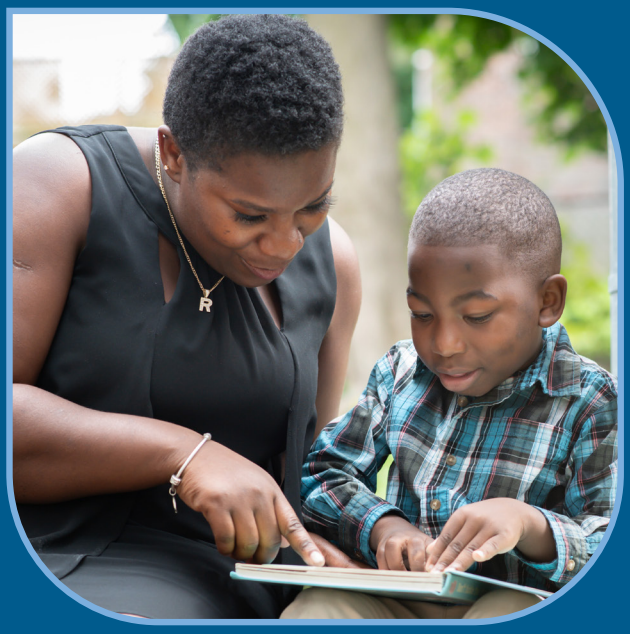

Technical Documentation of the UMass Boston Early Education Cost and Usage Simulator

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UMass Boston

UMass Boston Early Education Cost and Usage Simulator Project (CUSP)

The UMass Boston Early Education CUSP is led by a multidisciplinary team that designed a simulator to produce current, relevant, accurate, and responsive estimates about the key impacts of proposed legislation to expand access to affordable, quality child care and early education. One of the simulator's valuable features is that it can generate estimates for a range of policy parameters and provisions. The team's publications aim to provide essential information to guide policymaking on child care and early education affordability, quality, and access in Massachusetts.

Updates, future briefs, and additional information about this project may be found at **umb.edu/earlyedinstitute/research-policy**.

About the Authors

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TABLE OF CONTENTS

Figures, Tables, and Exhibits

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Overview

This publication contains technical documentation for UMass Boston's Early Education Cost and Usage Simulator Project (CUSP) simulator, referred to simply as the "simulator" below.

What the Simulator Does

The simulator estimates current childcare usage and out-of-pocket costs for Massachusetts families, including the number of childcare arrangements by 13 non-parental care types, as well as parental care only. A childcare arrangement is a child and type of provider combination. For each childcare arrangement, it also estimates:

- Weekly hours of care
- Weekly out-of-pocket costs for that care

Estimates are available at a detailed demographic level, for example:

- By age and race/ethnicity of the child
- By characteristics of the family:
    - By single or two-parent family
    - Family size
    - Working characteristics of the parent(s)

Estimates are also available at the sub-state geographies of Massachusetts Department of Early Care and Education (EEC) regions and Census PUMAs. A PUMA is a contiguous geography that contains at least 100,000 persons. Massachusetts contains 52 PUMAs.

The simulator also estimates the impacts of programs that provide financial assistance to families to cover some or all of out-of-pocket childcare costs, based on income and childcare expenses. Such programs would include, for example, the Massachusetts Senate Bill 2707 or the child-care portion of the Biden administration's Build Back Better plan. The types of impacts it estimates include:

- Changes in demand for child care use by families (the demand assuming no supply constraints of providing care)
- Financial assistance costs of the program to the state (net of administrative costs of the program)
- All of the demographic and micro detail available in the estimates of current usage
- Change in parental employment due to the increased usage of child care and corresponding changes in family income as parental earnings increase

How the Simulator Works

CUSP is a micro simulator. The input is the American Community Survey's Massachusetts Public Use Micro Sample (PUMS) for 2015-19. The PUMS is a (5-percent) representative sample of households and the persons who live in them. The simulator processes each household in the PUMS using the following steps:

1. Households are divided into families. Typically there is one family per household, but households may contain more than one family. Families in this case are two or more people related to one another in the household with one of those persons as an eligible child.
2. The current childcare usage for each child in the family is simulated. This forms the "baseline" or "pre-program" scenario. Details on how this works are in the following section on the *Child Care Behavior Model*.
3. The childcare usage for each child in the family is simulated in the presence of the program. This forms the "post-program" or "with-program" scenario.
4. The post-program scenario includes the program's effects on parents' work behavior and on the choice of types of child care used. It also includes the amount of financial assistance the family receives, if any. Details on how this works are in the section on the *Program Model*.

The difference between the post-program and baseline scenarios is the program impact. Results for each family are accumulated to form aggregate estimates for baseline and post-program childcare usage, changes in work status of parents, and the total financial assistance costs of the program.

Outputs of the Simulator

The simulator produces two types of outputs:

1. Summary tables. These report aggregate outputs for the state by type of child care, and can be broken down by age of child (infant, toddler, pre-school, and school-age), by race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, and Other non-Hispanic), or by age and race/ethnicity combination.
2. Micro record files that can be linked to the PUMS for data analysis. These files include both baseline and post-program scenarios. Separate files–that can be linked–are provided for children and parents. This allows for detailed demographic analysis.

The flow of households through the simulator and results output from the simulator are illustrated in Figure 1.

Documentation Audiences

This documentation is intended for:

- Analysts who want to "look under the hood" to understand the capabilities–and limitations–of the simulator.
- Potential users of the simulator. CUSP is meant to be usable by data analysts. Users who work with data sets like the PUMS using software like Stata, SPSS, R, or SAS can use the micro record output files to do analysis. For users who want to "run" the simulator, a user interface can be added that would work on any laptop that uses the Windows OS.
- Policy proponents who want to have this documentation at their disposal. It's like a car owner's user manual that is kept in the glove compartment to be retrieved when needed.

- Developers. The simulator is based on a national survey of child care and on the Census PUMS, and could easily be adapted for other states or for the national level. It is written in C++. To be adapted for other states developers would probably want to calibrate the model for that state. See the section on *Calibration* to see what was done for Massachusetts.

Note on the Use of "Model"

The term "model" in this documentation is used in a general way.[1] It refers to stochastic and other equations, procedures or functions used to operationalize parts of the simulator, to sets of equations and procedures, and to sets of models. The CUSP simulator may be called a simulation model.

