCSI Score - Peripheral Vascular Disease	1.089
Indicator for problems with care provider dependency	1.088
CCW indicator for Parkinson's Disease or Secondary Parkinsonism	1.086
Indicator for cerebrovascular disease	1.083
Indicator for oral corticosteroid use	1.08
Indicator for previous conservative diabetic wound procedure	1.078
Indicator for provider administered drug	1.069
CCW indicator for anxiety disorders	1.062
Indicator for diabetes with complications	1.062
DCSI Score – Neuropathy	1.06
Indicator for urinary tract infection	1.06
CCW indicator for fibromyalgia, chronic pain and fatigue	1.058

Risk Factor	Odds Ratio
DCSI Score – Retinopathy	1.058
Indicator for rheumatoid arthritis/collagen vascular disease	1.055
Number of emergency department visits within the past 6 months	1.054
CCW indicator for obesity	1.053
Indicator for no vaccination (flu or pneumonia)	1.05
CCW indicator for pneumonia, all-cause	1.049
Number of avoidable hospitalizations	1.047
Number of home health visits	1.038
DCSI Score – Cerebrovascular	1.031
Number of urgent care visits	1.031
Number of hospitals	1.021
Age	1.012
Prior admission length of stay	1.005
Percent in poverty	1.004
Number of outpatient visits	1.003
National ranking of deprivation	1.002
Percent Native American	1.001
Diabetes Duration	1.001
Physician diversity	1
Continuity of primary care - Duration	1
Total health spending	1
Number of specialist visits	.999
Number of primary care visits	.997
CCW indicator for glaucoma	.967
CCW indicator for rheumatoid arthritis/osteoarthritis	.964
Number of HbA1c tests	.96
Number of heart-related procedures	.96
CCW indicator for non-Alzheimer's dementia	.949
CCW indicator for osteoporosis with or without pathological fracture	.948
CCW indicator for hyperlipidemia	.933
Number of prior admissions	.925
CCW indicator for viral hepatitis	.921
CCW indicator for schizophrenia and other psychotic disorders	.908
Indicator for statin use	.904
CCW indicator for cataracts	.901
Indicator for prior nursing home stay	.84

Table 22 presents summary statistics from a recent month of Pre-DC Model risk scores in the MC-FFS patient population.

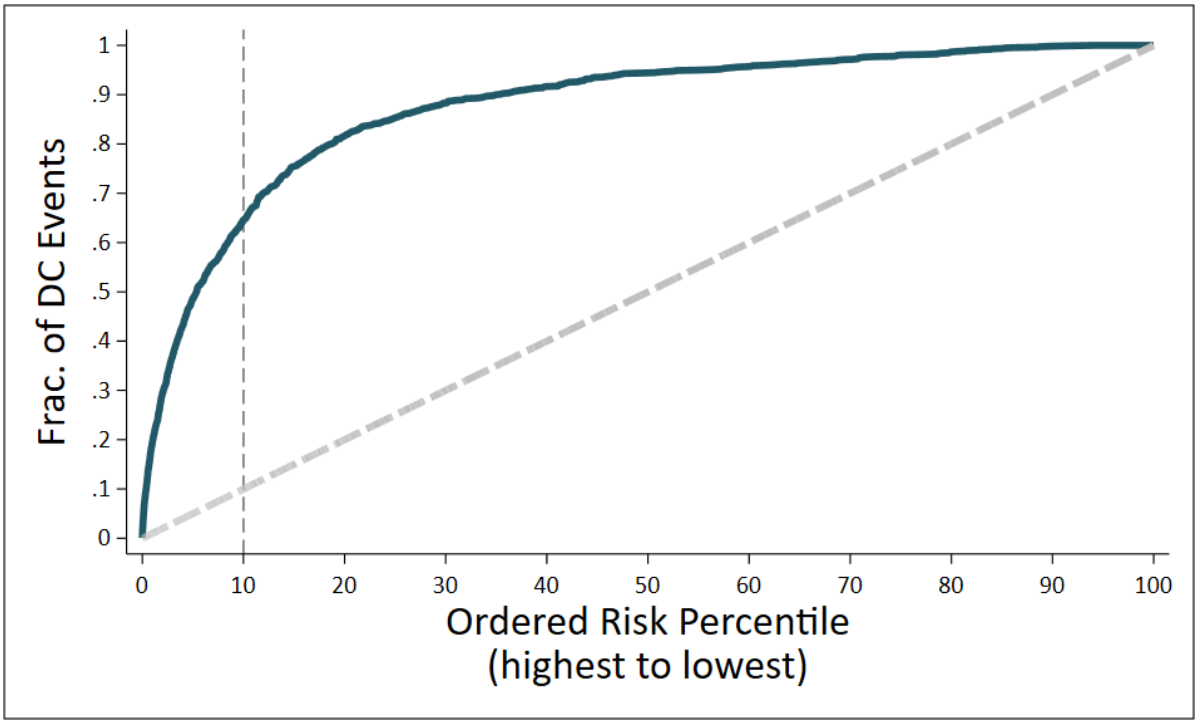
Table 22. Summary Statistics for Pre-DC Scores in the MC-FFS Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	369,608	.015	91,131	NA*

*Multiple months of production scores were not yet available at the time of writing

Figure 6 shows the concentration curve for the Pre-DC scores in one month of the holdout data. This curve shows how well the risk scores predict DC events in the following month. We find that the top 10% riskiest patients account for approximately 65% of all severe type 2 diabetes complication events in the following month.

Figure 6. Pre-DC Concentration Curve as of August 2024 in the MC-FFS Population



The first Pre-DC risk scores were released for the MC-FFS population in January 2025, and as of the time of writing, data are not yet available to assess their predictive power in the production environment.

MA-MCO

Table 23 presents the risk factor coefficient estimates for Model 1 for the Pre-DC Model trained in the Medicaid HealthChoice (MA-MCO) population in September 2024.

Table 23. Pre-DC MA-MCO Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
CCW indicator for sensory (blindness and visual) impairment	2.313
CCW indicator for heart failure and non-ischemic heart disease	2.196
Indicator for sickle cell anemia	2.085
Indicator for dual eligibility with Medicaid	2.063
Prior hospitalization discharge status - other	1.973
CCW indicator for other developmental delays	1.97
Prior hospitalization discharge status - transferred to inpatient care	1.835
DCSI Score – Cardiovascular	1.831
CCW indicator for spina bifida and other congenital anomalies of the nervous system	1.752

Risk Factor	Odds Ratio
CCW indicator for cerebral palsy	1.68
CCW indicator for hypertension	1.623
Beneficiary race - Native American	1.557
CCW indicator for atrial fibrillation and flutter	1.548
CCW indicator for pressure and chronic ulcers	1.462
Beneficiary race - Black	1.392
CCW indicator for tobacco use	1.356
Beneficiary race - White	1.346
Located in whole county primary care shortage area	1.345
Indicator for arrhythmia	1.334
Indicator for fluid and electrolyte imbalance	1.316
CCW indicator for drug use disorders	1.312
Indicator for use of Anti-Hypertensive Treatment	1.304
CCW indicator for intellectual disabilities and related conditions	1.302
Indicator for beta blocker use	1.285
Indicator for insulin use	1.282
DCSI Score - Peripheral Vascular Disease	1.282
Discontinuity of primary care - Index	1.281
Beneficiary race - Unknown	1.277
Indicator for gastroparesis	1.262
DCSI Score – Nephropathy	1.255
Number of Previous Severe Type 2 Diabetes Complications	1.248
CCW indicator for diabetes	1.223
CCW indicator for anemia	1.201
CCW indicator for epilepsy	1.198
Indicator for warfarin use	1.187
Indicator for albuminuria	1.174
Indicator for rheumatoid arthritis/collagen vascular disease	1.173
CCW indicator for asthma	1.164
Indicator for no vaccination (flu or pneumonia)	1.163
DCSI Score – Retinopathy	1.161
Indicator for oral antibiotic use	1.144
CCW indicator for migraine and chronic headache	1.135
Indicator for diabetic ulcer	1.124
Indicator for urinary tract infection	1.118
Indicator for cerebrovascular disease	1.116
CCW indicator for anxiety disorders	1.116
Indicator for oral corticosteroid use	1.107
CCW indicator for depression, bipolar, and other depressive mood disorders	1.106
CCW indicator for obesity	1.104
Indicator for pulmonary circulatory disorder	1.066
Age	1.037
Number of hospitals	1.032
Number of emergency department visits within the past 6 months	1.025
Number of urgent care visits	1.02

Risk Factor	Odds Ratio
Number of avoidable hospitalizations	1.019
Percent Native American	1.003
National ranking of deprivation	1.002
Population density	1
Number of primary care visits	.998
Number of medications	.997
Percent married	.994
Number of prior admissions	.972
Number of heart-related procedures	.951
Indicator for lifestyle problems	.931
Indicator for neuropathy	.925
CCW indicator for rheumatoid arthritis/osteoarthritis	.9
CCW indicator for ischemic heart disease	.886
DCSI Score - Metabolic	.876
CCW indicator for benign prostatic hyperplasia	.874
Indicator for problems with care provider dependency	.868
CCW indicator for hyperlipidemia	.865
CCW indicator for acute myocardial infarction	.862
Beneficiary sex - female	.847
CCW indicator for cataracts	.818
Prior hospitalization admission type - elective	.814
Indicator for peripheral and visceral atherosclerosis	.809
Prior hospitalization admission type - urgent	.791
CCW indicator for non-Alzheimer's dementia	.765
Prior hospitalization admission type - none	.735
Indicator for prior nursing home stay	.7
CCW indicator for prostate cancer	.658
CCW indicator for learning disabilities	.622

Table 24 presents summary statistics from a recent month of Pre-DC Model risk scores in the MA-MCO patient population.

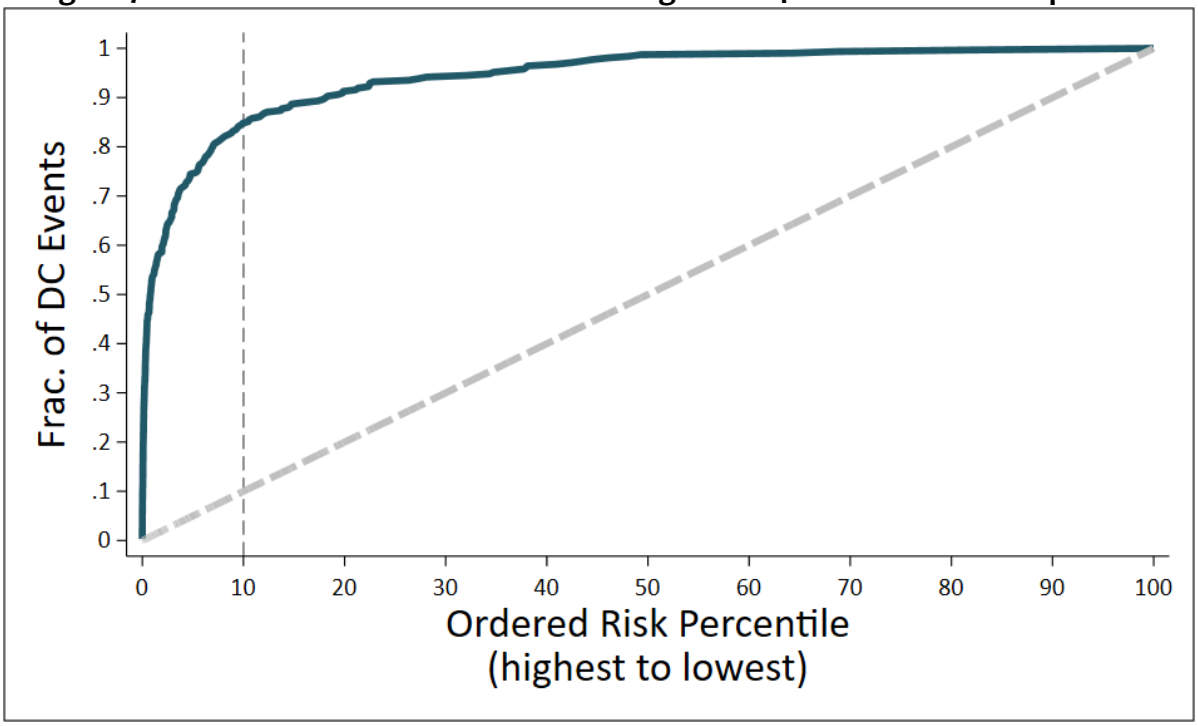
Table 24. Summary Statistics for Pre-DC Scores in the MA-MCO Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	1,400,946	.0014	20,999	NA*

*Multiple months of production scores were not yet available at the time of writing

Figure 7 shows the concentration curve for the Pre-DC scores in one month of the holdout data. This curve shows how well the risk scores predict DC events in the following month. We find that the top 10% riskiest patients account for approximately 85% of all severe type 2 diabetes complication events in the following month.

