HISIM2:
The Health Insurance Simulation Model Used in Preparing CBO's July 2021 Baseline Budget Projections

July 2021

The Role of CBO's
Health Insurance Simulation Model,
Known as HISIM2

What Is HISIM2 Used For?

HISIM2 is an updated version of the model CBO uses to generate estimates of health insurance coverage and premiums for people under age 65.

The model is used along with other models to develop CBO's baseline budget projections (which incorporate the assumption that current law generally remains the same).

It is also used to estimate the effects of proposed changes in policies that affect health insurance coverage.

How Does CBO Use HISIM2 to Develop Its Baseline Projections?

The process has six main steps.

1. CBO updates the model at least once a year to incorporate new information, specifically:
   - The most recent administrative and survey data on enrollment and premiums;
   - Recently enacted legislation, judicial decisions, or changes in regulations; and
   - CBO's most recent macroeconomic forecast (including demographic projections).

2. CBO projects coverage estimates through the end of the 11-year period covered by the agency's baseline and reviews the model's output.

3. CBO adjusts the model's coverage projections using the agency's Medicaid enrollment model and separate models that analyze aspects of current law that are simplified in HISIM2.

How Does CBO Use HISIM2 to Develop Its Baseline Projections? (Continued)

4. CBO estimates spending for Medicaid, the Children's Health Insurance Program (CHIP), and the Basic Health Program, using models for those programs.

5. CBO determines the net costs of federal subsidies for employment-based coverage and coverage through the nongroup (or individual) market, as well as taxes and penalties related to coverage, using the Joint Committee on Taxation's tax models.

6. CBO reviews its final baseline budget projections and writes a report.

For details, see Congressional Budget Office (2018) and Congressional Budget Office (2020).

Data Underlying HISIM2

CPS Data

Microdata from the Current Population Survey (CPS) are the foundation of HISIM2.

▪ Microdata are data on the characteristics of units in a population (such as individuals, households, or establishments) collected by a census, survey, or experiment.

▪ The CPS is a nationally representative monthly survey of about 95,000 households. It provides reliable, timely, and detailed information about many of the key variables needed to model health insurance coverage.

▪ Those variables include demographic and family characteristics, income, employment, availability of employment-based insurance coverage, and self-reported health status.

▪ The survey is sponsored jointly by the Census Bureau and the Bureau of Labor Statistics.

Modifications to CPS Data

CBO modifies the CPS data in three ways.

First, CBO edits the following variables, which are likely to have been reported with some error, so that they better match other survey and administrative data:

- The size of firms,

- Self-employment income, and

- Whether a worker's employer offers health insurance.

Modifications to CPS Data (Continued)

Second, CBO supplements the CPS data with additional variables necessary for modeling people's and employers' decisions about health insurance coverage, such as:

▪ Immigration status;

▪ Capital gains, marginal tax rates, and wealth;

▪ The probability distribution of health care spending for each individual;

▪ The characteristics of an employer's potential insurance offerings for three plan types (HDHP, HMO, and PPO) and two coverage types (single and family); and

▪ Eligibility for Medicaid and CHIP.

High-deductible health plans (HDHPs) allow the use of a tax-preferred health savings account to cover expenses not paid by the plans. Health maintenance organizations (HMOs) are insurance plans in which services obtained outside a specified network of providers are not generally covered. Preferred provider organizations (PPOs) tend to offer wider provider networks, cover services from providers outside of their network, and limit costs through cost-sharing arrangements and a deductible.

The characteristics of an employer's potential insurance offerings are assigned on the basis of the firm's characteristics, such as its size, the state in which it operates, and the fraction of low-wage workers in it. Those characteristics also include the plan's cost-sharing requirements and premium, the employer's contribution to the premium, and (for HDHP plans) whether and how much an employer contributes to a health savings account or health reimbursement account.

Modifications to CPS Data (Continued)

Third, CBO defines various units to help model consumers' and employers' behavior.

CBO groups household members to build four types of units used to calculate income and taxes, determine eligibility for subsidies, and define the coverage choices that are available to people. Those units are called tax-filing units, marketplace units, Medicaid units, and health insurance units (HIUs).

CBO also builds a synthetic firm for most employed respondents consisting of an imputed set of coworkers whose characteristics mimic selected characteristics of actual coworkers. CBO assigns coworkers on the basis of the size of the worker's firm (using the agency's edited version of firm size as reported in the CPS); whether the firm offers health insurance; and the age, earnings, marital status, health care spending, and state of residence of the worker and his or her potential coworkers.