[1] "Of all the terms that policy analysts like to toss about, *model* is perhaps the most confusing to the layman, for models are many things to many people. A model is a simplified representation of some aspect of the real world, sometimes of an object, sometimes of a situation or a process. It may be an actual physical representation – a globe, for instance – or a diagram, a concept, or even a set of equations. It is a purposeful reduction of a mass of information to a manageable size and shape, and hence is a principal tool in the analyst's workbox." Stockey and Zeckhauser (1978), p. 8.

Child Care Behavior Model

Role in the Simulator

The childcare behavioral model is a set of models that estimate the use of childcare and out-of-pocket costs for each child in each family conditional on the characteristics of the child and the child's family structure and demographics. The models are estimated with data from a national survey and are applied to households and persons from the Census Bureau's American Community Survey PUMS for Massachusetts.

The simulator is designed to estimate the impacts of proposed legislation that bases state financial assistance for child care on family income and family out-of-pocket costs. To do this, childcare usage and out-of-pocket costs are simulated twice for each family: once in the absence of the proposed program legislation–sometimes called the "baseline" scenario, and once in the presence of the program legislation. By lowering out-of-pocket costs for licensed care for income-eligible families, the program affects childcare usage directly by lowering the cost of licensed care, and indirectly by increasing the families' working income net of out-of-pocket childcare costs. The estimated impacts of the program are obtained by summing the differences between the two simulations for each child and family. Because the PUMS Census data have detailed demographic information for each person and family and are representative of the state's population, the impacts estimated by the simulator can be presented with substantial demographic detail.

The simulator does not take into account capacity constraints of the childcare system and so the simulated impacts represent demand for increased childcare usage. For these changes to be realized, sufficient capacity would have to be available.

The Models

The unit of analysis for each of these models is the child. There are four sets of models that are applied to several types of child care. The four sets of models are:

1. The probability that a child would use a particular type of child care
2. Given that a child uses a particular type of child care, the number of weekly hours in that type of care for that child
3. Given that a child uses a particular type of child care, the probability that the family pays for some or all of that care for that child out-of-pocket. "Out-of-pocket" means net of any financial assistance for that child for that type of care
4. Given that a family has out-of-pocket costs for that care, the family's weekly out-of-pocket cost for that type of care for that child

The types of child care modeled include the following:

1. Licensed, regulated, or formal care
    a. Head Start
    b. Public Pre-K
    c. Early Child Care Centers (regular and irregular use, <6 years old only)
    d. Other Organizations (regular and irregular use)
    e. Family Providers
2. Unlicensed or informal care
    a. In-home care
    b. Individual providers (paid and unpaid)
    c. Irregular care, generally less than 5 hours per week
3. K-8 (In-school, that is, not including “after school” care)
4. Other types, not elsewhere classified or settings unknown
5. Parental care only

Not every type of child care has each of the four models. For childcare types that are explicitly unpaid, only the usage and weekly hours of use models are available. For some other types, the survey on which the models were estimated did not ask about out-of-pocket costs, so only usage and weekly hours of use models are estimated. Table 1 lists the models. In all there are 14 different types of care and 45 models. The table briefly describes the types. More detailed information and definitions of the types are given below. The model names and numbers in this table are used in the simulator output and in this documentation.

Data Sources

The data used to estimate these models are from the Household survey of the 2019 NSECE (National Survey of Early Care and Education Project Team, 2021), referred to as the NSECE survey in this documentation. This nationally-representative, publicly available survey includes 8,576 households with 15,981 children under 13 years of age with demographic information on children and adults in the household, household income, parental employment, and information on early care and education usage for each child in the household, including hours of care, types of care, and out-of-pocket costs during the survey week.

These models are applied to children and families from the 2015-2019 PUMS for Massachusetts, a 5 percent representative sample of Massachusetts households (U.S. Census Bureau, 2021). The Census Bureau’s American Community Survey (ACS) Public Use Microdata Sample (PUMS) files are a set of records from individual people or housing units, with disclosure protection enabled so that individuals or housing units cannot be identified. The PUMS contains a rich set of demographic data for each person and household in the survey.

For harmonizing the PUMS with the NSECE, the following data were used:

- Births, by month, U.S., 2018 and 2019 (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2020).
- Urban density by PUMA for Massachusetts. (U.S. Census Bureau, 2010 Census)
- Percent of population below the poverty level, by PUMA, for Massachusetts. (U.S. Census Bureau, American Community Survey, 2015-2019).

Harmonization is described further in a later section.

Statistical Models

Unit of Analysis

The unit of analysis in the models is the child, that is, each observation or "case" in the data on which the model is estimated is a specific child or refers to that specific child, for example, the child's age, sex, race/ethnicity, disability status, the child's parent or parents, other aspects of the child's family, and characteristics of the community in which the child's family lives.

The Dependent Variable and Universe of the Models

The dependent variable for each of the four types of models is constructed from one or more variables from the NSECE survey. The set of survey children that are used for each model is called the universe for that model and the number of such children the sample size for the model estimation.

A key variable in these models is the type of care. The NSECE defines 9 broad types of care (*User's Guide*, pp. 167-8):

1. Individual, No prior relationship, Paid
2. Individual, Prior relationship, Paid
3. Individual, Unpaid
4. Center-Based ECE
5. Other Organizational ECE
6. K-8 schooling
7. Irregular ECE
8. All other settings unknown
9. Parental Care

The NSECE type of care is a derived concept that relies on survey respondents' replies to a variety of questions. Each child is assigned a care type for each hour of the survey week. Hours for which none of the first 8 types apply are considered hours of parental care. Age of the child and number of weekly hours of care are considered in defining the types. Type 4, center-based care, is restricted to children under 6 years of age. Type 6, K-8, is restricted to children 5 years of age and older. For types 1-5, usual weekly hours of care are at least 5 hours. Type 7, irregular care, is for less than 5 hours per week. These types are described with examples in Exhibit 5.1 in the *User's Guide*, pp. 167-8 (see Exhibit 1)

The NSECE includes information on the type of provider as well as the type of care. Type-of-provider variables identify certain characteristics of the person or entity providing the child's care. These include whether the provider:

- Is a Head Start provider
- Is a public pre-K
- Is a kindergarten
- Is a school (grades 1-8)
- Provided drop-in care
- Provided a single activity
- Is an individual, in-home, with no prior relationship to the respondent
- Is an individual, in-home, with a prior relationship to the respondent
- Is an individual, in-home, with a prior relationship unknown
- Is individual, not in-home, with a prior relationship to the respondent
- Is an individual, not in-home, with no prior relationship to the respondent
- Is not one of the above, or unknown

The combination of care type and provider characteristics are used to assign each type of care arrangement–that is, a child-provider pair–into one of 14 simulator types, with the 14th being parental care only. The simulator types and their relation to the NSECE type is described in Table 2. The combinations of NSECE type and provider characteristics that define the 13 non-parental care simulator types are given in Table 3, along with the number of sample care arrangements in the survey that match each combination. In Table 3, the simulator types are denoted by colored or clear regions of the combinations of NSECE care type and provider types that define them. The total number of sample care simulator types are denoted under the columns of the table, using the descriptors in Table 2. Two small cells with a total sample size of 17 were combined with the "in_home_npr" type. Note that a child may have more than one care arrangement, and often does.