Figure 7. Pre-DC Concentration Curve as of August 2024 in the MA-MCO Population



The first Pre-DC risk scores were released for the MA-MCO population in January 2025, and as of the time of writing, data are not yet available to assess their predictive power in the production environment.

MA-FFS

Table 25 presents the risk factor coefficient estimates for Model 1 for the Pre-DC Model trained in the Medicaid FFS (MA-FFS) population in September 2024.

Table 25. Pre-DC MA-FFS Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Indicator for sickle cell anemia	1.801
CCW indicator for heart failure and non-ischemic heart disease	1.766
CCW indicator for hypertension	1.542
Prior hospitalization discharge status - transferred to inpatient care	1.534
Discontinuity of primary care - Index	1.533
DCSI Score – Cardiovascular	1.444
Indicator for fluid and electrolyte imbalance	1.41
CCW indicator for sensory (blindness and visual) impairment	1.402
CCW indicator for spinal cord injury	1.382
Indicator for use of Anti-Hypertensive Treatment	1.362
Indicator for rivaroxaban use	1.34
CCW indicator for atrial fibrillation and flutter	1.336
DCSI Score – Nephropathy	1.295
Prior hospitalization admission type - other	1.275

Risk Factor	Odds Ratio
CCW indicator for intellectual disabilities and related conditions	1.273
Indicator for rheumatoid arthritis/collagen vascular disease	1.262
DCSI Score - Peripheral Vascular Disease	1.258
Number of hospitals	1.234
CCW indicator for anemia	1.213
Indicator for arrhythmia	1.205
Indicator for diabetic ulcer	1.192
Beneficiary race - Black	1.189
CCW indicator for stroke/ischemic transient attack	1.171
DCSI Score – Retinopathy	1.164
CCW indicator for tobacco use	1.158
CCW indicator for drug use disorders	1.154
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.147
Beneficiary race - White	1.141
Indicator for use of Anticoagulants	1.139
Number of Previous Severe Type 2 Diabetes Complications	1.128
Indicator for oral corticosteroid use	1.127
Indicator for frailty	1.121
Number of emergency department visits within the past 6 months	1.012
Age	1.007
Number of medications	1.006
Percent Native American	1.003
National ranking of deprivation	1.003
Number of outpatient visits	1.001
Continuity of primary care - Duration	.999
Number of primary care visits	.997
Indicator for protein-calorie malnutrition	.892
CCW indicator for hypothyroidism	.883
Indicator for peripheral and visceral atherosclerosis	.882
CCW indicator for non-Alzheimer's dementia	.878
Prior hospitalization admission type - elective	.809
CCW indicator for glaucoma	.8
Prior hospitalization admission type - none	.671
Indicator for Use of Fibrates	.634
Indicator for prior nursing home stay	.633
Discontinuity of primary care - Proportion	.592
Number of hospitals per 1000 residents	.02

Table 26 presents summary statistics from a recent month of Pre-DC Model risk scores in the MA-FFS patient population.

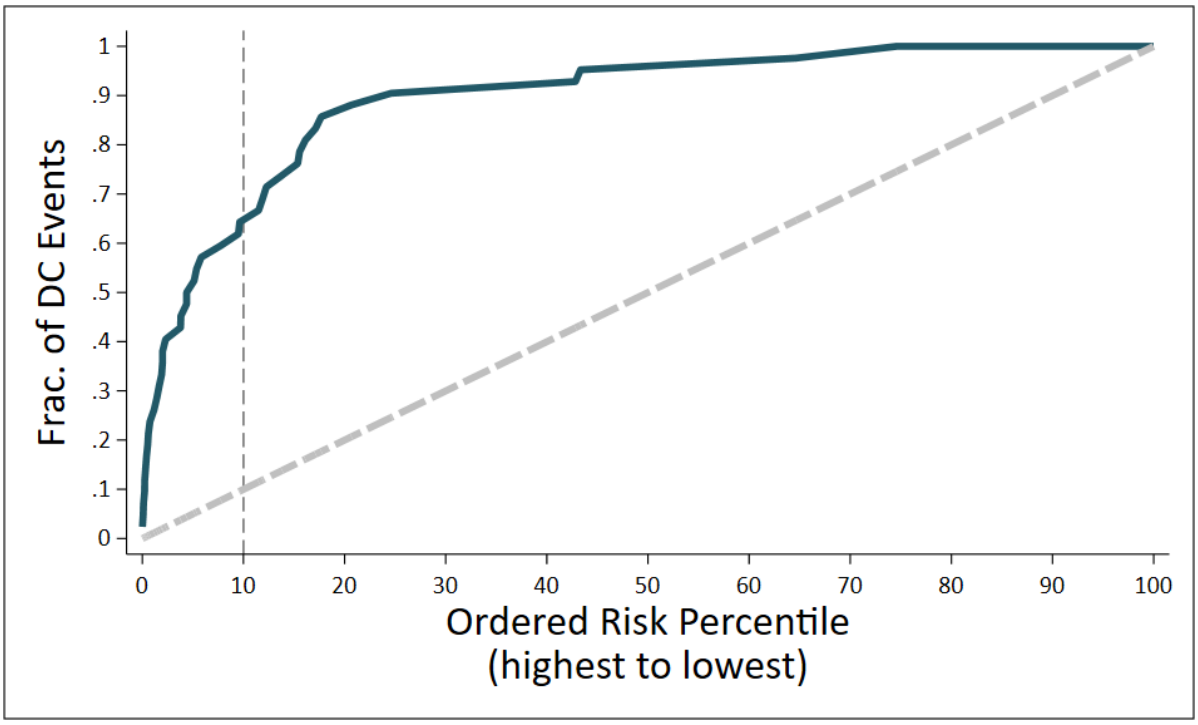
Table 26. Summary Statistics for Pre-DC Scores in the MA-FFS Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	47,784	.0082	6,848	NA*

*Multiple months of production scores were not yet available at the time of writing

Figure 8 shows the concentration curve for the Pre-DC scores in one month of the holdout data. This curve shows how well the risk scores predict DC events in the following month. We find that the top 10% riskiest patients account for approximately 61% of all severe type 2 diabetes complication events in the following month.

Figure 8. Pre-DC Concentration Curve as of August 2024 in the MA-FFS Population



The first Pre-DC risk scores were released for the MA-FFS population in January 2025, and as of the time of writing, data are not yet available to assess their predictive power in the production environment.

Pre-HE

MC-PCP

Table 27 presents the risk factor coefficient estimates for Model 1 for the Pre-HE Model trained in the MDPCP-attributed Medicare FFS (MC-PCP) population in September 2024.

Table 27. Pre-HE MC-PCP Risk Model Odds Ratios for Model 1

Risk Factor	Odds Ratio
Severity of Frailty	178.248
Indicator for hospice enrollment	48.148
Prior hospitalization discharge status - other	5.74
CCW indicator for non-Alzheimer's dementia	5.27
Indicator for Cancer of Pancreas	2.929
Number of rural clinic visits	2.707
Indicator for metastatic cancer	2.619

Risk Factor	Odds Ratio
Indicator for Cancer of Liver and Intrahepatic Bile Duct	2.295
Indicator for Cancer of Brain and Nervous System	2.266
Indicator for Cancer of Esophagus	2.064
Indicator for no rural health clinic	1.916
Indicator for having Received Chemotherapy	1.896
CCW indicator for alcohol use disorders	1.894
CCW indicator for muscular dystrophy	1.863
Indicator for Cancer of Bone and Connective Tissue	1.692
Indicator for Cancer of Ovary	1.616
Prior hospitalization discharge status - transferred to inpatient care	1.605
Indicator for Cancer of Bronchus; Lung	1.603
Indicator for original Medicare eligibility for a non-age related cause	1.524
CCW indicator for cerebral palsy	1.483
CCW indicator for leukemias and lymphomas	1.451
CCW indicator for heart failure and non-ischemic heart disease	1.448
CCW indicator for intellectual disabilities and related conditions	1.442
CCW indicator for Parkinson's Disease or Secondary Parkinsonism	1.395
Beneficiary race - White	1.348
Indicator for frailty	1.344
Indicator for no mental health center	1.339
CCW indicator for pressure and chronic ulcers	1.334
Indicator for oncologist visit	1.312
Indicator for Cancer of Stomach	1.305
Indicator for protein-calorie malnutrition	1.298
CCW indicator for Alzheimer's disease	1.291
Indicator for retinopathy	1.29
CCW indicator for tobacco use	1.277
CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis	1.276
CCW indicator for traumatic brain injury and nonpsychotic mental disorders due to brain damage	1.271
Indicator for having Received Dialysis	1.267
CCW indicator for liver disease, cirrhosis and other liver conditions (except viral hepatitis)	1.243
Prior hospitalization discharge status - transferred to post-acute care	1.232
CCW indicator for anemia	1.232
Recent Increase in Frailty severity	1.232
CCW indicator for chronic kidney disease	1.189
Prior hospitalization admission type - urgent	1.184
Indicator for fluid and electrolyte imbalance	1.179
CCW indicator for atrial fibrillation and flutter	1.176
Indicator for solid tumor without metastasis	1.176
CCW indicator for peripheral vascular disease	1.168
CCW indicator for HIV/AIDS	1.163
CCW indicator for multiple sclerosis and transverse myelitis	1.163
CCW indicator for cystic fibrosis and other metabolic developmental disorders	1.162

Risk Factor	Odds Ratio
Indicator for insulin use	1.156
Prior hospitalization admission type - emergency	1.149
Indicator for problems with care provider dependency	1.136
CCW indicator for acute myocardial infarction	1.124
Indicator for pulmonary circulatory disorder	1.123
Indicator for Oxygen Usage in DME	1.122
Beneficiary race - Black	1.111
Indicator for dual eligibility with Medicaid	1.107
Indicator for warfarin use	1.106
Indicator for no vaccination (flu or pneumonia)	1.101
CCW indicator for mobility impairments	1.1
Indicator for albuminuria	1.098
Indicator for beta blocker use	1.09
Indicator for oral corticosteroid use	1.088
Indicator for diabetes with complications	1.083
CCW indicator for pneumonia, all-cause	1.075
Indicator for rheumatoid arthritis/collagen vascular disease	1.073
Age	1.071
CCW indicator for epilepsy	1.066
CCW indicator for diabetes	1.059
Indicator for urinary tract infection	1.055
Number of emergency department visits within the past 6 months	1.053
Indicator for no VA clinic or VA medical center	1.052
Number of avoidable hospitalizations	1.05
Located in whole county mental health care shortage area	1.045
CCW indicator for depression, bipolar, and other depressive mood disorders	1.038
Prior admission length of stay	1.013
Number of medications	1.012
Percent aged 0-4	1.008
Number of primary care visits	1.003
National ranking of deprivation	1.002
Continuity of primary care - Duration	1.001
Population	1
Total health spending	1
Physician diversity	1
Percent Native American	.999
Number of outpatient visits	.996
Number of specialist visits	.995
Number of lab tests	.976
Number of heart-related procedures	.966
Indicator for endocrinologist visit	.957
Indicator for provider administered drug	.952
Indicator for rivaroxaban use	.943
Indicator for prior surgery	.939
CCW indicator for breast cancer	.93

Risk Factor	Odds Ratio
CCW indicator for osteoporosis with or without pathological fracture	.928
CCW indicator for sensory (deafness and hearing) impairment	.928
CCW indicator for asthma	.928
Number of HbA1c tests	.928
CCW indicator for glaucoma	.927
Number of urgent care visits	.919
Indicator for sepsis	.915
Indicator for sleep apnea	.915
Indicator for anti-diabetes medication use	.91
CCW indicator for fibromyalgia, chronic pain and fatigue	.901
CCW indicator for hip/pelvic fracture	.895
CCW indicator for benign prostatic hyperplasia	.895
Indicator for gastroesophageal reflux disease	.891
Indicator for difficulty with life management	.883
Indicator for leukotriene receptor modifier use	.868
Indicator for losartan use	.864
Indicator for problems with social environment	.855
CCW indicator for obesity	.842
Indicator for respiratory infection	.829
Indicator for statin use	.821
CCW indicator for rheumatoid arthritis/osteoarthritis	.81
Indicator for Hospital Bed Usage in DME	.801
CCW indicator for migraine and chronic headache	.797
Prior hospitalization admission type - elective	.794
Indicator for prior nursing home stay	.79
CCW indicator for hyperlipidemia	.785
CCW indicator for cataracts	.78
Indicator for diabetic foot procedure	.777
CCW indicator for prostate cancer	.726
Beneficiary sex - female	.667
Discontinuity of primary care - Index	.615
Interaction of ADRD and Frailty Index	.011