Projecting Data Through the Entire Projection Period

After supplementing and adjusting the CPS data for a base year, CBO projects input data for each year through the end of the 11-year period covered by the agency's baseline budget projections. The base year of data for CBO's July 2021 baseline projections is 2017, and the 11-year period covered by those projections is 2021 to 2031.

CBO uses two main approaches to project population characteristics from the base-year data:

- The agency projects income, health care spending, and the characteristics of employment-based insurance offers to identify the growth patterns of those variables.

- CBO uses an optimization routine to simultaneously adjust the sample weights of people in the CPS during the period to match CBO's projections of population characteristics, including population growth and changes in patterns of employment.

Adjustments for the 2020–2021 Coronavirus Pandemic

The pandemic has disrupted the economy since early 2020, and millions of jobs have been lost.

Those employment losses have been concentrated in industries that offer health insurance to their employees at below-average rates and that pay lower-than-average wages. CBO's standard method of adjusting person weights to match employment totals would have led to an upwardly biased estimate of the reduction in employment-based coverage.

Significantly fewer unemployment insurance (UI) claimants in 2017 in the CPS meant that CBO would have had to increase the weights of existing observations of UI claimants by at least five times their initial value to reflect the large increase in claims in 2020.

People who reported being unemployed and receiving UI in the base year were also unlikely to accurately reflect claimants in 2020 and in later years affected by the pandemic.

Adjustments for the 2020–2021 Coronavirus Pandemic (Continued)

To account for those challenges in baselines issued after the disruption, CBO deterministically changes the 2020 employment status of some workers, causing those workers to lose employment and some people to lose health insurance offers.

The probability of losing employment is based on CBO's projections of employment losses by industry and firm size, monthly CPS data through May 2020, and workers' employment and demographic characteristics.

A fraction of workers who lose employment are assigned imputed UI amounts based on 2020 state UI formulas and eligibility rules, current legislation, CBO's projections of initial UI payments, and individuals' earnings and employment information in the base year.

Workers are probabilistically reemployed over time based on more recent monthly CPS data, the agency's quarterly macroeconomic forecast, and the workers' industry and furlough status.

How HISIM2 Models
Decisions by Consumers

Overview of HIUs' Behavior

What Is a Health Insurance Unit? An HIU is the decisionmaking unit in HISIM2. A single person is his or her own HIU. Otherwise, an HIU is the set of individuals who could be covered by a family plan—that is, a plan that covers an employee and his or her dependents—if an employer offered that plan.

What Decisions Do HIUs Make? An HIU collectively chooses the type of health insurance coverage in which to enroll each of its members. People within the same HIU may not be eligible for the same type of coverage and do not necessarily choose the same coverage option.

How Do HIUs Make Decisions? HIUs make decisions by maximizing utility in a random utility model. Each alternative in the set of insurance choices is assigned a probability derived from a statistical model.

HIUs' Utility

The utility of each alternative depends on the HIU's total income, health care spending (including premiums, an out-of-pocket spending distribution, and any applicable subsidies, taxes, and mandate penalties), risk aversion, and unobserved factors.

Many utility function parameters are estimated by minimizing the difference between the coverage predictions from the model and coverage targets for the base year of data. (Coverage targets are CBO's preliminary estimates from individual data sources of the actual number of people with a particular coverage status.) Some parameters are set on the basis of CBO's assessment of the research literature.

HIUs' Insurance Options

HIUs select the type of health insurance for each person in the unit from choices such as these:

- Employment-based coverage: single or family

- Nongroup coverage in the marketplaces: bronze, silver, or gold

- Nongroup coverage outside the marketplaces: bronze, silver, or gold

- Medicaid

- CHIP

- Medicare

- None (Uninsured)

Employment-based coverage is coverage offered by a current or former employer—either one's own or a family member's. Firms are restricted to offer no more than one plan of each type and up to three types: an HDHP, HMO, or PPO. Nongroup coverage is coverage that a person purchases directly from an insurer or through a health insurance marketplace, rather than through an employer. Plans in the nongroup market are categorized into tiers (which are named after metals) on the basis of their actuarial value (which is the percentage of total average costs for covered benefits for which a plan pays). "Bronze" plans are those with an actuarial value of 60 percent, "silver" plans are those with an actuarial value of 70 percent, and "gold" plans are those with an actuarial value of 80 percent.

Sets of Insurance Choices and Utility Specifications

Choice Sets

The set of insurance choices available to each HIU is determined by the characteristics of that HIU (for example, income and members' ages).