Information of the location of estimation code, log files with parameter estimates, output files, and sample sizes of the child care behavior models is given in Table 4.

For the 14 probability of using care models, the dependent variable is the dichotomy of using that type of care arrangement in the survey week versus not using that type of care. The universe of children for each model depends on the age restriction, if any, for that type of care. For models 1-4, the universe is restricted to children under 6 years of age. For model 11 (K-8), the universe is restricted to children 5 years of age or older. The universe, and therefore the number of observations, is also restricted to cases with no missing values for any of the independent variables in the model. These models are estimated as logit models. Their evaluation is an estimate of the probability of using that type of care conditional on the values of the independent variables. "Evaluation" of a model in this documentation means the result of applying the coefficients of the model to the model's independent variables and then transforming that result appropriately. The transformation for logit models is converting the log-odds to a probability; the transformation for OLS models is converting the logarithm by exponentiation.

For the weekly hours models, the dependent variable is the logarithm of the number of hours in the survey week that the child was in that type of care. The universe for these models is conditioned on the child using that type of care arrangement, so weekly hours are positive. These models are estimated by ordinary least squares (OLS). Their evaluation is an estimate of the expected number of weekly hours of that type of care conditional on the values of the independent variables. Weekly hours are not modeled for parental care.

For the probability of out-of-pocket cost models, the dependent variable is the dichotomy of having out-of-pocket costs for that type of care for that child versus not. The universe for these models is restricted to having that type of care in the survey week, and the number of observations may be further restricted by cases with missing information on out-of-pocket costs. Their evaluation is an estimate of the probability of incurring out-of-pocket costs for that type of care conditional on the values of the independent variables. The NSECE does not ask respondents about out-of-pocket costs for types 10-14.

For the weekly out-of-pocket cost models, the dependent variable is the logarithm of the dollars of out-of-pocket costs in the survey week for that child that was in that type of care arrangement. The universe for these models is conditioned on the family having out-of-pocket costs for that arrangement, so weekly out-of-pocket costs are by definition positive. These models are estimated by ordinary least squares (OLS). Their evaluation is an estimate of the expected weekly out-of-pocket costs of that type of care conditional on the values of the independent variables.

Independent Variables

Independent variables measure factors related to demand for child care that are present in the survey data. These include household income; the structure of the family: number of children by age, number of parents and their working status and weekly hours of work, education, or training; other demographics of the family that might affect demand, including race and ethnicity of the child, sex of the child, and conditions that might affect supply of care opportunities such as population density and incidence of poverty in the community.
The set of independent variables in the models, their names used in the simulator, abbreviated names appearing in Stata log files, and descriptions are in Table 5.

Estimation Protocol

All plausible independent variables were tried in the model estimation and were subject to a test of the null hypothesis of no or zero impact on the dependent variable of the model. If the p-value indicated a significant relationship were plausible, the variable or set of variables was kept. A strict rule for inclusion, that is, a specific threshold for the p-value, was not enforced. If the relationship appeared to be plausible, the variable or set of variables were retained in the model even if the p-value exceeded the conventional level of .05.

Parameter Estimates

The parameter estimates of the child care behavior models are given in Table 6. Since there are many hundreds of parameters in all, a comprehensive interpretation of them is beyond the scope of this documentation. However, a few comments are in order.

- Household income is significant and has a moderate to strong impact in most models. Most child care types appear to be “normal” goods, in that higher incomes increase the probability of using non-parental care. However, income has small impacts on several types of care and on weekly hours of most care types. Some types of care appear to be “Giffen” goods, that is, higher incomes lower the probability of that type: drop-in or single-use care, family providers, individuals with a prior relationship and unpaid individuals, and the biggest negative impact is on parental care only.
- Single-parent families generally are more likely to use most non-parental care types and to use them more intensively, that is, more weekly hours and higher weekly out-of-pocket costs.
- Working parents generally are more likely to use most non-parental care types. The interpretation is a bit complicated to eyeball because hours of work also need to be evaluated together with employment status. However, it appears that work is generally associated with higher probability of using non-parental care and more intensive use of non-parental care.
- Age and race/ethnicity of children affects the use and intensity of use for many types of care.
- When children use multiple types of care, weekly hours and weekly costs for single types of care tend to be less than for children who only use one type of care. This makes sense because a given amount of weekly care is spread over more than one type.

Using the Model for Simulation

Processing the PUMS

In the simulation, households and children in those households from the PUMS are processed sequentially. Persons in each PUMS household are formed into families, based on the relationship of the person–adult or child–to the household head; and if the household has one or more subfamilies, which subfamily the person belongs to and their subfamily relationship (PUMS variables relshipp, sfn, and sfr).

Baseline and Post-Program Scenarios

Once the families in the household have been formed, the models are applied to each age-eligible child in each family. First, the 14 types of care models–that estimate the probability of receiving each type of care–are evaluated for the child. A comparison of the probability of each type with a random draw–described below in the section on logit models–determines which types of non-parental care the child receives, if any. The model evaluation of the 14th type of care–parental or K-8 care only–is not used since it is dependent on the outcomes of the 13 non-parental types of care.

If the child receives one or more types of care, then the remaining models are evaluated for that child for each type of care the child uses. First, weekly hours of care for each type used is evaluated. Next, the probability of incurring out-of-pocket cost for each type used is evaluated and compared to a random draw. Finally, if out-of-pocket costs are incurred for a care type, the corresponding weekly out-of-pocket cost is evaluated for each such care type.
Once each child in the household has been passed through the models, the outcomes for each child are cumulated to the family and household levels, determining, among other things, the family's (or families') out-of-pocket costs. This forms the "baseline" or "pre-program" scenario–the situation for the family in the absence of the proposed financial assistance program. The baseline scenario also includes, for each family, a calculation of what the financial assistance for that family would have been if the program were in effect. This forms an estimate of the potential cost of the financial benefits of the proposed program in the absence of any behavioral response (and supply of child care capacity constraints).