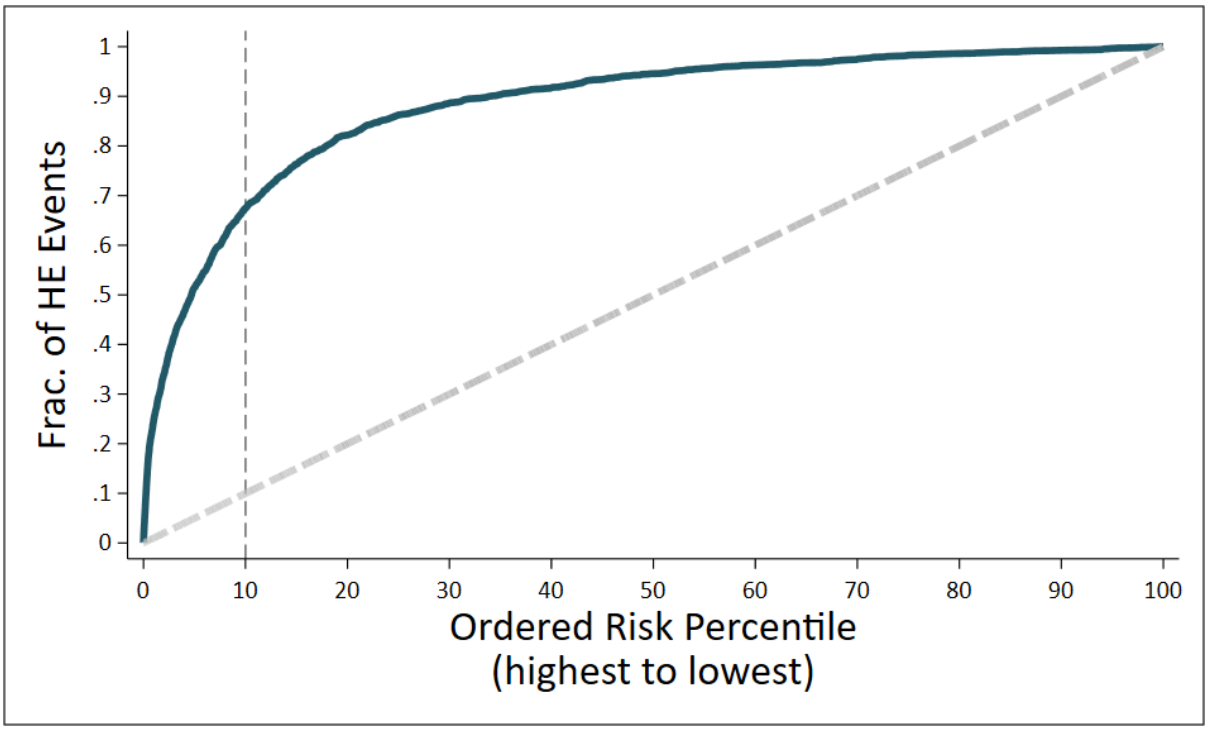
Table 28 presents summary statistics from a recent month of Pre-HE Model risk scores in the MC-PCP patient population.

Table 28. Summary Statistics for Pre-HE Scores in the MC-PCP Population

Scoring Cohort	Cohort Size	Average Score	N > 1% Risk	Monthly Correlation
Nov 2024	346,083	.0189	106,443	.9171

Figure 9 shows the concentration curve for the Pre-HE scores in one month of the holdout data. This curve shows how well the risk scores predict DC events within six months. We find that the top 10% riskiest patients account for approximately 67% of mortality events within six months.

Figure 9. Pre-HE Concentration Curve as of January 2024 in the MC-PCP Population



The first Pre-HE risk scores were released for the MC-PCP population in October 2022 and have since been regularly updated. Hilltop monitors the accuracy of the Pre-HE Model predictions in a production environment by comparing the risk scores released in a given month with the true outcomes that occur within the next six months. Table 29 shows the percentage of all HE events incurred by patients with the top 1% and top 10% of Pre-DC scores within six months following the score release for six sets of risk scores.

Table 29. Production Predictive Performance of the MC-PCP Pre-HE Scores by Month

Model Version	Score Release Date	Top 1% of Patients	Top 10% of Patients
y5q2m06	08/11/2023	11.71%	58.62%
y5q2m06	09/15/2023	13.43%	58.49%
y5q2m06	10/13/2023	11.78%	58.07%
y5q3m09	11/10/2023	13.30%	58.45%
y5q3m09	12/08/2023	13.44%	58.32%
y5q3m09	01/12/2024	12.97%	58.17%

Note: The evaluation period is for 6 months following the score release date.

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Section 5: FAQs

Differentiation from CMS HCC Risk Scores

It is important to note that the Hilltop Preventive Predictive Model risk scores are conceptually distinct from the CMS Hierarchical Condition Category (HCC) risk scores that are currently presented in CRISP. The Hilltop risk scores use risk factors based on diagnoses, procedures, medications, utilization, demographics, and geographic factors in order to produce a practice-specific ranking of patient risk in the near future. The CMS HCC risk scores are based on a model that uses diagnosis codes and a limited set of demographic information from a base year in order to predict *expenditures* over the following year. There is likely to be some overlap among individuals who incur potentially preventable utilization and individuals who experience high medical spending, but the overlap is unlikely to be complete.[23] High medical expenditure can reflect multiple factors ranging from moderate utilization of high-cost procedures, high utilization of moderate-cost procedures, underlying morbidity, or geographic differences in treatment or referral practices.

Moreover, the theoretical interpretation of each risk score differs substantially. The CMS HCC risk score was developed as a capitated payment risk adjustment methodology for Medicare Advantage participants in order to "address [the] issue of risk selection and to compensate Medicare Advantage health plans for accepting the risk of enrolling beneficiaries of varying health statuses" (Centers for Medicare and Medicaid Services, 2018, pp. 9–10). Additionally, "the underlying risk assessment is designed to accurately explain the variation at the group level, not at the individual level, because risk adjustment is applied to large groups" (Centers for Medicare and Medicaid Services, 2018, pp. 9–10). Note that "risk" for the CMS HCC risk model refers to *actuarial* risk: this model seeks to predict average expenditures over large groups of individuals. In contrast, the Hilltop risk scores are designed to estimate, as closely as possible, event risk: for example, an *individual's* risk of an avoidable hospital event in the following month.

There are also differences in the time horizons of each risk score. CMS HCC "final risk scores are generally available 16-18 months after the close of the base year. For example, 2017 risk scores (based on 2016 diagnoses) will be available in the spring of 2018"(Center for Medicare and Medicaid Innovation, 2017, p. 26). The Hilltop risk scores, however, are updated monthly and use patient-level risk factor information current to the most recently available month of claims in order to generate risk scores. This is a strength of the Hilltop models because these risk scores reflect the underlying patient condition with a lag of only, at most, three months.[24] Finally, by definition, avoidable hospital events are preventable through timely primary care and so, in principle, the identification and management of individuals at high risk of incurring potentially

[23] Internal testing shows a limited degree of substitutability between the two sets of risk scores. Specifically, we find that the Hilltop Pre-AH Model™ outperforms the CMS HCC risk score in predicting avoidable hospitalization in the following month. Both concentration curves are presented below.

[24] This lag is related to the unavoidable delay in obtaining and processing administrative claims data. For example, claims data delivered to Hilltop in late October 2021 reflect utilization through mid-September 2021. We discuss this point further in the "Limitations" section below.

preventable health care utilization may result in the avoidance of that particular utilization event. High medical expenditures, however, may reflect underlying morbidities that would necessitate utilization *regardless* of primary care intervention.

What Makes the Pre-DC Outcome Different from the Pre-AH Outcome?

Both the Pre-AH Model and the Pre-DC Model outcomes include diabetes complications; however, they are conceptually and statistically distinct. The Pre-AH outcome is a composite of 10 conditions that are determined to be potentially preventable with high-quality outpatient care by the AHRQ.[25] These PQIs are intended to serve as a high-level check of primary/outpatient care access in a community and to help organizations identify potentially unmet needs in their communities. The Pre-AH outcome indexes, among other non-diabetes-related conditions, uncontrolled diabetes complications as well as complications from type 1 diabetes, type 2 diabetes, and other forms of diabetes (e.g., gestational diabetes). In comparison, the Pre-DC outcome is based on the DCSI, which is designed to quantify the severity of diabetes complications based on risk for adverse medical outcomes including future medical needs, high treatment costs, hospitalizations, and mortality (described in more detail above). Although the DCSI can measure non-severe and severe complications from all forms of diabetes, we focused on severe complications related to type 2 diabetes only.

In order to confirm that the Pre-DC outcome was statistically distinct from the Pre-AH outcome, we quantified the overlap in the ICD-10 diagnosis codes included in both outcomes and calculated the correlation between the Pre-AH and Pre-DC outcome frequency and risk scores in the MDPCP scoring data. See Table 30.

Table 30. Coding Differences in Pre-AH and Pre-DC Model Outcomes

Breakdown of ICD-10 Diagnosis Codes in AH & DC Outcomes	
Overlapping	*N*=36
Unique to Pre-AH Outcome	*N*=491
Unique to Pre-DC Outcome	*N*=244

Hilltop also determined that, as of July 2022, only 12.46% of the avoidable hospital events in the MDPCP scoring data were related to PQIs indexing diabetes or its complications (i.e., PQI#1, PQI#3, PQI#14, PQI#16). The most prevalent PQIs in the MDPCP population were PQI#14: Urinary Tract Infections (25.43%) and PQI#5: COPD or Asthma in Older Adults (18.47%).

For additional detail on the differences in these outcomes, please see the standalone document entitled "What's the Difference between the Pre-DC and Pre-AH Models?".

[25] For more information, see https://www.qualityindicators.ahrq.gov/modules/pqi_resources.aspx

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Appendix 1. Risk Factor Codebook

Age: For each person-month, this variable records person age as of the end of the month.

Variable Name: age

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
74.011	20	109	24.065	0	82	72.989	3	151	41.704	0	113

Air pollution level: For each person, this variable records the average daily fine particulate matter (PM 2.5) concentration from the EPA's Downscaler Model for 2011-2015 in the person's Census Tract or ZCTA of residence.

Variable Name: agg_air_pollution

Source: Environmental Protection Agency (2023)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
26.244	0	144	61.807	0	245	53.882	0	421	65.743	0	351

Number of hospital beds per 1000 residents: For each person, this variable records the number of active (short term or critical access or transplant) hospital beds per 1000 residents in the person's Census Tract or ZCTA of residence.

Variable Name: agg_certbed_count_per_1000

Source: CMS Provider of Service Files (December 2023) American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2.07	0	2012	2.473	0	2012	2.443	0	4589	3.292	0	119

National ranking of deprivation: For each person, this variable records the national ranking of deprivation for the person's Census Tract or ZCTA of residence. This index 'includes factors for the theoretical domains of income, education, employment, and housing quality.' See https://www.neighborhoodatlas.medicine.wisc.edu/ for additional detail. Higher values indicate a greater degree of deprivation.

Variable Name: agg_dep_index_natl

Source: Neighborhood Atlas

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
33.511	1	100	41.586	2	99	34.15	1	97	44.597	2	98

General internists per 1000 residents: For each person, this variable records the number of general internists per 1000 residents in the Census Tract or ZCTA of residence.

Variable Name: agg_gen_insts_per_1000

Source: National Provider Identifier Database, American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.905	0	180	.867	0	136	.9	0	1139	1.09	0	115

Indicator for presence of a for-profit hospital: For each person, this variable records whether the person's Census Tract or ZCTA of residence contains at least one active (short term or critical access or transplant) for-profit hospital.

Variable Name: agg_has_for_profit_hosp

Source: CMS Provider of Service Files (December 2023)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.045	0	1	.092	0	1	.087	0	1	.112	0	1

Indicator for no federally qualified health center: For each person, this variable records whether the person's Census Tract or ZCTA of residence does not contain at least one active federally qualified health center.

Variable Name: agg_has_fqhc

Source: CMS Provider of Service Files (December 2023)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.848	0	1	.643	0	1	.735	0	1	.592	0	1

Indicator for no mental health center: For each person, this variable records whether the person's Census Tract or ZCTA of residence does not contain at least one active community mental health center.

Variable Name: agg_has_mental_health_cente

Source: CMS Provider of Service Files (December 2023)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.995	0	1	.965	0	1	.984	0	1	.9570000000000001	0	1

Indicator for no rural health clinic: For each person, this variable records whether the person's Census Tract or ZCTA of residence does not contain at least one active rural health clinic.

Variable Name: agg_has_rhc

Source: CMS Provider of Service Files (December 2023)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.999	0	1	.999	0	1	.998	0	1	.999	0	1

Indicator for no VA clinic or VA medical center: For each person, this variable records whether the person's Census Tract or ZCTA of residence does not contain at least one VA clinic or medical center.

Variable Name: agg_has_va_clinic_or_center

Source: Veterans Affairs Facility Listing

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.939	0	1	.862	0	1	.879	0	1	.863	0	1

Median household income: For each person, this variable records the median household income in the person's Census Tract or ZCTA of residence (pooled from 2015-2019).

Variable Name: agg_median_hh_income

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
110098	0	250000	90659	0	250000	107400	0	250000	86749	0	250000

Located in partial county mental health care shortage area: For each person, this variable takes the value of 1 if the person's Census Tract or ZCTA of residence is located in a county that is designated by HRSA in 2018 to be a partial-county mental health care shortage area. The variable takes the value of 0, otherwise. If the census tract lies in two counties, the value is estimated as a weighted average of the county-level attributes.

