Childhood Obesity Intervention Cost-Effectiveness Study (CHOICES) Microsimulation Model Technical Documentation: Details on Model Parameters

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Introduction

The Childhood Obesity Intervention Cost-Effectiveness Study (CHOICES) microsimulation model estimates the impact of an intervention strategy to promote healthy weight on population health outcomes and costs in the United States. The modeling methods and data sources are described in detail in Gortmaker et al. 2015 *Health Affairs*, Appendix A3,[1] available at: https://www.healthaffairs.org/doi/suppl/10.1377/hlthaff.2015.0631. The CHOICES microsimulation model continues to use the same general approach, with updated model inputs and assumptions as noted below to reflect new data available and methodological refinements made over time.

Population characteristics were updated based on more recent available data, including data from the 2013-2017 American Community Survey (5-year microdata), 2013-2017 Behavioral Risk Factor Surveillance System, 2003-2018 National Survey on Children's Health, and 2011-2016 National Health and Nutrition Examination Survey (NHANES). Lifetime height and weight trajectories were based on a published analysis of data synthesized from multiple longitudinal cohort studies.[2] Population growth was projected based on infant population estimates by state and by race/ethnicity from the U.S. Census 2010-2018 National Population Projections. Annual total medical expenditures per person in the simulated population by BMI and age were estimated based on a published analysis of data from the 2011-2016 Medical Expenditure Panel Survey (MEPS).[3] Health-related quality of life (HRQoL) weights by

sex, age group, and weight status were estimated using published EQ-5D preference weights from a 2006 analysis of the 2000 MEPS,[4] and utility weights for children were extracted from a meta-analysis of 16 studies.[5] See Table 1 for model assumptions and sources used as of this model version. See the section "Health-related Quality of Life" for more detail on assumptions about health-related quality of life.

Table 1. CHOICES microsimulation model parameters, v4.6.1[a]

Model parameter	**Modeling assumption**	**Source**
Demographic characteristics: Sex, race, ethnicity, census tract, and age	Individuals were sampled randomly within census tracts to create a simulated population of 1,000,000 children and adults (or the local population size, if smaller) at model initiation.	U.S. 2010 Census
Demographic characteristics: Household income, poverty ratio, public school attendance, and SNAP participation[b]	Individual demographic variables not included in 2010 Census were assigned using non-parametric statistical matching techniques conditional on age, sex, race, ethnicity, and census tract.	2013-2017 American Community Survey 5-year microdata
Adult self-reported height and weight[b]	Individual self-reported height and weight were sampled (with replacement) proportional to sampling weights and assigned to individuals, conditional on age, sex, race, ethnicity, household income, and state. Adjusted for self-report bias[6] (see measured height and weight below).	2013-2017 Behavioral Risk Factor Surveillance System
Child and adolescent parent-reported height and weight[b]	Individual parent-reported height and weight were sampled (with replacement) proportional to sampling weights and assigned to individuals conditional on age, sex, race, ethnicity, household income, and state. Recent National Survey on Children's Health releases do not report individual-level BMI, so BMI categories are used. Adjusted for self-report bias[7] (see measured height and weight below).	2003-2018 National Survey on Children's Health

Model parameter	Modeling assumption	Source
Measured height and weight, and dietary intake[b]	Individual objectively-measured height and weight were sampled (with replacement) proportional to sampling weights and assigned to individuals conditional on age, sex, race, ethnicity, household income, and self- or parent-reported height and weight percentile. Food frequencies and dietary intake were sampled.	2011-2016 National Health and Nutrition Examination Survey (NHANES)
Lifetime height and weight trajectories[b]	Lifetime height and weight trajectories based on a published analysis of data synthesized from multiple longitudinal cohort studies.[2] Quantile regression used to account for secular trends. Trajectories calibrated to empirical data and projections of prevalence of 4 BMI categories (normal, overweight, obese, and severely obese) by sex, race/ethnicity and by age groups (2-5, 6-11, 12-19, 20-39, 40-59, 60-79, 80+)	National Longitudinal Survey of Youth; National Longitudinal Study of Adolescent to Adult Health; Early Childhood Longitudinal Study-Kindergarten; Panel Survey on Income Dynamics; NHANES I Epidemiologic Follow-Up Study; NHANES 1999-2012
Baseline smoking prevalence and smoking trajectories	Individual smoking histories modelled based on initiation and cessation rates from published estimates.[8]	2011 Behavioral Risk Factor Surveillance System; 1965-2009 U.S. National Health Interview Surveys
Open population characteristics[b]	Infant population estimates were obtained from the Census for 2010-2018 by state and race (White, Black, American Indian/Alaska Native, Asian, Native Hawaiian/Pacific Islander, Two or more races) and ethnicity (Hispanic/Not Hispanic). Projections were made using a log-linear model. Population trajectories were sampled from the (joint-normal) distribution of regression coefficients. Trajectories were independently sampled for the state overall and for each race.	U.S. Census 2010-2018 National Population Projections
Baseline mortality rates	2010 age, sex, and race-ethnicity life tables adjusted for smoking and BMI based on data from 527,000 members of the NIH-AARP Diet and Health Study.[9]	U.S. 2010 Period Life Tables; NIH-AARP Diet and Health Study