As each household is processed, the estimates for child care usage, out-of-pocket costs, and program financial assistance are cumulated to provide aggregate estimates at the state level. Next, each household is passed through the program model, described in the program model section of the documentation, that determines the effect of the proposed program on the family's labor supply and childcare choices. By subsidizing childcare costs, a family might decide that it "pays" to work or to work more; and, by limiting subsidies to licensed care options, a family might substitute licensed care for other care types, including parental-only care.
These changes affect the childcare behavior models' outcomes in two ways:

1. Changes in the independent variables in the models, particularly in employment status of parents, in parents' weekly hours of work, and in household income. Household income is affected by increased wage and salary income from working, and from financial assistance for out-of-pocket costs for licensed care.

2. Shifts to preferring licensed types of care do not affect the independent variables of the childcare behavior models, but they *do* affect the probability thresholds in the logit models for choice type and probability of incurring out-of-pocket costs, described in the program model section of the documentation. These changes in probability thresholds increase the probability of choosing licensed care alternatives and in incurring out-of-pocket costs in licensed care settings (which may be partially or fully offset by program financial assistance) and decrease the probability of choosing other care alternatives.

Next, each household is processed again, with the changes in independent variables and probability thresholds given by the program model module. Each child is processed through the child care models as in the baseline scenario, and results are cumulated to the family and household levels, and aggregated to the state level as households are processed. This pass is called the “post program” or “with program” scenario.

Evaluation of the Models

The coefficients of each model are applied to the independent–that is, right-hand side–variables of the model, where the values of the variables in the model are taken from the PUMS. This requires that the PUMS have the same variables as those in the national survey on which the models were estimated. For some variables, this involved imputing some values or adding data from another source to the PUMS data set. This is described in a following section on harmonization of the PUMS and the NSECE. The application of the coefficients to the independent variables forms an intermediate estimate of the value of the dependent variable, called the “right-hand side” of the model. There are two types of models: logit models and OLS models. How these are transformed into the final value for the dependent variable is described in the next two sections. In each case, the transformation involves the use of a random number generator.

Logit Models

Two of the model types, the model that determines whether or not a particular type of child care is used, and the model that determines whether or not the family incurs out-of-pocket costs for this care, are logit models. Logit models are used to estimate the probability of each of the binary outcomes–using a particular type of care or having out-of-pocket costs for that care. The outcome is determined by comparing that probability to a draw from a uniform random number generator. If the probability exceeds the random draw, the outcome occurs; otherwise, it does not occur. Probabilities and random draws are always between zero and one. For example, if model #3 (pcare03, the probability of use model for Early Childhood Center) estimates that the probability is 0.12 (12%) and the random draw is .09, the simulation result is that that type of care *is* used by that child. However, if the random draw is .56, the result is that that type of care *is not* used by that child. Since the random draws are uniformly distributed between 0 and 1, .12 would not be exceeded 12 percent of the time.

OLS Models

Two of the model types, weekly hours of use and weekly out-of-pocket costs, are OLS (ordinary least squares) models. OLS models estimate the expected value of the dependent variable conditional on the values of the independent variables. The expected value is the average value of the outcome, not the actual value. Children with the same set of characteristics, that is, the same values for their independent variables, will have different outcomes, but their average

value over *all* children with this same set of characteristics is the expected value. The difference between the child's actual value and expected value is called the disturbance or "error" for that child. The simulated outcome is calculated as the estimated expected value plus a random draw from the distribution of the errors for the model. The model errors from the estimation of the model using the national survey data are used to estimate this probability distribution. The location of the sample error distributions and their sample sizes are in Table 4.

Thresholds and Dependencies

Statistical models do not predict or measure outcomes exactly or without error. If they did, probabilities of binary events would be either 100% or 0%, and errors in OLS models would be zero. These deviations from certainty or from the expected value are due to factors that affect the outcome but are not included in the model. For families with more than one age-eligible child, these missing factors are likely to include common components between the children, given that they are from the same family. These common components lead to correlations in the missing factors. This means that the random draws that determine the outcomes are not independent across children; rather they are dependent. The simulator operationalizes these dependencies by using the random draws from the first child processed for the other children in the family. For example, if the random draw for the Early Childhood Center in model 3 was .09 for the first child evaluated, then .09 also becomes the threshold for model 3 for other children in the same family. For the OLS models this means that the errors drawn for the first child are used for the other children in the family. For example, if the weekly out-of-pocket cost in model 39 (Early Childhood Center) for one child exceeded the expected value for that child, it would also exceed the expected value for other children in the same family by the same proportion. Another type of dependency also exists. The errors in the weekly hours and weekly out-of-pocket costs for a child may be correlated. This dependency is operationalized by using the sample joint error distribution from the estimated models. When a child incurs an out-of-pocket cost for a child care arrangement, the errors for both weekly hours and weekly costs are drawn from their joint distribution. If another child in the same family also incurs an out-of-pocket cost for the same care type, the same errors are used.

Multiple Child Care Types

Many children use more than one type of child care. For example, they may use both licensed center care and in-home relative care. The national survey suggests that the probabilities of different care types are approximately independent of one another. This means that the probability that a child uses two particular types of care in a given week are approximately equal to the product of the probability of using the first type of care times the probability of using the second type of care. Independence greatly simplifies the estimation of the use models by limiting the number of models that must be estimated. If independence were a poor approximation to the joint probability distribution of multiple care types, then separate models would have to be estimated for each possible combination of multiple care types. Not only would this require the estimation of many more models, it would also lower the statistical power of each model by lowering the sample sizes of the joint models in the national survey. The independence assumption allows for the estimation of only one use model for each child care type. Multiple leave types occur when the random thresholds of more than one type are exceeded by the estimated probabilities for a particular child.

Although the independence assumption is a good approximation, it is not exact. Some combinations of care types are more likely than independence would imply, and some are less likely than independence would imply. The simulator adjusts for non-independence of certain care types by adjusting the probabilities for combinations of care types. These adjustments were estimated by a calibration procedure described in the calibration part of this documentation.

Harmonizing the PUMS and NSECE Variables

The strategy of constructing the simulator requires that the independent variables of the child care behavior model variables exist on both the NSECE and the PUMS. This may require adding or changing some variables on one or both data sets. In designing the simulator, the choice was made to harmonize by changing or adding variables to the PUMS. Fortunately, few variables were impacted. They are described here.