Variable Name: agg_mental_part

Source: Area Health Resources File

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.771	0	1	.867	0	1	.833	0	1	.884	0	1

Located in whole county mental health care shortage area: For each person, this variable takes the value of 1 if the person's Census Tract or ZCTA of residence is located in a county that is designated by HRSA in 2018 to be a whole-county mental health care shortage area. The variable takes the value of 0, otherwise. If the census tract lies in two or more counties, the value is estimated as a weighted average of the county-level attributes.

Variable Name: agg_mental_whole

Source: Area Health Resources File

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.189	0	1	.123	0	1	.156	0	1	.1	0	1

Number of hospitals: For each person, this variable records the number of active (short term or critical access or transplant) hospitals in the person's Census Tract or ZCTA of residence.

Variable Name: agg_num_hospitals

Source: CMS Provider of Service Files (December 2023)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.182	0	4	.38	0	5	.375	0	7	.466	0	7

Number of hospitals per 1000 residents: For each person, this variable records the number of active (short term or critical access or transplant) hospitals per 1000 residents in the person's Census Tract or ZCTA of residence.

Variable Name: agg_num_hospitals_per_1000

Source: CMS Provider of Service Files (December 2023) American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.011	0	4	.012	0	4	.012	0	6	.015	0	2

Located in partial county primary care shortage area: For each person, this variable takes the value of 1 if the person's Census Tract or ZCTA of residence is located in a county that is designated by HRSA in 2018 to be a partial-county primary care shortage area. The variable takes the value of 0, otherwise. If the census tract lies in two or more counties, the value is estimated as a weighted average of the county-level attributes.

Variable Name: agg_pc_short_partial

Source: Area Health Resources File

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.932	0	1	.962	0	1	.950	0	1	.961	0	1

Located in whole county primary care shortage area: For each person, this variable takes the value of 1 if the person's Census Tract or ZCTA of residence is located in a county that is designated by HRSA in 2018 to be a whole-county primary care shortage area. The variable takes the value of 0, otherwise. If the census tract lies in two or more counties, the value is estimated as a weighted average of the county-level attributes.

Variable Name: agg_pc_short_whole

Source: Area Health Resources File

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.006	0	1	.008	0	1	.007	0	1	.009	0	1

Number of primary care physicians per 1000 residents: For each person, this variable records the number of primary care physicians per 1000 residents in the person's Census Tract or ZCTA of residence.

Variable Name: agg_pcp_per_1000

Source: National Provider Identifier Database, American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1.967	0	385	1.801	0	385	1.944	0	3241	2.183	0	385

Percent aged 65 and over: For each person, this variable records the percentage of individuals in the person's Census Tract or ZCTA of residence aged 65 and over (pooled from 2013-2017).

Variable Name: agg_pct_65plus

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18.548	0	100	15.65	0	100	17.351	0	100	15.629	0	60

Percent with less than high school education, ages 65+: For each person, this variable records the percent of the population aged 65 and above in the person's Census Tract or ZCTA of residence that has less than a high school diploma.

Variable Name: agg_pct_eld_lessthan_hs

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
11.049	0	100	14.395	0	100	11.216	0	85	15.172	0	80

Percent live alone, ages 65+: For each person, this variable records the percent of the population aged 65 and above in the person's Census Tract or ZCTA of residence that lives alone.

Variable Name: agg_pct_eld_live_alone

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
25.945	0	100	29.311	0	100	27.317	0	100	31.14	0	74

Percent speak Spanish, aged 65+: For each person, this variable records the percent of the population aged 65 and above in the person's Census Tract or ZCTA of residence that speaks Spanish.

Variable Name: agg_pct_eld_spanish

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2.645	0	60	3.751	0	63	3.262	0	63	3.333	0	91

Percent in poverty age 65+: For each person, this variable records the percentage of people age 65+ whose income in the past 12 months is below the poverty level in the person's Census Tract or ZCTA of residence (pooled from 2015-2019).

Variable Name: agg_pct_elder_poverty

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
4.203	0	100	5.642	0	100	4.418	0	100	6.307	0	38

Percent foreign born: For each person, this variable records the percent of individuals who are foreign-born in the person's Census Tract or ZCTA of residence.

Variable Name: agg_pct_fb

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1.572	0	60	1.602	0	60	1.614	0	60	1.557	0	26

Percent Hispanic, ages 65+: For each person, this variable records the percent of the population aged 65 and above in the person's Census Tract or ZCTA of residence that is Hispanic.

Variable Name: agg_pct_hisp_age65plus

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2.937	0	61	4.156	0	67	3.55	0	73	3.582	0	98

Percent with less than high school education: For each person, this variable records the percent of individuals age 18 and older with less than a high school diploma in the person's Census Tract or ZCTA of residence.

Variable Name: agg_pct_lessthan_hs

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
14.809	0	147	11.135	0	67	8.685	0	67	11.345	0	48

Percent married: For each person, this variable records the percent of the population aged 15+ in the person's Census Tract or ZCTA of residence that is currently married (pooled from 2013-2017).

Variable Name: agg_pct_married

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
50.538	0	100	43.262	0	100	48.533	0	100	40.844	0	100

Percent Native American: For each person, this variable records the percent of the population in the person's Census Tract or ZCTA of residence that is Native American.

Variable Name: agg_pct_native_american

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
67.564	0	100	49.685	0	100	60.164	0	100	47.32	0	100

Percent non-English speakers: For each person, this variable records the percent of individuals who speak Spanish or other languages and who speak English less than 'very well' in the person's Census Tract or ZCTA of residence.

Variable Name: agg_pct_no_english

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
30.905	0	100	35.587	0	100	32.249	0	100	34.839	0	100

Percent non-white, ages 65+: For each person, this variable records the percent of the population aged 65 and above in the person's Census Tract or ZCTA of residence that is non-white.

Variable Name: agg_pct_nonwhite_age65plus

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
27.902	0	100	43.985	0	100	34.394	0	100	47.063	0	100

Physician diversity: For each person, this variable records the percentage of medical doctors who are minorities (African Americans, Hispanics, and others, but excluding Asian-Americans). If the zip code tabulation area lies in two or more counties, the value is estimated as a weighted average of the county-level attributes, with weights being the fraction of the ZCTA population residing within each county.

Variable Name: agg_pct_physician_diversity

Source: American Community Survey (2022, individual)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
139.161	0	2089	279.433	0	2595	266.441	0	3129	267.196	0	2147

Percent in poverty: For each person, this variable records the percentage of families whose income in the past 12 months is below the poverty level in the person's Census Tract or ZCTA of residence (pooled from 2015-2019) .

Variable Name: agg_pct_poverty

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
5.737	0	67	8.384	0	67	6.092	0	100	9.476	0	38

Percent single mothers: For each person, this variable records the percent of women aged 15-50 giving birth within the past 12 months who are not married in the person's Census Tract or ZCTA of residence.

Variable Name: agg_pct_single_mothers

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
24.344	0	100	36.466	0	100	28.078	0	100	38.519	0	100

Percent aged 0-4: For each person, this variable records the percentage of individuals in the person's Census Tract or ZCTA of residence aged 0-4 (pooled from 2013-2017) .

Variable Name: agg_pct_under5

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
5.438	0	31	6.04	0	31	5.593	0	31	5.954	0	31

Population: For each person, this variable records the population of the person's Census Tract or ZCTA of residence.

Variable Name: agg_pop

Source: American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
15864	0	71560	34785	0	108180	31869	0	88575	35023	0	108557

Population growth: For each person, this variable records the percent population growth recorded in the person's Census Tract or ZCTA of residence from 2013 - 2019.

Variable Name: agg_pop_growth

Source: American Community Survey (2020 and 2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2.28	-100	3900	2.095	-100	3900	2.474	-100	3900	1.355	-100	212

Population density: For each person, this variable records the population per square mile in the person's Census Tract or ZCTA of residence.

Variable Name: agg_popdens

Source: American Community Survey (2022, 5-year estimates), Census Gazetteer File (2020)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2848	0	57509	3774	0	109098	2830	0	144674	4490	0	112881

Social workers per 1000 residents: For each person, this variable records the number of social workers per 1000 residents in the Census Tract or ZCTA of residence.

Variable Name: agg_socwork_per_1000

Source: National Provider Identifier Database, American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2.359	0	885	2.127	0	885	2.299	0	885	2.576	0	885

Number of specialty care physicians per 1000 residents: For each person, this variable records the number of specialty care physicians per 1000 residents in the person's Census Tract or ZCTA of residence.

Variable Name: agg_spec_per_1000

Source: National Provider Identifier Database, American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1.973	0	536	1.872	0	244	1.989	0	2696	2.322	0	154

Taxable interest per capita: For each person, this variable records taxable interest (tax year 2018) per person in the person's Census Tract or ZCTA of residence.

Variable Name: agg_taxable_interest_per_ca

Source: IRS Statistics of Income and American Community Survey (2022, 5-year estimates)

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
4429	0	117671	5888	0	117671	10580	4	460536	6114	5	128373

Number of avoidable hospitalizations: For each person-month, this variable counts the number of avoidable hospitalizations incurred within the prior 12 months (not including the month in which the avoidable hospitalization occurred).

Variable Name: ah_num

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.052	0	19	.028	0	31	.059	0	32	.065	0	16

Indicator for anti-diabetes medication use: For each person-month, this variable takes the value of 1 if a person incurred a claim for anti-diabetes medication within the past 12 months, and 0 otherwise.

Variable Name: antidiabetes_medications

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.156	0	1	.036	0	1	.13	0	1	.079	0	1

Indicator for beta blocker use: For each person-month, this variable takes the value of 1 if a person incurred a claim for beta blockers within the past 12 months, and 0 otherwise.

Variable Name: beta_blockers

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.288	0	1	.037	0	1	.249	0	1	.109	0	1

CCW indicator for acute myocardial infarction: For each person-month, this variable records whether the person meets the CCW clinical criteria for acute myocardial infarction. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_acute_myocardial_infarc

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.007	0	1	.001	0	1	.008	0	1	.003	0	1

CCW indicator for ADHD, conduct disorders, and hyperkinetic syndrome: For each person-month, this variable records whether the person meets the CCW clinical criteria for ADHD, conduct disorders, and hyperkinetic syndrome. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_adhd__conduct_disorders

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.011	0	1	.073	0	1	.013	0	1	.059	0	1

Indicator for albuminuria: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for albuminuria within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_albuminuria

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.027	0	1	.004	0	1	.029	0	1	.008	0	1

CCW indicator for alcohol use disorders: For each person-month, this variable records whether the person meets the CCW clinical criteria for alcohol use disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_alcohol_use_disorders

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.003	0	1	.027	0	1	.003	0	1	.063	0	1

CCW indicator for Alzheimer's disease: For each person-month, this variable records whether the person meets the CCW clinical criteria for Alzheimer's Disease. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_alzheimers_disease

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.016	0	1	0	0	1	.02	0	1	.003	0	1

CCW indicator for anemia: For each person-month, this variable records whether the person meets the CCW clinical criteria for anemia. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_anemia

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.218	0	1	.055	0	1	.244	0	1	.128	0	1

CCW indicator for anxiety disorders: For each person-month, this variable records whether the person meets the CCW clinical criteria for anxiety disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_anxiety_disorders

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.187	0	1	.144	0	1	.166	0	1	.166	0	1

Indicator for arrhythmia: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for arrhythmia within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_arrhythmia

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.243	0	1	.037	0	1	.22	0	1	.116	0	1

CCW indicator for asthma: For each person-month, this variable records whether the person meets the CCW clinical criteria for asthma. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_asthma

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.084	0	1	.086	0	1	.071	0	1	.08	0	1

CCW indicator for atrial fibrillation and flutter: For each person-month, this variable records whether the person meets the CCW clinical criteria for atrial fibrillation and flutter. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_atrial_fibrillation_and

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.127	0	1	.004	0	1	.119	0	1	.028	0	1

CCW indicator for autism spectrum disorders: For each person-month, this variable records whether the person meets the CCW clinical criteria for autism spectrum disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_autism_spectrum_disorde

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.004	0	1	.016	0	1	.004	0	1	.02	0	1

CCW indicator for benign prostatic hyperplasia: For each person-month, this variable records whether the person meets the CCW clinical criteria for benign prostatic hyperplasia. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_benign_prostatic_hyperp

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.139	0	1	.004	0	1	.125	0	1	.024	0	1

CCW indicator for breast cancer: For each person-month, this variable records whether the person meets the CCW clinical criteria for breast cancer. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_breast_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.056	0	1	.002	0	1	.044	0	1	.005	0	1

CCW indicator for cataracts: For each person-month, this variable records whether the person meets the CCW clinical criteria for cataracts. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_cataract

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.326	0	1	.003	0	1	.249	0	1	.016	0	1