Single-person and multiperson HIUs have different choice sets.

The choice set of an HIU is restricted by the eligibility of its members for public insurance, subsidized marketplace insurance, and employment-based insurance.

CBO restricted the choice sets in the model to maintain as much realism as possible while keeping the model simple enough to limit the computing time needed to simulate coverage effects of proposed policies.

Choice Set for Single-Person HIUs

The choice set for single-person HIUs consists of alternatives that are categorized into one of five "nests."

Alternatives within the same nest are considered closer substitutes than alternatives in different nests.

Nest	Alternatives
Employment-based coverage	Employment-based coverage
Nongroup coverage in the marketplaces	Bronze, silver, gold
Nongroup coverage outside the marketplaces	Bronze, silver, gold
Public insurance	Medicaid, Medicare
Uninsured	Uninsured

Within the public-insurance nest, the choices between Medicaid and Medicare are mutually exclusive. CHIP is not an alternative for single-person HIUs in the model because only children are eligible for CHIP and a child cannot be in an HIU by himself or herself.

Utility Specification for Single-Person HIUs

The utility specification for HIU i from alternative n, U_{in}, is a separable function of observed inputs (such as the alternative's premium) and unobserved factors, which include an alternative-specific constant (ASC) and an idiosyncratic component. The specification implies a nested logit model.

$$U_{in} = \underbrace{\beta_1 V_{in}}_{\text{function of observed inputs}} + \underbrace{\delta_n(y_i, a_i, e_i) + \varepsilon_{in}}_{\text{unobserved factors}}$$

The function of observed inputs, V_{in}, is normalized by a scaling factor β_1. The scaling factor determines HIUs' responsiveness to changes in observable factors such as income, premiums, taxes, mandate penalties, and out-of-pocket spending.

δ_n is an ASC for alternative n and is allowed to vary with HIU i's age a_i, eligibility e_i, and income y_i.

ε_{in} is an individual-specific unobserved component.

For details about the generalized nested logit model, see Train (2009).

Health Care Spending

Each HIU has a probability $p_i(s)$ of being in one of 14 health states, s, each of which corresponds to a different level of health care spending $H_i(s)$.

Health care spending is how much a person would spend in each health state to arrive at a given health status at the end of the year, as imputed from survey data.

HISIM2 does not allow the distribution of health care spending to differ across coverage options in the choice set. Thus, health is not affected by the type of insurance a person has. However, the degree of financial exposure to that health care spending does vary by coverage type. For example, uninsured people do not pay the full costs of their health care (which is consistent with academic research).

Based on the health care spending of the only person in that HIU and the cost-sharing characteristics of the plan associated with the alternative n, CBO calculates out-of-pocket spending, $OOP_{in}(s)$.

Factors Affecting Utility

Utility in HISIM2 is affected by the following factors:

- The HIU's gross income, Y_i^G

- The total tax burden, τ_{in}

- The net premium of the alternative, $prem_{in}$

- Any applicable individual mandate penalty, π_{in}

- Out-of-pocket spending for an alternative, $OOP_{in}(s)$, which depends on the health state of the individual and the cost-sharing characteristics of the plan, and

- Any applicable unpaid medical debt when uninsured, $debt_{in}$

The Function of Observed Inputs to Utility for Single-Person HIUs

The function of observed inputs to utility for HIU i is as follows:

$$V_{in} = \sum_{s=1}^{14} p_i(s) \ln\left(Y_i^G - \tau_{in} - prem_{in} - k_i^\pi \pi_{in} - OOP_{in}(s) - \theta(w_i)debt_{in}(s)\right)$$

The natural logarithmic function, ln(), incorporates the diminishing marginal utility of income into the analysis—that is, that less and less utility is gained for each additional dollar of income.

HIUs respond less to a dollar of individual mandate penalties (k_i^π < 1) than to a decrease in gross income because of limited collection of the statutory penalty amount. The k_i^π parameter is allowed to vary across HIUs and is specified as a random coefficient.

The responsiveness of an HIU to a dollar of unpaid medical debt (θ) increases discretely with the HIU's wealth (w_i) because HIUs with more assets face larger penalties for unpaid debt. Additionally, HIUs respond less to a dollar of unpaid medical debt ($\theta(w_i)$ < 1) than to a decrease in gross income because of limited collection and bankruptcy protection.

Alternative-Specific Constants

The alternative-specific constants increase or decrease the utility of each type of coverage.