Age of Child

Children's ages on the NSECE are in months. On the PUMS, they are in years. To harmonize ages on the PUMS, month of birth is drawn from the distribution of births for 2018-19 for U.S. (U.S. Department of Health and Human Services, 2020).

Poverty Density

Poverty density is defined for the same thresholds as the NSECE (for low, médium, and high) by obtaining the proportion of the population below the poverty level by PUMA from the American Community Survey 2015-19 (U.S. Census Bureau). The geography used in the NSECE is at a more detailed geography–a "catchment area"–so the harmonized value used in the simulator is not quite the same concept.

Urban Density

Urban density is defined for similar thresholds as the NSECE (for low, medium, and high) by obtaining population density from the 2010 Decennial Census by PUMA (U.S. Census Bureau). The geography used in the NSECE is at a more detailed geography–a weighted average of nearby census tracts–so the harmonized value used in the simulator is not quite the same concept.

Weekly Hours of Work, Education, and Training

An ideal harmonization of this variable was not possible. Usual weekly hours of work from the PUMS was used as a proxy for this, imparting some bias in the estimated model parameters.

Program Model

The program model is a set of models that simulate the impact of the financial assistance program on families' work and childcare choices. Every household gets run through the program model after the baseline run. The baseline run simulates current (pre-program) work and childcare usage. The program model simulates the labor supply response and the effect of the financial assistance program on families switching from non-licensed or parent-only care to licensed care, or using a greater amount of licensed care. This latter effect is called "switching-behavior" below. For brevity the amount of childcare financial assistance received under the program is frequently called "subsidy" below. The terms "financial assistance" and "subsidy" are used interchangeably.

Labor Supply Model

The impacts of the proposed program on the supply of labor by parents with age-eligible children is estimated with the following two labor supply models:

1) $Pr(working) = f(E - C, D)$
2) $H = g(E - C, D)$

where:

E is the parent's expected earnings from working,
C is the parent's expected net childcare costs, i.e., out-of-pocket costs less any subsidy received,
D is a vector of demographic factors that affect these labor supply outcomes, including the parent's race and ethnicity, age, whether there is a spouse in the family, whether there is a working spouse in the family, and the presence of young children, and.
H is the parent's annual hours of work.

The first model says that a parent's probability of working depends on the return from working, earnings less net childcare costs, or $E - C$, and on their demographic characteristics and the composition of the family. The second model says that a parent's annual hours of work also depend on these same factors.

Labor theory suggests that E and $E - C$ have positive effects on the probability of working and the intensity–number of hours–of work. Childcare costs, C, provide a disincentive to work since they lower $E - C$, the net return to working. The proposed legislation lowers C, net childcare costs, and so increases the net return to work and therefore parents' labor supply.

These models are used to calculate the semi-elasticity of the probability of working (extensive) and the elasticity of annual hours of work (intensive) to a change in net earnings:

3) $\Delta Pr(working) / \frac{\Delta(E-C)}{E-C}$

4) $\frac{\Delta H}{H} / \frac{\Delta(E-C)}{E-C}$

These elasticities, in turn, are applied to the proportional change in expected net earnings given by the proposed legislation to simulate the change in parents' labor supply, giving the change in the probability of working and the proportional change in hours of work respectively.

Program Model Estimation

The labor supply models in equations 1 and 2 are applied to parents who are either not currently working or are working less than full-time. Earnings, E and net earnings $E - C$ are both expectations that are conditional on working or working more intensively and using paid child care, so they are not observed for such parents. For this reason, educational attainment is used as an instrument for these concepts.

The data observations are for parents of age-eligible children from the 2015-2019 PUMS for Massachusetts. For the first model, all parents of age-eligible children are included as observations. The dependent variable for the first model is an indicator for being employed in the survey week (ESR =1 or 2: civilian employed with a job or at work). The model is estimated by logistic regression.

The second model is restricted to parents with positive annual hours of work in 2019. Observations are restricted to 2019 because in prior years the PUMS variable for weeks of work in the past 12 months was coded in categories, e.g., 13 weeks or less, 14 to 26 weeks, etc. Annual hours of work are the product of WKHP (usual hours worked per week in the past 12 months) and WKWN (weeks worked during the past 12 months). The dependent variable is the logarithm of annual hours of work. The model is estimated by ordinary least squares (OLS) regression.

The independent variables for both models include:

- Indicators for educational attainment, derived from SCHL (educational attainment). In increasing order of educational attainment, the indicators are:
  - less than high school, including 12 years without a high school diploma
  - high school, including regular high school diploma or GED; this category serves as the reference group in the model estimation
  - some college, including associate's degree
  - bachelor's degree
  - master's degree
  - professional or doctorate degree
- Indicators for race and ethnicity, derived from HISP (Hispanic origin) and RAC1P (recoded detailed race code)
  - Hispanic
  - White, non-Hispanic; this category serves as the reference group in the model estimation
  - Black, non-Hispanic
  - Asian, non-Hispanic
  - Other race category (including 2 or more races), non-Hispanic
- Age of parent
- Age of parent squared
- An indicator for one, and only one, child less than 6 years old in the household
- An indicator for two or more children less than 6 years old in the household
- An indicator that the parent has a spouse or partner in the household
- An indicator that the parent has a working spouse or partner (ESR of spouse or partner is 1 or 2)

Models are estimated separately for men and women.

Earnings and Expected Subsidy Models

Two additional models are needed to implement the labor supply effects of the program.

A model for earnings is required so the education instruments can be used to calculate elasticities. The dependent variable in the earnings model is the logarithm of the person's earnings over the last 12 months (PERNP*ADJINC, where PERNP=WAGP+SEMP (wage and salary income plus self-employment income), and ADJINC is a factor that adjusts earnings to $2019). Observations are restricted to 2019. The same set of independent variables is used as in the labor supply models, and the earnings model is estimated separately for men and women. The model is estimated by OLS regression.

Another model is required to complete the simulation of the employment effects of the proposed legislation. That is the expected subsidy used to form the expectation of net childcare costs. The dependent variable for this model is constructed from an initial run of the simulator using the observations on the households which receive financial assistance in the initial run. This initial run is needed only to provide the data required to estimate the expected subsidy model. Households are run through the childcare usage model and their subsidy is calculated as if all their childcare out-of-pocket costs, including costs paid to non-licensed providers, were counted

in calculating the subsidy. This is done to get an estimate of what their subsidy would be if, under the program, they were to switch to licensed care only. These subsidies can then be used to form expected subsidies under the program conditional on the household's characteristics. The dependent variable in this model is the logarithm of the household's subsidy.