CCW indicator for cerebral palsy: For each person-month, this variable records whether the person meets the CCW clinical criteria for cerebral palsy. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_cerebral_palsy

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.003	0	1	.001	0	1	.003	0	1	.048	0	1

Indicator for cerebrovascular disease: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for cerebrovascular disease within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_cerebrovascular_disease

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.135	0	1	.009	0	1	.128	0	1	.067	0	1

CCW indicator for chronic kidney disease: For each person-month, this variable records whether the person meets the CCW clinical criteria for chronic kidney disease. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_chronic_kidney_disease

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.183	0	1	.011	0	1	.179	0	1	.074	0	1

CCW indicator for chronic obstructive pulmonary disease (COPD) and bronchiectasis: For each person-month, this variable records whether the person meets the CCW clinical criteria for chronic obstructive pulmonary disease (COPD) and bronchiectasis. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_chronic_obstructive_pul

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.112	0	1	.016	0	1	.101	0	1	.058	0	1

CCW indicator for colorectal cancer: For each person-month, this variable records whether the person meets the CCW clinical criteria for colorectal cancer. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_colorectal_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.015	0	1	.001	0	1	.013	0	1	.003	0	1

CCW indicator for cystic fibrosis and other metabolic developmental disorders

: For each person-month, this variable records whether the person meets the CCW clinical criteria for cystic fibrosis and other metabolic developmental disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_cystic_fibrosis_and_oth

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.007	0	1	.002	0	1	.008	0	1	.014	0	1

CCW indicator for depression, bipolar, and other depressive mood disorders

: For each person-month, this variable records whether the person meets the CCW clinical criteria for depression, bipolar, or other depressive mood disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_depression_bipolar_or_o

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.189	0	1	.146	0	1	.185	0	1	.212	0	1

CCW indicator for diabetes: For each person-month, this variable records whether the person meets the CCW clinical criteria for diabetes. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_diabetes

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.296	0	1	.046	0	1	.274	0	1	.125	0	1

Indicator for diabetes with complications: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for diabetes with complications within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_diabetes_with_complicat

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.206	0	1	.028	0	1	.182	0	1	.083	0	1

Indicator for diabetic ulcer: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for diabetic ulcer within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_diabetic_ulcer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.046	0	1	.002	0	1	.045	0	1	.009	0	1

CCW indicator for drug use disorders: For each person-month, this variable records whether the person meets the CCW clinical criteria for drug use disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_drug_use_disorders

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.003	0	1	.071	0	1	.004	0	1	.155	0	1

CCW indicator for endometrial cancer: For each person-month, this variable records whether the person meets the CCW clinical criteria for endometrial cancer. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_endometrial_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.007	0	1	0	0	1	.006	0	1	.001	0	1

CCW indicator for epilepsy: For each person-month, this variable records whether the person meets the CCW clinical criteria for epilepsy. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_epilepsy

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.023	0	1	.012	0	1	.026	0	1	.076	0	1

CCW indicator for fibromyalgia, chronic pain and fatigue: For each person-month, this variable records whether the person meets the CCW clinical criteria for fibromyalgia, chronic pain and fatigue. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_fibromyalgia__chronic_p

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.237	0	1	.053	0	1	.205	0	1	.099	0	1

Indicator for fluid and electrolyte imbalance: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for fluid and electrolyte imbalance within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_fluid_and_electrolyte_i

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.143	0	1	.04	0	1	.158	0	1	.136	0	1

Indicator for gastroesophageal reflux disease: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for gastroesophageal reflux disease within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_gastroesophageal_reflux

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.24	0	1	.042	0	1	.196	0	1	.1	0	1

Indicator for gastroparesis: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for gastroparesis within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_gastroparesis

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.004	0	1	.001	0	1	.004	0	1	.004	0	1

CCW indicator for glaucoma: For each person-month, this variable records whether the person meets the CCW clinical criteria for glaucoma. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_glaucoma

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.217	0	1	.011	0	1	.18	0	1	.023	0	1

CCW indicator for heart failure and non-ischemic heart disease: For each person-month, this variable records whether the person meets the CCW clinical criteria for heart failure and non-ischemic heart disease. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_heart_failure_and_non_i

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.089	0	1	.008	0	1	.105	0	1	.055	0	1

CCW indicator for hip/pelvic fracture: For each person-month, this variable records whether the person meets the CCW clinical criteria for hip/pelvic fracture. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_hip_pelvic_fracture

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.008	0	1	.001	0	1	.01	0	1	.005	0	1

CCW indicator for HIV/AIDS: For each person-month, this variable records whether the person meets the CCW clinical criteria for HIV/AIDS. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_hiv_aids

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.005	0	1	.006	0	1	.006	0	1	.019	0	1

CCW indicator for hyperlipidemia: For each person-month, this variable records whether the person meets the CCW clinical criteria for hyperlipidemia. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_hyperlipidemia

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.8	0	1	.084	0	1	.613	0	1	.179	0	1

CCW indicator for hypertension: For each person-month, this variable records whether the person meets the CCW clinical criteria for hypertension. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_hypertension

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.751	0	1	.099	0	1	.621	0	1	.268	0	1

CCW indicator for hypothyroidism: For each person-month, this variable records whether the person meets the CCW clinical criteria for hypothyroidism. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_hypothyroidism

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.218	0	1	.017	0	1	.18	0	1	.039	0	1

CCW indicator for intellectual disabilities and related conditions: For each person-month, this variable records whether the person meets the CCW clinical criteria for intellectual disabilities and related conditions. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_intellectual_disabiliti

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.009	0	1	.005	0	1	.008	0	1	.043	0	1

CCW indicator for ischemic heart disease: For each person-month, this variable records whether the person meets the CCW clinical criteria for ischemic heart disease. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_ischemic_heart_disease

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.211	0	1	.009	0	1	.187	0	1	.047	0	1

CCW indicator for learning disabilities: For each person-month, this variable records whether the person meets the CCW clinical criteria for learning disabilities. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_learning_disabilities

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	.026	0	1	.002	0	1	.07	0	1

CCW indicator for leukemias and lymphomas: For each person-month, this variable records whether the person meets the CCW clinical criteria for leukemias and lymphomas. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_leukemias_and_lymphomas

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.017	0	1	.001	0	1	.016	0	1	.004	0	1

CCW indicator for liver disease, cirrhosis and other liver conditions (except viral hepatitis): For each person-month, this variable records whether the person meets the CCW clinical criteria for liver disease, cirrhosis and other liver conditions (except viral hepatitis). If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_liver_disease__cirrhosi

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.059	0	1	.018	0	1	.05	0	1	.039	0	1

CCW indicator for lung cancer: For each person-month, this variable records whether the person meets the CCW clinical criteria for lung cancer. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_lung_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.012	0	1	.001	0	1	.01	0	1	.004	0	1

Indicator for metastatic cancer: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for metastatic cancer within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_metastatic_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.018	0	1	.001	0	1	.019	0	1	.01	0	1

CCW indicator for migraine and chronic headache: For each person-month, this variable records whether the person meets the CCW clinical criteria for migraine and chronic headache. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_migraine_and_chronic_he

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.038	0	1	.025	0	1	.031	0	1	.018	0	1

CCW indicator for mobility impairments: For each person-month, this variable records whether the person meets the CCW clinical criteria for mobility impairments. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_mobility_impairments

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.022	0	1	.003	0	1	.029	0	1	.061	0	1

CCW indicator for multiple sclerosis and transverse myelitis: For each person-month, this variable records whether the person meets the CCW clinical criteria for multiple sclerosis and transverse myelitis. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_multiple_sclerosis_and_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.006	0	1	.001	0	1	.006	0	1	.004	0	1

CCW indicator for muscular dystrophy: For each person-month, this variable records whether the person meets the CCW clinical criteria for muscular dystrophy. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_muscular_dystrophy

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	0	0	1	0	0	1	.004	0	1

Indicator for neuropathy: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for neuropathy within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_neuropathy

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.063	0	1	.006	0	1	.059	0	1	.021	0	1

CCW indicator for non-Alzheimer's dementia: For each person-month, this variable records whether the person meets the CCW clinical criteria for non-Alzheimer's dementia. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_non_alzheimers_dementia

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.052	0	1	.001	0	1	.075	0	1	.035	0	1

CCW indicator for obesity: For each person-month, this variable records whether the person meets the CCW clinical criteria for obesity. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_obesity

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.256	0	1	.1	0	1	.177	0	1	.091	0	1

Indicator for occupational exposure to risk factors: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for occupational exposure to risk factors within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_occupational_exposure_t

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	0	0	1	.001	0	1	0	0	1

CCW indicator for osteoporosis with or without pathological fracture: For each person-month, this variable records whether the person meets the CCW clinical criteria for osteoporosis with or without pathological fracture. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_osteoporosis_with_or_wi

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.137	0	1	.002	0	1	.103	0	1	.019	0	1

CCW indicator for other developmental delays: For each person-month, this variable records whether the person meets the CCW clinical criteria for other developmental delays. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_other_developmental_del

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	.013	0	1	.001	0	1	.067	0	1

Indicator for other problems with primary support group: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for other problems with primary support group within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_other_problem_primary_s

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.006	0	1	.005	0	1	.006	0	1	.008	0	1

Indicator for pancreatitis: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for pancreatitis within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_pancreatitis

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.019	0	1	.004	0	1	.017	0	1	.013	0	1

CCW indicator for Parkinson's Disease or Secondary Parkinsonism: For each person-month, this variable records whether the person meets the CCW clinical criteria for Parkinson's Disease or Secondary Parkinsonism. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_parkinsons_disease_and_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.012	0	1	0	0	1	.013	0	1	.003	0	1

Indicator for peptic ulcer disease: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for peptic ulcer disease within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_peptic_ulcer_disease

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.01	0	1	.002	0	1	.01	0	1	.007	0	1

Indicator for peripheral and visceral atherosclerosis: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient

claims with any diagnosis for peripheral and visceral atherosclerosis within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_peripheral_and_visceral

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.123	0	1	.005	0	1	.128	0	1	.037	0	1

CCW indicator for peripheral vascular disease: For each person-month, this variable records whether the person meets the CCW clinical criteria for peripheral vascular disease. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_peripheral_vascular_dis

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.137	0	1	.005	0	1	.139	0	1	.038	0	1

CCW indicator for personality disorders: For each person-month, this variable records whether the person meets the CCW clinical criteria for personality disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_personality_disorders

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.009	0	1	.007	0	1	.009	0	1	.01	0	1

Indicator for pneumonia: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for pneumonia within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_pneumonia

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.046	0	1	.017	0	1	.055	0	1	.067	0	1

CCW indicator for pneumonia, all-cause: For each person-month, this variable records whether the person meets the CCW clinical criteria for pneumonia, all-cause. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_pneumonia_all_cause

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.034	0	1	.011	0	1	.042	0	1	.045	0	1

CCW indicator for post-traumatic stress disorder: For each person-month, this variable records whether the person meets the CCW clinical criteria for post-traumatic stress disorder. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_post_traumatic_stress_d

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.011	0	1	.032	0	1	.013	0	1	.04	0	1

CCW indicator for pressure and chronic ulcers: For each person-month, this variable records whether the person meets the CCW clinical criteria for pressure and chronic ulcers. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_pressure_and_chronic_ul

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.035	0	1	.004	0	1	.049	0	1	.045	0	1

Indicator for problems with education and literacy: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for problems with education and literacy within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_education_and_l

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.008	0	1	.008	0	1	.01	0	1	.016	0	1

Indicator for problems with employment and unemployment: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for problems with employment and unemployment within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_employment_and_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	.004	0	1	.002	0	1	.009	0	1

Indicator for problems with housing and economic conditions: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for problems with housing and economic conditions within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_housing_and_eco

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.007	0	1	.018	0	1	.008	0	1	.135	0	1

Indicator for difficulty with life management: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for difficulty with life management within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_life_management

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.003	0	1	.001	0	1	.004	0	1	.004	0	1

Indicator for lifestyle problems: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for lifestyle problems within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_lifestyle

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.024	0	1	.016	0	1	.02	0	1	.026	0	1

Indicator for psychosocial problems: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for psychosocial problems within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_psychosocial

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	.003	0	1	.001	0	1	.011	0	1

Indicator for problems with social environment: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for problems with social environment within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_social_environm

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.006	0	1	.002	0	1	.007	0	1	.005	0	1

Indicator for problems with upbringing: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for problems with upbringing within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problem_upbringing

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	.003	0	1	.001	0	1	.005	0	1

Indicator for problems with care provider dependency: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for problems with care provider dependency within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_problems_care_provider_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.085	0	1	.002	0	1	.106	0	1	.052	0	1

CCW indicator for prostate cancer: For each person-month, this variable records whether the person meets the CCW clinical criteria for prostate cancer. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_prostate_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.051	0	1	.001	0	1	.046	0	1	.005	0	1

Indicator for protein-calorie malnutrition: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with

any diagnosis for protein-calorie malnutrition within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_protein_calorie_malnutr