ASCs measure such concepts as:

- Awareness of insurance alternatives,

- Access to insurance alternatives (including the ease of enrolling through a web portal and the ease of determining eligibility),

- Attitudes toward insurance (which may be affected, for example, by the stigma associated with public coverage), and

- Unmeasured differences among insurance alternatives, such as network size.

Utility Specifications for Uninsured People

Uninsured people are not fully exposed to the financial risk of medical costs, for three main reasons.

- Some health care providers provide free and discounted charity care to people with lower income,

- Many medical bills are never collected, and

- Bankruptcy policies allow households to discharge debt while protecting some assets.

The cost of the uninsured alternative consists of two terms: out-of-pocket spending and the cost of bad debt.

Utility Specifications for Uninsured People (Continued)

Out-of-Pocket Spending. Health care spending for uninsured people is scaled down for lower-income people to reflect their greater access to charity care. Out-of-pocket spending is then capped at a dollar value that increases with income and wealth. That approach is consistent with research indicating that uninsured people do not pay their full medical bills but that people with more assets make higher out-of-pocket payments.

The Cost of Bad Debt. This term reflects the downstream costs of having unpaid medical bills—including borrowing costs, hassle costs, possible repayment, and at the extreme, bankruptcy. This cost applies to uninsured people if their health care spending exceeds the cap on their out-of-pocket payments. The value of this term rises with the amount of debt and increases with wealth, reflecting a larger reduction in utility for people with more debt and with more assets at risk.
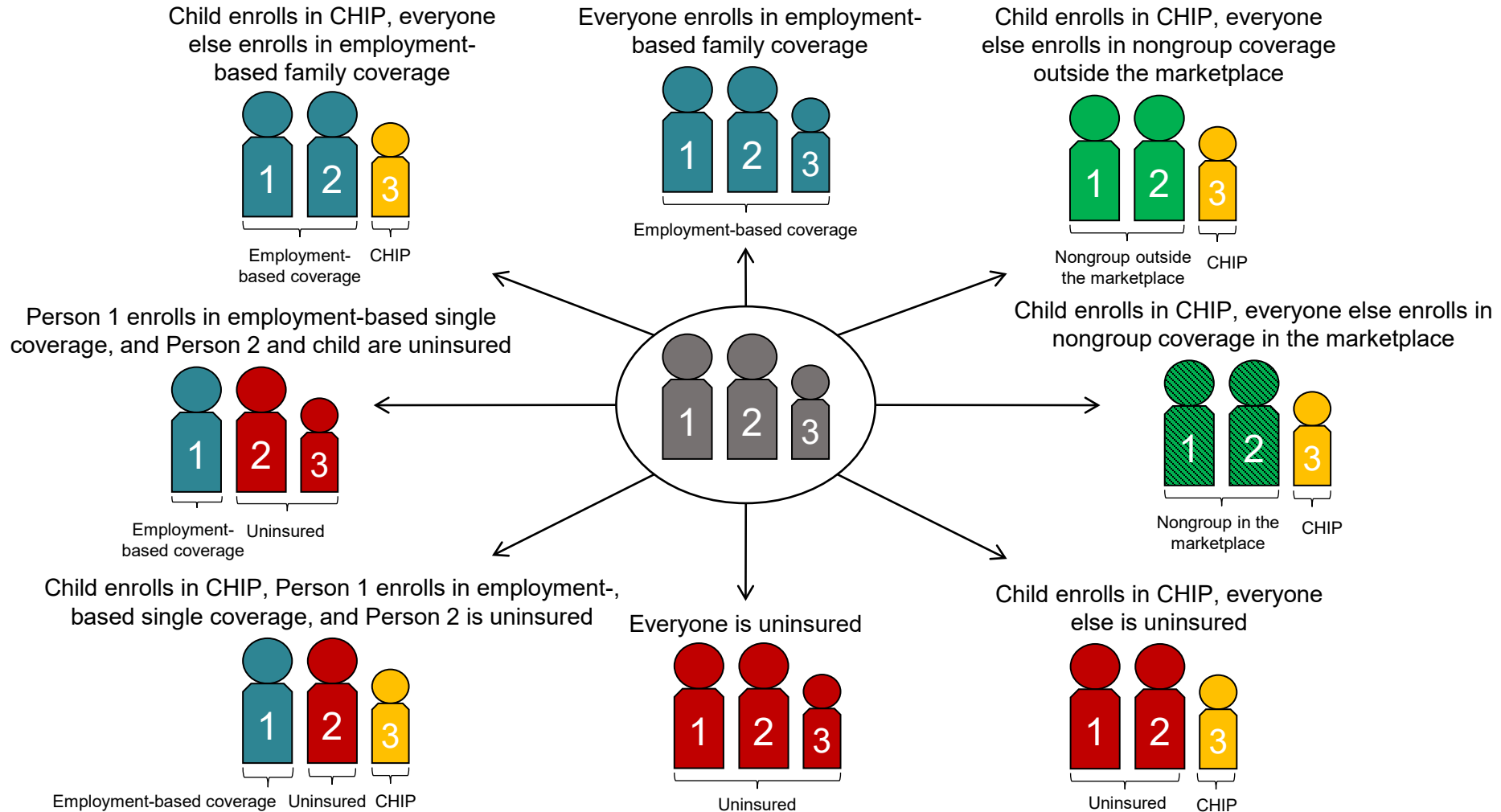
Choice Set for Multiperson HIUs