The independent variables include:

- The educational attainment and race of the first adult household member in the household (essentially the first parent), using the same categories as in the labor supply models
- An indicator for one, and only one, child less than 6 years old in the household
- An indicator for two or more children less than 6 years old in the household
- Whether the first adult household member has a spouse or partner

The model is estimated by OLS regression.

Table 7 (source: simulator log file) contains the coefficient estimates for these models. The location of the code, statistical procedures, and statistical output for these models is: C:\Users\a.clayton-matthews\Dropbox\ACM\Projects\Professional\2022\Early Education\Model Development\Employment Model at http://192.168.1.13.

Calculation of Elasticities

The extensive elasticity in (3) above is calculated as the change in the probability of working given by model (1) divided by the proportional change in earnings given by the earnings model. The change for each parent is the change from their educational attainment category to the next higher educational attainment category–a "step-up" in the education instrument. For example, for a parent with some college, the change in the probability of working is calculated by evaluating the model for the parent with some college, and subtracting that from the evaluation of the model for the parent if they had a Bachelor's degree instead. Similarly, the change in expected earnings is calculated by evaluating the earnings model for the parent with some college, and subtracting that from the evaluation of the earnings model for the parent if they had a Bachelor's degree instead. For parents with the highest educational attainment–a professional degree or PhD–the "step-up" used to calculate the elasticity is from a Master's degree to a professional degree. Because model (1) is a non-linear model, each parent's elasticity is also affected by their demographic and family structure characteristics contained in the model.

The intensive elasticity in (4) is calculated as the proportional change in annual hours given by model (2) divided by the proportional change in earnings given by the earnings model. The same "step-up" in education procedure is used to calculate these elasticities. Since both model (2) and the earnings model are log-linear models, each parent's elasticity is determined solely by their educational attainment and their sex.

Table 8. contains mean elasticities for extensive and intensive employment changes by educational attainment and race/ethnicity of the parent.

The mean elasticity for extensive employment is approximately .25, which means that a one percent increase in expected wage and salary income net of childcare costs would increase the probability of working by .25 percentage points for a parent who is currently not working. For a typical non-working parent whose expected subsidy would increase their expected net earnings after childcare costs, $E - C$, by 20 percent, their probability of working would increase by 5 percentage points.

The mean elasticity for intensive employment is roughly .2, which means that a one percent increase in expected wage and salary income net of childcare costs would increase annual hours of work by .2 percent. For a typical parent who is working at a less than full-time/full-year schedule of 1500 annual hours, and whose expected subsidy would increase their expected net earnings after childcare costs, $E - C$, by 15 percent, their annual hours of work on average would increase by 3 percent, or 45 hours.

Implementation of the Model in the Simulator

The elasticity estimates described above are expected or average. Applied to the average change in net income realized by the financial assistance program they imply certain aggregate changes in employment or annual hours of work. The simulator produces changes in employment and hours on an individual level and should meet the following criteria:

1. These changes go to the "right" persons, that is, to parents who are increasing their use of licensed child care and who–after subsidy receipt–have increased net incomes.
2. The aggregate changes in employment and hours are consistent with the elasticities and the average change in expected net income from the financial assistance program.
3. The changes are realistic and plausible for sample individuals.
4. The new weeks worked and usual hours per week meet the coding requirements of the PUMS, that is, they are integral (integers) and within acceptable and plausible ranges.

Regarding criterion 3, the average change in annual hours for parents who are already working is small. It is not realistic and plausible that every working parent would increase their annual hours by a small amount. Rather, the average is attained by many parents not increasing hours at all and other parents having significantly larger changes in annual hours–for example, part-time workers changing to full-time or part-year workers increasing their weeks of work.

Criterion 3 is simple to implement for changes in employment. The non-working parent simply becomes employed or remains not employed. This is easily simulated with a random draw from a uniform distribution.

There are many ways to meet these criteria that are reasonable and plausible. This section describes the choices made for this simulator.

The program model first identifies one non-working adult household member as a candidate for an extensive labor supply change, i.e., a person who might become employed, and one working adult household member who works less than full-time/full-year (2080 annual hours) as a candidate for an intensive labor supply change, i.e., who might have an increase in annual hours of work. If there is more than one non-working adult in the household, the first one with

the least annual hours of work is chosen. If there is more than one working adult with less than a full-year/full-time schedule, the first one with the fewest annual hours is chosen.

At most only one adult from a household has a labor supply response. All families are exposed to switching behavior. Ninety-four percent of adults in the simulation households are parents of age-eligible children–the others are grandparents or guardians. Ninety-nine percent of the simulation households are one-family households–the others are multi-family households.

The candidates, if any, are evaluated in a hierarchy. First, the extensive candidate, if any, is evaluated. If there is no extensive candidate who becomes employed, then the intensive candidate, if any, is evaluated. If no extensive or intensive candidate has a labor supply response, then the first family is evaluated for switching behavior. The families of both extensive and intensive candidates are evaluated for switching behavior, so every household, in effect, is evaluated for switching behavior.

Extensive Evaluation

The extensive candidate's change in probability of employment is calculated as follows:

5) $\Delta Pr(Working) = \eta_{ex} \times \frac{E(subsidy)}{E(earnings)} \times f_{ex}$

where:

- η_{ex} is the person's extensive semi-elasticity calculated with the labor supply model and the earnings model.
- $E(subsidy)$ is the household's expected subsidy, calculated with the subsidy model.
- $E(Earnings)$ is the person's expected earnings, calculated with the earnings model.
- f_{ex} is the extensive elasticity calibration factor. It is used to satisfy criterion 2 above, that is, to make the aggregate change in employment consistent with the expectation given by the elasticities and the size of the financial assistance program. The value for this factor used in the current version of the model is 2.0 (two).

The middle factor in equation (5) is the person's expected proportional change in earnings net of childcare expenses, since the expected subsidy is the savings in net childcare expenses.

The increment in the probability of working is compared to a random draw from a standard uniform probability distribution–called the employment probability threshold, and if it is greater, the person's employment status is changed to employed. In addition, the person's earnings, annual hours, weeks of work, and usual weekly hours of work are updated from the earnings and hours models.