Model parameter	Modeling assumption	Source
BMI-related mortality reduction due to intervention	Based on data from 900,000 participants, each 5 BMI unit increase within the range of 25-50 BMI units was associated with a 30% higher risk of death (hazard ratio: 1.29; 95% CI: 1.27-1.32). The estimated hazard ratio was used to shift individual-level mortality risk due to BMI reductions compared to the individual's risk in the natural history model. Values are available at: https://doi.org/10.7910/DVN/H0OWKN.	Prospective Studies Collaborative[10]
Healthcare costs[b]	Annual total medical expenditures per person in the simulated population by BMI and age based on a published analysis of data.[3] Values are available at: https://doi.org/10.7910/DVN/872OW1.	2011-2016 Medical Expenditure Panel Survey (MEPS)
Health-related quality of life (HRQoL)[b]	HRQoL weights for males and females, age groups (18-25, 25-44, 45-64, 65-74, and >75), for three BMI categories: 23-25 (normal), 25-30 (overweight), >30 (obesity), using published EQ-5D preference weights from 2006 analysis of MEPS 2000.[4] Utility weights for children extracted from meta-analysis of 16 studies by Kwon et al. 2018.[5] See the section "Health-related Quality of Life" below for more detail on assumptions about health-related quality of life.	2000 MEPS; Kwon et al. 2018 meta-analysis

BMI, body mass index.

[a] CHOICES microsimulation model methods and data sources were introduced in Gortmaker et al. 2015 *Health Affairs*, Appendix A3,[1] available at: https://www.healthaffairs.org/doi/suppl/10.1377/hlthaff.2015.0631. Some model assumptions and data sources have been updated since introduced to reflect new data available and methodological refinements made over time.

[b] Parameter differs from prior publication[1]

Health-related Quality of Life

One of the important consequences of excess body weight gain is reduced quality of life. We estimate the quality-adjusted life years (QALYs) for individuals ages 2 years and older in the simulated population using utility weights from prior studies, along with the estimated time spent with overweight and obesity. For those ages 18 years and older we used health-related quality of life (HRQoL) weights based on a published analysis of EQ-5D data from the 2000 Medical Expenditure Panel Survey,[4] using published preference weights from a nationally representative sample.[11] These preference weights follow the

recommendations of the Second Panel on Cost Effectiveness in Health and Medicine[12] by being scaled from 0 to 1 and based on a time trade off method. The use of the EQ-5D also aligns with the U.K. National Institute for Health and Care Excellence (NICE) guidelines.[13] Across gender and age groups (18-25, 25-44, 45-64, ≥75 years), individuals with overweight and obesity had lower HRQoL weights compared to individuals with normal body weight, and the HRQoL weights declined with age. The decrements in HRQoL weights associated with obesity compared to those with a BMI of 23-25 kg/m^2 in this analysis across age and gender groups ranged from 0.033 to 0.11, indicating lower HRQoL associated with obesity compared with body weight in the normal range. Another recent meta-analysis of 12 adult studies using a few different HRQoL measures including the EQ-5D found similar decrements.[14]

For children ages 2-17 years we used results from a recent meta-analysis that calculated the decrement in HRQoL weights associated with overweight and obesity (compared to the reference category with BMI 23-25 kg/m^2) of 0.015 and 0.032 (i.e., lower HRQoL). Sixteen different studies were used in the estimation of HRQoL weights for overweight and obesity, using a variety of measures: the EQ-5D, EQ-5D VAS, AQoL-6D, CHUD9D, HUI2, HUI3.[5] We also used the published Muennig et al.[4] weights by age, gender and BMI category (23-25 kg/m^2, 25-29 kg/m^2, 30 kg/m^2 and above) to predict HRQoL weights for ages 2-17, relying on that fact that HRQoL weights decline substantially with age. Using the midpoints of the age categories, we fit linear regressions; these fit well with adjusted R^2 ranging from 0.97 to 0.99. The predicted HRQoL weight for ages 2-17 with a BMI in the normal range (not having overweight or obesity) was 0.980, and the predicted HRQoL weights for this age group indicated decrements associated with overweight and obesity of -0.020 and -0.034, very similar to the results from the published meta-analysis.[5] We thus used the predicted HRQoL weight of 0.980 for children with BMI in the normal range, and the decrements reported from the meta-analysis of -0.015 and -0.032 to calculate HRQoL weights for overweight and obesity in the 2-17 age group (see Table 2). Incremental quality-adjusted life years were calculated by multiplying these HRQoL weights by the years spent in these states.

There are limited data concerning the validity of these estimated HRQoL weights associated with overweight and obesity among different racial/ethnic groups. One study reports HRQoL weights in an ethnically diverse sample of 10-12 year old children: the total sample of 4,979 individuals was 57% Hispanic, 21% Black, and 21% White. They used the HUI3 measure to obtain HRQoL weights. Results indicate utility decrements similar to other studies: Overweight: -0.01; Obesity: -0.019; Severe obesity: -0.046.[15]

Table 2. Health-related quality of life weights for adults and children by body mass index category based on Muennig et al.[4] and Kwon et al.[5]

	Female			Male		
	BMI Category			BMI Category		
	<25	25-29	30+	<25	25-29	30+
Age (years)						
2-17	0.98048	0.96548	0.94848	0.98048	0.96548	0.94848
18-25	0.92516	0.90802	0.88316	0.95445	0.94077	0.91861
25-44	0.91075	0.88203	0.84476	0.92839	0.91870	0.88926
45-64	0.87366	0.83570	0.78697	0.87634	0.87358	0.83674
65-74	0.83138	0.79254	0.72933	0.81771	0.82209	0.77778
>75	0.80139	0.77603	0.69134	0.77192	0.78088	0.72911

BMI, body mass index.

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