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.019	0	1	.004	0	1	.03	0	1	.042	0	1

Indicator for pulmonary circulatory disorder: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for pulmonary circulatory disorder within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_pulmonary_circulatory_d

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.044	0	1	.005	0	1	.046	0	1	.029	0	1

CCW indicator for rheumatoid arthritis/osteoarthritis: For each person-month, this variable records whether the person meets the CCW clinical criteria for rheumatoid arthritis/osteoarthritis. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_ra_oa__rheumatoid_arthr

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.404	0	1	.039	0	1	.339	0	1	.087	0	1

Indicator for respiratory infection: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for respiratory infection within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_respiratory_infection

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.162	0	1	.247	0	1	.124	0	1	.13	0	1

Indicator for retinopathy: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for retinopathy within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_retinopathy

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	0	0	1	.002	0	1	.001	0	1

Indicator for rheumatoid arthritis/collagen vascular disease: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for rheumatoid arthritis/collagen vascular disease within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_rheumatoid_arthritis___

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.07	0	1	.009	0	1	.057	0	1	.012	0	1

CCW indicator for schizophrenia and other psychotic disorders: For each person-month, this variable records whether the person meets the CCW clinical criteria for schizophrenia and other psychotic disorders. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_schizophrenia_and_other

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.015	0	1	.02	0	1	.029	0	1	.076	0	1

CCW indicator for sensory (blindness and visual) impairment: For each person-month, this variable records whether the person meets the CCW clinical criteria for sensory (blindness and visual) impairment. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_sensory___blindness_and

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.004	0	1	0	0	1	.005	0	1	.004	0	1

CCW indicator for sensory (deafness and hearing) impairment: For each person-month, this variable records whether the person meets the CCW clinical criteria for sensory (deafness and hearing) impairment. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_sensory___deafness_and_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.099	0	1	.007	0	1	.075	0	1	.018	0	1

Indicator for sepsis: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for sepsis within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_sepsis

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.032	0	1	.008	0	1	.044	0	1	.063	0	1

Indicator for sleep apnea: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for sleep apnea within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_sleep_apnea

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.18	0	1	.044	0	1	.162	0	1	.083	0	1

Indicator for solid tumor without metastasis: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for solid tumor without metastasis within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_solid_tumor_without_met

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.134	0	1	.006	0	1	.115	0	1	.024	0	1

CCW indicator for spina bifida and other congenital anomalies of the nervous system: For each person-month, this variable records whether the person meets the CCW clinical criteria for spina bifida and other congenital anomalies of the nervous system. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_spina_bifida_and_other_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	.002	0	1	.002	0	1	.037	0	1

CCW indicator for spinal cord injury: For each person-month, this variable records whether the person meets the CCW clinical criteria for spinal cord injury. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_spinal_cord_injury

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.006	0	1	.001	0	1	.006	0	1	.007	0	1

CCW indicator for stroke/ischemic transient attack: For each person-month, this variable records whether the person meets the CCW clinical criteria for stroke/ischemic transient attack. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_stroke_transient_ischem

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.066	0	1	.006	0	1	.069	0	1	.042	0	1

CCW indicator for tobacco use: For each person-month, this variable records whether the person meets the CCW clinical criteria for tobacco use. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_tobacco_use

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.069	0	1	.06	0	1	.06	0	1	.117	0	1

CCW indicator for traumatic brain injury and nonpsychotic mental disorders due to brain damage: For each person-month, this variable records whether the person meets the CCW clinical criteria for traumatic brain injury and nonpsychotic mental disorders due to brain damage. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_traumatic_brain_injury_

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.003	0	1	.001	0	1	.003	0	1	.005	0	1

Indicator for urinary tract infection: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any

diagnosis for urinary tract infection within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_urinary_tract_infection

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.118	0	1	.034	0	1	.13	0	1	.074	0	1

CCW indicator for urologic cancer: For each person-month, this variable records whether the person meets the CCW clinical criteria for urologic cancer. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_urologic_cancer

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.008	0	1	0	0	1	.008	0	1	.001	0	1

CCW indicator for viral hepatitis: For each person-month, this variable records whether the person meets the CCW clinical criteria for viral hepatitis. If so, this variable takes the value 1; if not, then 0.

Variable Name: ccw_viral_hepatitis__genera

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.008	0	1	.007	0	1	.011	0	1	.027	0	1

Indicator for cilostazol use: For each person-month, this variable takes the value of 1 if a person incurred a claim for cilostazol within the past 12 months, and 0 otherwise.

Variable Name: cilostazol

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	0	0	1	.002	0	1	.001	0	1

DCSI Score – Cardiovascular: For each person-month, this variable records the person's cardiovascular DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication; 2 = had at least 1 severe complication.

Variable Name: d_comp_cardio

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.626	0	2	.056	0	2	.578	0	2	.233	0	2

DCSI Score – Cerebrovascular: For each person-month, this variable records the person's cerebrovascular DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication; 2 = had at least 1 severe complication.

Variable Name: d_comp_cereb

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.23	0	2	.014	0	2	.211	0	2	.097	0	2

DCSI Score - Metabolic: For each person-month, this variable records the person's metabolic DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication; 2 = had at least 1 severe complication.

Variable Name: d_comp_metab

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.011	0	2	.003	0	2	.014	0	2	.01	0	2

DCSI Score – Nephropathy: For each person-month, this variable records the person's nephropathy DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication; 2 = had at least 1 severe complication.

Variable Name: d_comp_neph

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.147	0	2	.012	0	2	.19	0	2	.084	0	2

DCSI Score – Neuropathy: For each person-month, this variable records the person's neuropathy DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication.

Variable Name: d_comp_neur

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.134	0	1	.019	0	1	.123	0	1	.061	0	1

DCSI Score - Peripheral Vascular Disease: For each person-month, this variable records the person's PVD DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication; 2 = had at least 1 severe complication.

Variable Name: d_comp_pvd

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.158	0	2	.012	0	2	.16	0	2	.083	0	2

DCSI Score – Retinopathy: For each person-month, this variable records the person's retinopathy DCSI score over the past 12 months: 0 = had no complications; 1 = had at least 1 non-severe complication; 2 = had at least 1 severe complication.

Variable Name: d_comp_retin

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.132	0	2	.021	0	2	.124	0	2	.052	0	2

Diabetes Duration: For each person-month, this variable records the time since the person's first recorded diagnosis of diabetes.

Variable Name: d_diab_dur

Source: Beneficiary demographics

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
22.514	0	105	NA	NA	NA	21.819	0	105	NA	NA	NA

Number of Previous Severe Type 2 Diabetes Complications: For each person-month, this variable records the number of severe type-2 diabetes complications in the previous 12 months.

Variable Name: d_diabcomp_num

Source: Institutional and professional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.148	0	74	.019	0	100	.192	0	120	.138	0	32

Indicator for Use of Insulin AND Another Glucose-Lowering Medication: For each person-month, this variable records whether the person has been prescribed both insulin AND another glucose-lowering drug within the same month in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: d_int_insul_gluc

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.029	0	1	.006	0	1	.027	0	1	.016	0	1

Part D OOP spending: For each person-month, this variable records the total amount of out-of-pocket spending for prescriptions in the previous 12 months.

Variable Name: d_ptd_oop_spend

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
328.456	0	12654	NA	NA	NA	288.199	0	13269	NA	NA	NA

Indicator for use of Anticoagulants: For each person-month, this variable records whether the person has been prescribed an anticoagulant in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: d_rx_anticoag

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.1	0	1	.005	0	1	.092	0	1	.033	0	1

Indicator for use of Anti-Hypertensive Treatment: For each person-month, this variable records whether the person has been prescribed an anti-hypertensive in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: d_rx_antihyp

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.535	0	1	.087	0	1	.446	0	1	.205	0	1

Indicator for Use of Fibrates: For each person-month, this variable records whether the person has been prescribed a fibrate in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: d_rx_fibrate

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.017	0	1	.003	0	1	.013	0	1	.006	0	1

Indicator for use of Sulfonylureas: For each person-month, this variable records whether the person has been prescribed a sulfonylurea in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: d_rx_sulfon

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.042	0	1	.008	0	1	.033	0	1	.017	0	1

Indicator for use of Thiazolidinediones: For each person-month, this variable records whether the person has been prescribed a thiazolidinedione or glitazone in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: d_rx_thiaz

Source: Pharmacy claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.008	0	1	.001	0	1	.007	0	1	.002	0	1

Cumulative Number of Days for Inpatient Stays: For each person-month, this variable records the number of days for inpatient hospital stays in the previous 12 months.

Variable Name: d_total_inpt_days

Source: Institutional claims

Models: Pre-DC

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.896	0	216	.363	0	1806	1.253	0	324	4.182	0	1014

Indicator for frailty: For each person-month, this variable takes the value of 1 if a person meets the definition for frailty within the past twelve months, and 0 otherwise. The clinical definition for frailty is derived from Kim and Schneeweiss 2014.

Variable Name: dis_frailty

Source: Institutional, professional, and DME claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.365	0	1	.077	0	1	.332	0	1	.185	0	1

Indicator for sickle cell anemia: For each person-month, this variable records whether the person has incurred at least one inpatient or two non-inpatient claims with any diagnosis for sickle cell anemia within the past two years. If so, this variable takes the value 1; if not, then 0.

Variable Name: dis_sickle

Source: Institutional and professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	.001	0	1	.001	0	1	.001	0	1

Indicator for durable medical equipment (DME) use: For each person-month, this variable takes the value of 1 if a person used any durable medical equipment in the previous 12 months, and 0 otherwise.

Variable Name: dme_use

Source: DME claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.278	0	1	.061	0	1	.24	0	1	.105	0	1

Indicator for dual eligibility with Medicaid: For each person-month, this variable takes the value of 1 if a person was dually eligible for both Medicaid and Medicare within the past 12 months, and 0 otherwise.

Variable Name: dual_eligible_mon

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.123	0	1	0	0	1	.18	0	1	0	0	1

Number of emergency department visits within the past 6 months: For each person-month, this variable counts the number of emergency department visits incurred within the prior 6 months.

Variable Name: ed_num

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.169	0	88	.071	0	50	.177	0	101	.274	0	89

Indicator for endocrinologist visit: For each person-month, this variable takes the value of 1 if a person visited an endocrinologist within the past 12 months, and 0 otherwise.

Variable Name: endocrin_visit

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.088	0	1	.004	0	1	.073	0	1	.009	0	1

Indicator for diabetic foot procedure: For each person-month, this variable takes the value of 1 if a person incurred an inpatient diabetic foot procedure over the last 12 months and 0 otherwise.

Variable Name: foot_toe_amputation

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	0	0	1	.001	0	1	.001	0	1

Indicator for having Received Chemotherapy: For each person-month, this variable records whether the person has received chemotherapy in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_chemo

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.013	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for having Received Dialysis: For each person-month, this variable records whether the person has been on dialysis in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dialysis

Source: Professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Bone and Connective Tissue: For each person-month, this variable records whether the person has had a diagnosis for cancer of the bone or connective tissue in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_bone

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Brain and Nervous System: For each person-month, this variable records whether the person has had a diagnosis for cancer of the brain or nervous system in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_brain

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Esophagus: For each person-month, this variable records whether the person has had a diagnosis for cancer of the esophagus in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_esoph

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Liver and Intrahepatic Bile Duct: For each person-month, this variable records whether the person has had a diagnosis for cancer of the liver or intrahepatic bile duct in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_liv

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Bronchus; Lung: For each person-month, this variable records whether the person has had a diagnosis for cancer of the bronchus/lung in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_lung

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.011	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Ovary: For each person-month, this variable records whether the person has had a diagnosis for cancer of the ovary in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_ovar

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Pancreas: For each person-month, this variable records whether the person has had a diagnosis for cancer of the pancreas in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_panc

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Cancer of Stomach: For each person-month, this variable records whether the person has had a diagnosis for cancer of the stomach in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_canc_stom

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.002	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Paraplegia or Hemiplegia: For each person-month, this variable records whether the person has had a diagnosis for paraplegia or hemiplegia in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_dis_paraplegia

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.013	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Hospital Bed Usage in DME: For each person-month, this variable records whether the person has a DME claim for a home hospital bed in the previous 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_hospbed_dme

Source: Professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.008	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Interaction of ADRD and Frailty Index: For each person-month, this variable records the interaction between whether a person has a dementia diagnosis AND their frailty index score.

Variable Name: h_int_ccw_alz_frail

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.014	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Morphine Use: For each person-month, this variable records whether the person has received or been prescribed morphine in the past 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_morphine

Source: Institutional, professional, and pharmacy claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.036	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Indicator for Oxygen Usage in DME: For each person-month, this variable records whether the person has a DME claim for home oxygen therapy in the previous 12 months. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_o2_dme

Source: Professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.086	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Severity of Frailty: For each person-month, this variable records each patient's claims-based frailty index (CFI) score using claims from the previous 12 months. CFI calculated using methods detailed in Gautam et al., 2020, Journals of Gerontology: Medical Sciences.