Multiperson HIUs have a larger choice set than single-person HIUs do because different members of an HIU can have different types of coverage.

Each alternative represents a combination of coverage types in which HIUs can enroll their members.

Under each alternative, members of the HIU are sorted into different types of coverage on the basis of their eligibility.

The generalized nested logit model used in HISIM2 allows an HIU's health insurance coverage choice to span multiple nests.

For more information about the generalized nested logit model, see Train (2009) and Wen and Koppelman (2001).

Example of the Choice Set for a Multiperson HIU

Child enrolls in CHIP, everyone else enrolls in employment-based family coverage

Employment-based coverage   CHIP

Everyone enrolls in employment-based family coverage

Employment-based coverage

Child enrolls in CHIP, everyone else enrolls in nongroup coverage outside the marketplace

Nongroup outside the marketplace   CHIP

Person 1 enrolls in employment-based single coverage, and Person 2 and child are uninsured

Employment-based coverage   Uninsured

Child enrolls in CHIP, everyone else enrolls in nongroup coverage in the marketplace

Nongroup in the marketplace   CHIP

Child enrolls in CHIP, Person 1 enrolls in employment-, based single coverage, and Person 2 is uninsured

Employment-based coverage   Uninsured   CHIP

Everyone is uninsured

Uninsured

Child enrolls in CHIP, everyone else is uninsured

Uninsured   CHIP

In this HIU, one person has an offer of employment-based single or family coverage, one person (a child) is eligible for CHIP, and all three people are lawfully present in the U.S. Such an HIU would have 8 groups of alternatives to choose from (or 12 total alternatives, because an HIU that enrolls in nongroup coverage could choose a bronze, silver, or gold plan).

Utility Specification for Multiperson HIUs

The utility for an HIU i with multiple members $j = 1, \ldots, J_i$ is similar to the utility for a single-person HIU.

$$U_{in} = \beta_2 V_{in} + \sum_{j=1}^{J_i} \Delta_n(y_i, a_j, e_j) + \varepsilon_{in}$$

The function of observed inputs to utility, V_{in}, is normalized by a different scaling factor β_2.

The alternative-specific constant for an HIU is the sum of the HIU members' alternative-specific constants for each alternative n.

The distribution used for the idiosyncratic unobservable component implies a generalized nested logit model.

The Function of Observed Inputs to Utility for Multiperson HIUs

The function of observed inputs to utility for an HIU i with multiple members $j = 1, \dots, J_i$ is similar to that for a single-person HIU.

$$V_{in} =$$

$$\sum_{s_1=1}^{14} \dots \sum_{s_{J_i}=1}^{14} p_1(s_1) \dots p_i(s_{J_i}) \ln\left(Y_i^G - \tau_{in} - prem_{in} - k_i^\pi \pi_{in} - OOP_{in}(s_1, \dots, s_{J_i}) - \theta(w_i)debt_{in}(s_1, \dots, s_{J_i})\right)$$

For a multiperson HIU, total out-of-pocket spending for an alternative $OOP_{in}(s_1, \dots, s_J)$ depends on the health care spending of each member and the cost-sharing characteristics of the plans in which members of the HIU would be enrolled.

For family insurance policies, out-of-pocket spending is determined by applying cost-sharing characteristics to the total spending of members of the HIU enrolled in the policy.