Usual weekly hours of work are needed by the childcare usage models, and weeks of work, usual weekly hours, and annual hours of work must form a consistent set of relationships to conform with the PUMS: usual weeks of work and number of weeks of work must be integers, and their product must equal annual hours of work. The change in the person's annual hours of work is initially taken from the annual hours model and this change is used to update the

person's usual weekly hours (WKHP) and number of weeks of work (WKWN). The procedure to do this aims to assign a usual weekly hours of 40, which is the modal value on the PUMS. Also, each person's annual hours of work are constrained to not exceed 2600 (50 hours x 52 weeks). Because of these constraints, the final change in the person's annual hours of work can be–and usually is–slightly different from that given by the annual hours model.

Because the subsidy effectively increases the household's income the household's income is incremented by the amount of the expected subsidy.

The household is then run through the childcare usage models. The expected usage of licensed childcare is generally expected to increase because:

- In the childcare models, household income, the number of working parents, and the weekly hours of parents' work are expected to increase childcare usage. See the section above on the childcare model for documentation on these models.
- The program model simulates switching behavior by decreasing the probability thresholds of licensed care usage and increasing the probability thresholds of non-licensed care usage; and by decreasing the probability thresholds of incurring out-of-pocket costs in licensed care settings. See the section on the childcare model for an explanation of how these thresholds work and how they are set.

The actual subsidy that the household receives–rather than the expected subsidy from the program model–is then calculated based on the family's income and out-of-pocket licensed childcare costs.

The household is then passed through a test to determine whether the candidate parent's labor supply response is consistent with the rationale for becoming employed. The rationale for choosing to work is that the change in income from working net of childcare costs is positive and that there is a more intensive use of non-parental child care, since the parent is going to work to be able to afford an increased usage of child care resulting from working.
The candidate passes this test if all the following conditions are met:

- The household has an increase in childcare out-of-pocket costs or hours of childcare usage relative to the baseline (current) usage.
- The change in the household's income is greater than or equal to their net change in out-of-pocket childcare costs from the baseline situation.
- The household receives a subsidy.
- The change in the probability of working given the actual subsidy–rather than the expected subsidy–is still above the employment probability threshold.

If the candidate parent passes this test, then the employment change from the program model is accepted. About 50 percent of candidates pass this test.

The extensive elasticity calibration factor, f_{ex}, is set so that the number of newly employed parents is consistent with the elasticity estimated from the labor supply model. Several aspects of the program model affect the size of f_{ex}:

- The way extensive candidates are selected; Not every non-working parent is selected as a candidate.
- The difference between the initial expected subsidy and the actual subsidy calculated in this program model
- The passing rate for the test; The calibration factor, f_{ex}, is inversely proportional to the passing rate for this test.

Intensive Evaluation

The increase in annual hours worked for parents who are employed (the intensive labor supply change) is calculated as follows:

6) $\Delta Annual\ hours = \eta_{in} \times \frac{E(subsidy)}{E(Earnings)} \times max\big(annual\ hours, E(annual\ hours)\big) \times f_{in}$

   where:

   - η_{in} is the person's intensive elasticity calculated with the labor supply model and the earnings model.
   - $E(subsidy)$ is the household's expected subsidy, calculated with the subsidy model.
   - $E(Earnings)$ is the person's expected earnings, calculated with the earnings model.
   - The elasticity is applied to either the person's current annual hours or their expected annual hours given by the labor supply model, whichever is larger.
   - f_{in} is the intensive elasticity calibration factor. It is used to satisfy criterion 2 above, that is, to make the aggregate change in hours of work for currently employed parents consistent with the expectation given by the elasticities and the size of the financial assistance program. The value for this factor used in the current version of the model is 10.0 (ten).

In order to satisfy criterion 3, that the changes in annual hours for parents who work more intensively is realistic and plausible, not every intensive candidate is selected for evaluation. There are two ways in which the number of parents who increase their hours is limited. One is the procedure that tests for criterion 1, that the parent's family increases their use of licensed child care and–after the subsidy receipt–has a larger net income. The other is a probability threshold that determines whether the candidate is evaluated at all. This intensive threshold is set to .56 for the current version of the model, which limits the evaluation to a random selection of 56% of the intensive candidates. Together with the intensive elasticity calibration factor, these two parameters are used to satisfy criteria 2 and 3.

The parent's change in annual hours is allocated to weeks worked and usual weekly hours by the same procedure described in the extensive evaluation above.

As in the extensive evaluation,

- the household's income is increased by the amount of the expected subsidy
- the household is run through the childcare usage models, where the household's actual subsidy is determined, and
- the household is passed through the test to determine whether the candidate parent's labor supply response is consistent with the rationale for increasing annual hours of work. About 15% of candidates pass this test.

If the candidate passes the test, then the intensive labor supply change from the program model is accepted.

Switching Behavior

A program that provides financial assistance for licensed care–but not for non-licensed or informal care–increases the use of licensed care. It lowers the price or cost to families of using licensed care relative to other types of care, including parental care only. This induces families to switch to using licensed care from using other types of care, and to use more licensed care. The magnitude of this effect has been studied and reported in academic literature. Size effects from this literature are incorporated in the simulator by lowering the probability thresholds for the use of licensed care and increasing the probability thresholds for other types of care.

The probability threshold is the random draw from the uniform probability distribution that is assigned to each child and each type of child care in the childcare behavioral models (described in the child care behavior section of this documentation). The childcare behavioral models determine the probability for each type of use–for both licensed and unlicensed care types–and probability of incurring out-of-pocket costs for each type. The probability from these models is compared to its corresponding probability threshold. If the probability from the model is greater than the threshold, that type of care is chosen, or out-of-pocket costs are incurred. Lowering the probability threshold is equivalent to biasing the random draw to favor the outcome, while raising the probability threshold biases the random draw to favor the alternative of not using that type of care or not incurring out-of-pocket costs.

The changes in these thresholds to model switching behavior are operationalized as a set of add factors to the thresholds in the childcare behavior models. These add factors are presented in Table 9. The determination of the magnitude of these add factors is described in the section on calibration.

Calibration

What is Calibration and Why is it Needed?

The simulator's childcare behavior models are estimated on data from a national survey, the 2019 NSECE survey (National Survey of Early Care and Education Project Team (2021)). These models are applied to the 2015-2019 American Community Survey PUMS for Massachusetts. The accuracy of the simulator depends on how well the models and the PUMS reflect current day Massachusetts. In particular:

- How well does the NSECE survey represent Massachusetts? There are obvious differences between Massachusetts and other states that might suggest that the answer is "not well," but the models are estimated and conditioned on demographic characteristics, so the answer to that question is not obvious. For example, although median household income in Massachusetts and Mississippi are quite different, the relevant question is "does income affect demand for child care differently in Massachusetts than Mississippi?" Other state differences not captured in the survey nor the model data might also make Massachusetts different. For example, differences in state and local government support for child care, differences in "culture" between states, etc.
- Have there been national shifts in behavior or other conditions that affect behavior since 2019? Certainly the Covid-19 pandemic, which started in the United States in 2020 comes to mind.
- Have the demographics of Massachusetts residents changed significantly from the 2015-19 period?