Variable Name: h_sev_frail

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.161	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Recent Increase in Frailty severity: For each person-month, this variable records whether the person's claims-based frailty index score has increased compared to the previous month. If so, this variable takes the value 1; if not, then 0.

Variable Name: h_sev_frail_inc

Source: Institutional and professional claims

Models: Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.334	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA

Number of HbA1c tests: For each person-month, this variable counts the number of visits within the past 12 months in which a person received a Hemoglobin A1C (HbA1c) test. We define visits as unique combinations of person-provider-day.

Variable Name: hba1c

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.80	0	13	.041	0	11	.659	0	13	.02	0	5

Number of heart-related procedures: For each person-month, this variable counts the number of heart-related procedures incurred over the past year.

Variable Name: heart_related_procs

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.021	0	12	.004	0	20	.027	0	14	.023	0	9

Number of home health visits: For each person-month, this variable counts the number of home health visits incurred within the past 12 months. We apply a logarithmic transformation to non-zero values. We define visits as unique combinations of person-provider-day.

Variable Name: home_health_visits

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.044	0	5	.048	0	6	.078	0	5	.562	0	7

Indicator for hospice enrollment: For each person-month, this variable takes the value of 1 if a person enrolled in hospice within the past 12 months, and 0 otherwise.

Variable Name: hospice

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.004	0	1	NA	NA	NA	.008	0	1	NA	NA	NA

Indicator for insulin use: For each person-month, this variable takes the value of 1 if a person incurred a claim for insulin within the past 12 months, and 0 otherwise.

Variable Name: insulin

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.042	0	1	.014	0	1	.044	0	1	.036	0	1

Indicator for leukotriene receptor modifier use: For each person-month, this variable takes the value of 1 if a person incurred a claim for leukotriene receptor modifiers within the past 12 months, and 0 otherwise.

Variable Name: leukotrine_receptor_modifie

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.041	0	1	.023	0	1	.033	0	1	.018	0	1

Indicator for losartan use: For each person-month, this variable takes the value of 1 if a person incurred a claim for losartan within the past 12 months, and 0 otherwise.

Variable Name: losartan

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.148	0	1	.022	0	1	.114	0	1	.052	0	1

Indicator for original Medicare eligibility for a non-age related cause: Beneficiary was originally eligible for Medicare for a reason other than age.

Variable Name: mc_elig_reason_nonage

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.142	0	1	NA	NA	NA	.19	0	1	NA	NA	NA

Total health spending: For each person-month, this variable measures the total health spending incurred within the past 12 months. We define this as the sum of claim total charge amount (Part A), claim payment amount (Part B claim lines, aggregated to the claim level), and claim line beneficiary payment amount (part D).

Variable Name: medicare_payment_tot

Source: Institutional, professional, and pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
15934	0	3323343	NA	NA	NA	35481	0	4149271	NA	NA	NA

Indicator for mental health use: For each person-month, this variable takes the value of 1 if a person incurred a visit with a mental health professional over the past 12 months, and 0 otherwise.

Variable Name: mental_health_use

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.05	0	1	.115	0	1	.067	0	1	.135	0	1

Number of medications: For each person-month, this variable counts the number of distinct medications (as measured by NDC codes) for which there are Pharmacy claims within the past 12 months.

Variable Name: number_of_meds

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
9.082	0	108	4.956	0	188	8.209	0	131	7.211	0	138

Indicator for oncologist visit: For each person-month, this variable takes the value of 1 if a person visited an oncologist within the past 12 months, and 0 otherwise.

Variable Name: oncologist_visit

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.128	0	1	.006	0	1	.111	0	1	.014	0	1

Indicator for oral antibiotic use: For each person-month, this variable takes the value of 1 if a person incurred a claim for oral antibiotics within the past 12 months, and 0 otherwise.

Variable Name: oral_antibiotics

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.396	0	1	.35	0	1	.337	0	1	.259	0	1

Indicator for oral corticosteroid use: For each person-month, this variable takes the value of 1 if a person incurred a claim for oral corticosteroids within the past 12 months, and 0 otherwise.

Variable Name: oral_corticosteroids

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.169	0	1	.08	0	1	.138	0	1	.062	0	1

Number of outpatient visits: For each person-month, this variable counts the number of visits in an outpatient setting incurred within the past 12 months. We define visits as unique combinations of person-provider-day.

Variable Name: outpatient_visits

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
17.836	0	320	8.618	0	787	14.901	0	250	10.165	0	575

Continuity of primary care - Duration: For each person-month, this variable calculates the average time interval between primary care visits over the past 12 months. Visits that occur within 14 days are aggregated. Individuals with no primary care visits over the past 12 months are assigned a value of 365. We define visits as unique combinations of person-provider-day.

Variable Name: pcp_continuity_avg_interval

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
87.346	15	365	208.603	15	365	132.974	15	365	225.982	15	365

Discontinuity of primary care - Index: For each person-month, this variable calculates (1 - the continuity of care index), from Boxerman and Bice, 1977. This score ranges from 0 to 1 and is intended to measure dispersion in person-provider contact. If the person sees the same provider for all visits, indicating highly continuous care, the index score is 0; if the person sees a different physician for every visit, indicating fragmented care, the index score is 1. If a person has no primary care visits within the past year, they are assigned a value of 0. We define visits as unique combinations of person-provider-day.

Variable Name: pcp_continuity_index

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.74	0	1	.299	0	1	.602	0	1	.326	0	1

Discontinuity of primary care - Proportion: For each person-month, this variable estimates (1 - the fraction of primary care visits within the past 12 months provided by the same provider). For example, if a person had 10 primary care visits over the past 12 months, and four visits were with the same provider, then this measure would take a value of (1 - .4) = .6. We define visits as unique combinations of person-provider-day.

Variable Name: pcp_continuity_proportion

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.568	0	1	.424	0	1	.595	0	1	.636	0	1

Number of primary care visits: For each person-month, this variable counts the number of primary care visits within the past 12 months. We define visits as unique combinations of person-provider-day.

Variable Name: pcp_visits

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
11.167	0	261	4.758	0	441	11.1	0	459	8.935	0	446

Indicator for previous conservative diabetic wound procedure: For each person-month, this variable takes the value of 1 if a person underwent at least one conservative diabetic procedure within the past 12 months, and 0 otherwise.

Variable Name: prev_diab_wound

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.01	0	1	.001	0	1	.012	0	1	.006	0	1

Number of prior admissions: For each person-month, this variable counts the number of all inpatient hospital admissions incurred within the past twelve months.

Variable Name: prior_admit_count

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.17	0	23	.069	0	29	.205	0	25	.343	0	47

Prior admission length of stay: For each person-month, this variable calculates the length of the most recently incurred hospital inpatient stay over the past 12 months. For individuals without a previous inpatient stay, this value is set to zero.

Variable Name: prior_admit_los

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.534	0	92	.188	0	900	.68	0	165	.896	0	600

Prior hospitalization admission source - none: For each person-month, this variable indicates the individual did not incur an inpatient hospital stay within the past 12 month.

Variable Name: prior_admit_src_none

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.89	0	1	.953	0	1	.878	0	1	.875	0	1

Prior hospitalization admission source - other: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission source was: other.

Variable Name: prior_admit_src_oth

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	0	0	0	0	0	0	0	0	0	0

Prior hospitalization admission source - physician referral: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission source was: physician referral.

Variable Name: prior_admit_src_phy

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.094	0	1	.025	0	1	.1	0	1	.015	0	1

Prior hospitalization admission source - transferred from facility: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission source was: transferred from facility.

Variable Name: prior_admit_src_trans

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.016	0	1	.021	0	1	.022	0	1	.11	0	1

Prior hospitalization admission type - elective: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission type was: elective.

Variable Name: prior_admit_type_elect

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.027	0	1	.01	0	1	.024	0	1	.023	0	1

Prior hospitalization admission type - emergency: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission type was: emergency.

Variable Name: prior_admit_type_emerg

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.078	0	1	.02	0	1	.091	0	1	.084	0	1

Prior hospitalization admission type - none: For each person-month, this variable indicates the individual did not incur an inpatient hospital stay within the past 12 month.

Variable Name: prior_admit_type_none

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.89	0	1	.953	0	1	.878	0	1	.875	0	1

Prior hospitalization admission type - other: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission type was: other.

Variable Name: prior_admit_type_oth

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	.011	0	1	0	0	1	.006	0	1

Prior hospitalization admission type - trauma center: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission type was: trauma center.

Variable Name: prior_admit_type_traum

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	0	0	1	.001	0	1	.002	0	1

Prior hospitalization admission type - urgent: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's admission type was: urgent.

Variable Name: prior_admit_type_urgent

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.004	0	1	.005	0	1	.005	0	1	.009	0	1

Prior hospitalization discharge status - home: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's discharge status was: home.

Variable Name: prior_discharge_home

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.089	0	1	.045	0	1	.087	0	1	.08	0	1

Prior hospitalization discharge status - none: For each person-month, this variable indicates the individual did not incur an inpatient hospital stay within the past 12 month.

Variable Name: prior_discharge_none

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.89	0	1	.953	0	1	.878	0	1	.875	0	1

Prior hospitalization discharge status - other: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's discharge status was: other.

Variable Name: prior_discharge_other

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	.001	0	1	.001	0	1	.021	0	1

Prior hospitalization discharge status - transferred to inpatient care: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's discharge status was: transferred to inpatient care.

Variable Name: prior_discharge_trans_inpt

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.001	0	1	0	0	1	.002	0	1	.002	0	1

Prior hospitalization discharge status - transferred to post-acute care: For each person-month, this variable indicates that for the individual's most recently incurred inpatient hospital stay within the past 12 months, the individual's discharge status was: transferred to post-acute care.

Variable Name: prior_discharge_trans_post

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.02	0	1	.001	0	1	.032	0	1	.021	0	1

Indicator for prior nursing home stay: For each person-month, this variable takes the value of 1 if a person incurred a nursing home stay within the last 12 months, and 0 otherwise.

Variable Name: prior_nh_stay

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.023	0	1	.001	0	1	.038	0	1	.069	0	1

Indicator for prior readmission: For each person-month, this variable takes the value of 1 if a person incurred an all-cause 30-day hospital readmission within the last 12 months, and 0 otherwise. We define readmission as two inpatient stays occurring fewer than 30 days apart.

Variable Name: prior_readmission

Source: Institutional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.022	0	1	.008	0	1	.028	0	1	.037	0	1

Indicator for prior surgery: For each person-month, this variable takes the value of 1 if a person underwent a surgery within the past 12 months, and 0 otherwise.

Variable Name: prior_surgery

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.656	0	1	NA	NA	NA	.551	0	1	NA	NA	NA

Indicator for provider administered drug: For each person-month, this variable takes the value of 1 if a person received a provider-administered drug as defined by a 'J code' in the past 12 months, and 0 otherwise.

Variable Name: provider_admin_drug

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.269	0	1	.057	0	1	.217	0	1	.051	0	1

Beneficiary race - Asian: Beneficiary's Research Triangle Institute (RTI) race code is Asian.

Variable Name: race_asian

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.033	0	1	.059	0	1	.047	0	1	.048	0	1

Beneficiary race - Black: Beneficiary's Research Triangle Institute (RTI) race code is Black.

Variable Name: race_black

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.183	0	1	.382	0	1	.253	0	1	.447	0	1

Beneficiary race - Hispanic: Beneficiary's Research Triangle Institute (RTI) race code is Hispanic.

Variable Name: race_hispanic

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.023	0	1	.102	0	1	.032	0	1	.044	0	1

Beneficiary race - Native American: Beneficiary's Research Triangle Institute (RTI) race code is Native American.

Variable Name: race_nativeamer

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	.005	0	1	0	0	1	.003	0	1

Beneficiary race - Other: Beneficiary's Research Triangle Institute (RTI) race code is Other.

Variable Name: race_other

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.009	0	1	.002	0	1	.011	0	1	.001	0	1

Beneficiary race - Unknown: Beneficiary's Research Triangle Institute (RTI) race code is Unknown.

Variable Name: race_unknown

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.03	0	1	.198	0	1	.033	0	1	.233	0	1

Beneficiary race - White: Beneficiary's Research Triangle Institute (RTI) race code is White.

Variable Name: race_white

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.721	0	1	.253	0	1	.624	0	1	.223	0	1

Indicator for rivaroxaban use: For each person-month, this variable takes the value of 1 if a person incurred a claim for rivaroxaban within the past 12 months, and 0 otherwise.

Variable Name: riva

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.022	0	1	.001	0	1	.019	0	1	.006	0	1

Number of rural clinic visits: For each person-month, this variable counts the number of rural clinic visits incurred within the past 12 months. We define visits as unique combinations of person-provider-day.

Variable Name: rural_clinic_visits

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
0	0	1	.001	0	16	0	0	3	0	0	10

Beneficiary sex - female: Beneficiary sex is female.