The Generalized Nested Logit Model

The idiosyncratic unobservable component (ε_{in}) is assumed to be independent and is identically distributed extreme value such that it implies a generalized nested logit (GNL) model. For notation purposes, the GNL choice probability is:

$$P_{in} = \frac{\sum_{\ell} \left[\left(\alpha_{n\ell} \exp\left(\beta V_{in} + \sum_{j=1}^{J_i} \Delta_n \right) \right)^{\frac{1}{\mu_\ell}} \left(\sum_{k \in B_\ell} \left(\alpha_{k\ell} \exp\left(\beta V_{ik} + \sum_{j=1}^{J_i} \Delta_n \right) \right)^{\frac{1}{\mu_\ell}} \right)^{\mu_\ell - 1} \right]}{\sum_{\ell} \left(\sum_{k \in B_\ell} \left(\alpha_{k\ell} \exp\left(\beta V_{ik} + \sum_{j=1}^{J_i} \Delta_n \right) \right)^{\frac{1}{\mu_\ell}} \right)^{\mu_\ell}}$$

In this equation, nests (employment-based coverage, nongroup coverage in the marketplaces, nongroup coverage outside the marketplaces, public insurance, and uninsured) are indexed by ℓ and the set of choices in nest ℓ is denoted B_ℓ.

HIUs' Utility Function Parameters

CBO estimates most utility function parameters by fitting the model's equations to the data. For example, the alternative-specific constants (δ_n and Δ_n) are estimated.

The scaling, dissimilarity, and allocation parameters are set exogenously in the generalized nested logit model on the basis of information from the research literature and from experts on health insurance markets and this type of model. CBO uses that approach to adjust for issues with reported health insurance coverage in the CPS, such as an undercount of Medicaid enrollees and a lack of detail about some specific types of coverage (for instance, silver plans sold in the marketplaces).

The dissimilarity parameters ($\boldsymbol{\mu}$), which determine correlation between choices within a nest, are set on the basis of the available evidence.

The allocation parameters ($\boldsymbol{\alpha}$) are set to match the fraction of individuals in the data who would be covered under each source of coverage from all the HIUs that are able to make a given choice.

The scaling parameter (β) is set to produce responses to changes in health insurance premiums that are consistent with available evidence. (Higher values of β result in HIUs responding more to changes in the function of observed inputs, which includes the premium.)

How the Alternative-Specific Constants Are Estimated

CBO estimates the alternative-specific constants (δ_n and Δ_n) by finding values that minimize the difference between coverage predictions from the model and coverage targets by type of insurance, age, and income.

The agency combines sample weights for each person with choice probabilities to obtain the predicted aggregate coverage distribution. For example, if the person's sample weight is 100, if the probability of choosing a silver plan through a marketplace is 75 percent, and if the probability of choosing to be uninsured is 25 percent, then that person would represent 75 people predicted to be enrolled in a silver plan through a marketplace and 25 people predicted to be uninsured.

Coverage targets are CBO's preliminary estimates from individual data sources of the actual number of people with a particular coverage status. For example, one coverage target is the number of people who were enrolled in a silver plan through a marketplace, who were under 30 years old, whose multiperson HIU's income was between 1.38 and 2.50 times the federal poverty level, and who received a premium tax credit.

Sources of Data CBO Used to Calibrate Utility Function Parameters

Coverage	Sources
Employment Based	Medical Expenditure Panel Survey—Insurance Component (MEPS-IC) and Household Component (MEPS-HC), OPM
Nongroup	CMS Medical Loss Ratio data, CMS effectuated enrollment reports, Healthcare.gov insurance marketplace data, MEPS-HC, Covered California data
Medicaid and CHIP	Form CMS-64, MSIS, Medicaid Analytic Extract data, Statistics Enrollment Data System (for CHIP)
None (Uninsured)	MEPS-HC and NHIS

People Whose Coverage Status Does Not Change Over Time

People with some types of health insurance coverage are projected to be unlikely to change their coverage status in response to the types of policy proposals that HISIM2 is designed to simulate.

For example, people who are under age 65, disabled, and enrolled in Medicare in the base year are generally enrolled in Medicare the following year.

To simplify the analysis, the coverage status of such people mirrors changes in the population over time, and their coverage decision is not allowed to change during the projection period.

How HISIM2 Models Decisions by Firms

Firms' Behavior

Firms decide whether to offer their employees health insurance and which plans to offer after weighing several factors:

- Employees' demand for health insurance,

- The tax benefit of offering that insurance,

- The cost of switching plans from last year's choice, and

- The firms' unobserved preferences.

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About This Document

This document was prepared to enhance the transparency of CBO's work and to encourage external review of that work. In keeping with CBO's mandate to provide objective, impartial analysis, the document makes no recommendations.

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