Variable Name: sex_female

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.596	0	1	.537	0	1	.547	0	1	.392	0	1

Beneficiary sex - male: Beneficiary sex is male.

Variable Name: sex_male

Source: Beneficiary demographics

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.404	0	1	.463	0	1	.453	0	1	.608	0	1

Number of specialist visits: For each person-month, this variable counts the number of specialist visits incurred within the past 12 months. We define visits as unique combinations of person-provider-day.

Variable Name: specialist_visits

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
5.537	0	252	.518	0	214	5.413	0	371	1.374	0	308

Indicator for statin use: For each person-month, this variable takes the value of 1 if a person incurred a claim for statins within the past 12 months, and 0 otherwise.

Variable Name: statin_use

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.511	0	1	.072	0	1	.406	0	1	.183	0	1

Number of lab tests: For each person-month, this variable counts the number of visits within the past 12 months in which a person received any laboratory test. We define visits as unique combinations of person-provider-day.

Variable Name: total_lab_tests

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.177	0	31	.022	0	14	.178	0	38	.01	0	7

Number of urgent care visits: For each person-month, this variable counts the number of urgent care visits incurred within the past 12 months. We define visits as unique combinations of person-provider-day.

Variable Name: urgent_care_visits

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.243	0	40	.549	0	68	.184	0	39	.179	0	27

Indicator for no vaccination (flu or pneumonia): For each person-month, this variable takes the value of 1 if a person did not receive a vaccination (flu or pneumonia) within the past 12 months, 0 otherwise.

Variable Name: vaccination

Source: Professional claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.61	0	1	.899	0	1	.723	0	1	.946	0	1

Indicator for warfarin use: For each person-month, this variable takes the value of 1 if a person incurred a claim for warfarin within the past 12 months, and 0 otherwise.

Variable Name: warfarin

Source: Pharmacy claims

Models: Pre-AH, Pre-DC, Pre-HE

Medicare MDPCP			Medicaid HealthChoice			Medicare FFS			Medicaid FFS		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
.014	0	1	.001	0	1	.011	0	1	.003	0	1

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Appendix 2. Social Determinants of Health Data Set

Geocoding Procedure

Hilltop enhanced the granularity of the SDOH risk factors from ZCTA to census tract as part of regular improvements to the MDPCP production model in October 2021. We increased the granularity of the SDOH covariates because research shows there can be substantial variability of SDOH within ZCTAs. Because census tract measures represent smaller areas, they may provide a more accurate representation of an individual's proximal environment (Moss et al., 2021), but it requires the additional (and potentially non-trivial) development step of geocoding patient addresses.

We used an automated two-step geocoding procedure to identify an individual's unique census tract. First, we used Microsoft® Azure Maps' "Get Search Address" feature to transform their home address from the CCLF data into geographical coordinates (i.e., latitude, longitude). Then, we mapped the coordinates to a census tract using the GeoPandas (v0.8.1) python package. Once a unique census tract was identified for an individual, we linked the environmental risk factors from both their census tract and their 5-digit ZCTA of residence to their individual utilization risk factors in SAS (v.9.4).

As of the time of writing, this geocoding is only performed for the Pre-AH Model, Pre-DC Model, and Pre-HE Model risk scores for the MDPCP population. All other models use ZCTA as the basis for geographic linkage to social determinants of health risk factors.

Description of Variables

Social and environmental variables play an important role in health; however, many individual-level demographic and socioeconomic factors are unavailable in administrative claims data. Consequently, Hilltop developed a database of area-level risk factors from publicly available data sources that can be linked to an individual's administrative claims using their recorded address to proxy for the unobserved individual-level variables. Other environmental risk factors are intended to capture social determinants of health—the neighborhood conditions in which people live and age that may affect health outcomes. Table 31 includes a list of the areal-level risk factors along with the data used to create them.

Table 31. Environmental Risk Factor Sources

Risk Factor	Source	Year	Original Granularity for Census Tract	Original Granularity for ZCTA
Population	ACS; Table B01003	2022	Census Tract	ZCTA
Population Growth[1]	ACS; Table B01003	2022	Census Tract	ZCTA
Population Density[2]	ACS; Table B01003	2022	Census Tract	ZCTA
Percent Age 0-4	ACS; Table S0101	2022	Census Tract	ZCTA
Percent Married	ACS; Table S1201	2022	Census Tract	ZCTA
Percent Single Mothers	ACS; Table S1301	2022	Census Tract	ZCTA
Median Household Income	ACS; Table S1901	2022	Census Tract	ZCTA
Percent in Poverty	ACS; Table S1702	2022	Census Tract	ZCTA
Percent Less than High School Diploma	ACS; Table S1501	2022	Census Tract	ZCTA
Percent Native American	ACS; Table DP05	2022	Census Tract	ZCTA
Percent Non-English Speakers	ACS; Table S1601	2022	Census Tract	ZCTA
Percent Foreign Born	ACS; Table DP02	2022	Census Tract	ZCTA
Percent Age 65+	ACS; Table S0101	2022	Census Tract	ZCTA
Percent Age 65+ Live Alone	ACS; Table S1101	2022	Census Tract	ZCTA
Percent Age 65+ Non-White	ACS; Table B01001A	2022	Census Tract	ZCTA
Percent Age 65+ Latinx	ACS; Table B01001L	2022	Census Tract	ZCTA
Percent Age 65+ in Poverty	ACS; Table S1702	2022	Census Tract	ZCTA
Percent Age 65+ Less than High School Diploma	ACS; Table S1501	2022	Census Tract	ZCTA
Area Deprivation Index	WISC	2021	Census Block[3]	ZCTA
Taxable Interest	IRS	2020	ZCTA[3]	ZCTA
Has a Mental Health Center	CMS	2023	Census Tract	ZCTA
Has a Federally Qualified Health Center	CMS	2023	Census Tract	ZCTA
Has a Rural Health Clinic	CMS	2023	Census Tract	ZCTA
Has a For Profit Hospital	CMS	2023	Census Tract	ZCTA
Number of Hospitals	CMS	2023	Census Tract	ZCTA
Hospitals/1000 Residents[4]	CMS	2023	Census Tract	ZCTA
Hospital Beds/1000 Residents[4]	CMS	2023	Census Tract	ZCTA
Has a VA Clinic or Center	VA	2024	Census Tract	ZCTA
Primary Care Providers/1000 Residents[4]	NPI	2024	Census Tract	ZCTA
Internists/1000 Residents[4]	NPI	2024	Census Tract	ZCTA
Specialists/1000 Residents[4]	NPI	2024	Census Tract	ZCTA
Social Workers/1000 Residents[4]	NPI	2024	Census Tract	ZCTA
Partial Primary Care Shortage Area	AHRF	2023	County[5]	County[3]
Whole Primary Care Shortage Area	AHRF	2023	County[5]	County[3]

Risk Factor	Source	Year	Original Granularity for Census Tract	Original Granularity for ZCTA
Partial Mental Health Care Shortage Area	AHRF	2023	County[5]	County[3]
Whole Mental Health Shortage Area	AHRF	2023	County[5]	County[3]
Percent Physician Diversity (racial or ethnic minority, excluding Asian Americans)	ACS Individual-Level Data	2022	County[5]	County[3]
Air Pollution (average daily PM2.5 concentration)	EPA	2023	Census Tract	Census Tract[3]

ACS = American Community Survey, 5-year estimates, data table number in ( ), AHRF = Area Health Resources File, CMS = Centers for Medicare and Medicaid Services, EPA = Environmental Protection Agency, IRS = Internal Revenue Service, NPI = National Provider Identified Database, USDA = United States Department of Agriculture, VA = Veteran's Affairs, WISC = Wisconsin School of Medicine and Public Health

[1]Population growth for census tracts is from 2013-2019 and from 2011-2019 for ZCTAs.

[2]Density calculated using land area (square miles) according to the 2019 Census Gazetteer records.

[3]Transformed to final geographic unit using **HUDuser.gov ratios**[26] **and the methods from Din & Wilson (2020).**

[4]Calcuated using the 2022 population estimates from ACS.

[5]FIPS county code was matched with the county code for each FIPS census tract.

[6]Tract estimate calculated from the average value across all blocks within a tract.

Update November 2024: In order to ensure that the SDOH risk factors accurately reflect individuals' neighborhood environment, we updated the data underlying the SDOH/environmental risk factors as part of regular model maintenance.

Additionally, two of the environmental risk factors, rural-urban index and walkability index, were removed because their underlying data had not been updated to use the current 2020 Census boundaries. We were unable to use the previous versions of these risk factors because there was a change in the number and boundaries of census tracts between the 2010 vs. 2020 Census, which means that the 2010 census tracts do not directly map to the 2020 versions.

Last, we retired the ZCTA-level risk factors engineered in the Pre-CH Model because production of that model was paused in March 2024. Those risk factors include:

- Percent 60+ minute commute
- Percent Workers who travel to work by car
- Percent Workers who travel to work by public transit
- Percent Black
- Percent Male
- Percent Population living in college group quarters
- Percent Population living in nursing home group quarters
- Percent of units with 0 or 1 bedrooms
- Population per household

[26] https://www.huduser.gov/portal/datasets/usps_crosswalk.html

Transformation Details

For risk factors that were only available at the ZCTA-level (*N*=1) or at the census tract level (or other census polygon, including county - *N*=7), we used the Department of Housing and Urban Development (HUD) USPS ZIP Code Crosswalk files to transform the variables to the appropriate geographic unit (Din & Wilson, 2020; Office of Policy Development and Research, 2021).

Imputation of Missing Values

To facilitate training the Pre- Models, a version of the data set was also created where all missing variables were imputed using the overall mean of the variable.

Census Tract-Level

Physician Diversity: Imputation of missing variables was done for the county_pct_physician_diversity variable because, in the ACS public-use microdata (from IPUMS), counties were not identified from 1950 onwards. Therefore, IPUMS assigns county based on other low-level geographic identifiers which is not possible for all counties. To avoid large amounts of missing data, county_pct_physician_diversity was imputed from a weighted average of physician diversity from the counties in that state.

ZCTA-Level

Physician Diversity: In the ACS public-use microdata (from IPUMS), counties were not identified from 1950 onwards. Therefore, IPUMS assigns county based on other low-level geographic identifiers which is not possible for all counties. To avoid large amounts of missing data, county_pct_physician_diversity was imputed from a weighted average of physician diversity from the counties in that state.

Taxable Interest Per Capita: Data for missing ZCTAs were imputed when possible based on a weighted average of taxable interest per capita from the other ZCTAs within the same ZIP code sorting area (first three digits of ZCTA).

Area Deprivation Index: Data for missing ZCTAs were imputed when possible based on a weighted average of the area deprivation index from the other ZCTAs within the same ZIP code sorting area (first three digits of ZCTA).

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Appendix 3. Inactive Models

Pre-CH

This predictive model was an extension of the Hilltop Pre-AH Model and was designed to estimate individual-level risk of hospitalization due to COVID-19 for Medicaid enrollees across the state of Maryland. This predictive model was intended to help health care providers prospectively identify individuals at risk of hospitalization for *current and future pandemics*. With the tool, it may be possible for them to have designed suitable proactive interventions to try to reduce these individuals' risk of hospitalization because health care providers could identify these individuals before they reach the hospital. Moreover, such an evidence-based forward-triage mechanism—particularly if implemented via telehealth—could help control the spread of COVID-19 through reduced hospital-based exposure and alleviate excess demand on critical acute care infrastructure.

This project was originally funded by the University of Maryland, Baltimore, Institute for Clinical and Translational Research (ICTR) through the Accelerated Translational Incubator Pilot (ATIP) Grant Program in October 2019 (awarded to Dr. Fei Han). Risk scores were deployed for the HealthChoice population starting in May 2021 and were last deployed in February 2024. These risk scores were not deployed for any other populations.

Outcome: COVID-19 Hospitalizations

The outcome measure in the Hilltop Pre-CH Model™ is a 0/1 indicator variable denoting whether an individual incurred a COVID-19-related hospitalization in a given month. To construct this measure, Hilltop uses ICD-10 diagnosis codes from inpatient claims to flag the following conditions, which are the basis for the composite COVID-19 hospitalization flag:[27]

- COVID-19 (U07.1)
- Other coronavirus as the cause of diseases classified elsewhere (B97.29)

This is implemented in the model as an indicator variable at the person-month level. If an individual incurs at least one COVID-19 inpatient hospital visit in a given month, then that person receives a value of 1 for this variable—and 0 otherwise.

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[27] Specifically, Hilltop defines these claims as those with a claim type of either 60 or 61 (indicating an inpatient claim) or a claim type of 40 (indicating an outpatient claim) and revenue center codes of 0450-0459 and 0981. Source: https://www.resdac.org/articles/how-identify-hospital-claims-emergency-room-visits-medicare-claims-data. To the extent that claims for observation stays are coded in this manner in the CCLF Medicare claims, observation stays are included in this outcome.

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