In addition to how well the simulator reflects current childcare behavior in current day Massachusetts, there is another important consideration: how well does it estimate the change in behavior to the proposed policies boosting financial assistance to families based on their childcare expenses and family income?

Calibration is the process of comparing and then adjusting the measurement of an estimation to measures that are known to be accurate. Here, it is "tweaking" the simulator's models and procedures by means of built-in handles or parameters to make the simulator reflect current day Massachusetts and its estimates of responses to proposed policy changes more accurate. This involves using information other than that used in the model to identify the differences between the simulator's baseline simulation and the current state of Massachusetts childcare usage. It also uses information to identify the differences between the simulator's estimated responses to a proposed policy change and the current state of knowledge about what that change would be. These differences inform the changes in handles or parameters in the model to calibrate it.

There are two other types of changes, other than calibration, that can be made to simulators to make them more accurate: updating and upgrading.

- Updating involves changing the models and database of the simulator by using new surveys for model estimation and/or newer releases of PUMS databases from the Census Bureau
- Upgrading or enhancing the simulator entails changing the code (rather than parameters or model coefficients), procedures, and model strategy to make the simulator perform better or more accurately, and/or to provide additional capabilities–for example, to be able to estimate impacts for new or different policies, and to fix "bugs"

All three activities–calibration, updating, and upgrading–are important aspects of creating and maintaining a simulator. All three should be ongoing and continuous as new information, new data, and new policy questions arise.

Targets of Calibration

The differences between the simulation outputs and current usage and state of knowledge of responses to policies provide targets for the calibrations. These targets include:

- Targets for current childcare use:
  - Number of childcare arrangements by type, including multiple arrangements
  - Intensity of use, as measured by weekly hours by type of arrangement
  - Out-of-pocket costs by type of arrangement, as measured by weekly out-of-pocket costs
- Sizes of program effects that lower the cost of licensed care to families on two types of responses to proposed policy changes:
  - Labor supply, including extensive effects–changes in the number of working parents, and intensive effects–change in parents' weekly hours of work
  - Changes in non-parental childcare usage and in types of childcare arrangements, especially changes in use of licensed care.

Types of Calibration Parameters

Calibration parameters–sometimes called "handles"–are used in the simulator to make simulator outcomes "hit" the targets referred to above. The values for these parameters are often estimated in a recursive procedure, by trying small differences and adjusting them until the target is "hit." Once determined, they enter the simulator as data and so could be entered by the user through means of a user interface. However, since these parameters are changed infrequently once estimated, they are entered in a data file and so are "fixed", i.e., not changed by the user. The types of parameters used in the simulator are:

- Add factors to models: These are additions (or subtractions) to the constant terms of models and can be applied to all the statistical models in the simulator.
- Add factors to thresholds: These are additions (or subtractions) to the thresholds of probability models, which directly affect the probabilities of outcomes.
- Multiplicative factors: These are factors that can increase or decrease an outcome. They can be applied to model expected values, probabilities, or elasticities.

Sources of Calibration Information

Several sources of information were used to calibrate the simulator. Broadly, they can be classified into academic studies, surveys, and administrative data. Surveys and administrative data are used to calibrate the number and types of childcare arrangements, and academic studies are used to calibrate the program effects on the supply of labor and on types of child care used. The academic studies used can be classified into two groups: (1) observational studies and (2) structural models. Observational studies use quasi-experimental designs and econometric techniques to estimate effects, for example difference-in-difference designs on a cross-section of states, relying on policy differences between states to identify the effects. Structural studies use economic models of utility (choice) and production. The parameters of these models are estimated using appropriate data. The estimated models are then used to evaluate the effects of policies. Structural models are sometimes called “equilibrium” models. Table 10 lists the sources used, indicates what types of calibration they were used for, and classifies the type of the source, e.g., observational study, survey, etc.

Calibrations of the Number and Types of Childcare Arrangements

Information for calibrating the number of childcare arrangements by type came from five sources:

1. Administrative data from the Massachusetts Department of Early Education and Care (EEC) on the capacity and enrollment in centers and family care
2. Administrative data from the Massachusetts Department of Elementary and Secondary Education on enrollment in public pre-K programs
3. Administrative data from the Massachusetts Head Start Association on the number of children served by Head Start programs
4. Survey tabulations from The Early Learning Study at Harvard on the number and types of care arrangements used by 3 and 4-year-olds in Massachusetts in 2017-2018
5. The American Community Survey PUMS 2015-19 for Massachusetts provides estimates of school enrollment for children 3 years and older by grade level attending

The information from these sources was used to form add factors for the probability of use models. Positive values increase the probability of using the corresponding type of care relative to estimates from the national NSECE survey, while negative values decrease that probability. These add factors are presented in Table 11.

The Early Learning Study at Harvard surveyed a representative sample of over 3,200 3 to 4-year old children in Massachusetts during 2017-18. This is the largest survey available to date that captures non-licensed and informal care of children in the state. The study assigned care arrangements into the following categories:

- Community center-based care (CCC)
- Head Start (HS)
- Public school prekindergarten (PSP)
- Family child care (FCC)
- Unlicensed care by a relative (URC)
- Unlicensed care by a non-relative (UNC)
- Parental care (PC)

The study also released sample counts of multiple care combinations. These data were used to calibrate not only the number of care arrangements by type of care for 3 and 4-year olds, but also to adjust the number of care arrangements for multiple care types given by the independence assumption. Several combinations were found to be less likely than what the independence assumption would imply. These types of care are called “substitutes,” meaning that the choice of one type lessens the probability of also using the other type. For example, center-based care and family child care tend to be substitutes. Children who use center-based care are less likely to use family child care than the independence assumption would imply, and vis-versa. On the other hand, other combinations were found to be more likely than what the independence assumption would imply. These types of care are called “complements,” meaning that the choice of one type increases the probability of using the other type. For example, center-based care and individual (relative or non-relative) care were found to be complements.

This survey was used to form multiplicative factors for types of childcare arrangements and combinations of types of care arrangements for 3- and 4-year old children. The factors are applied to the probability for that type of care estimated from the childcare behavioral models. These factors are presented in Table 12. In that table, combinations that were found to be substitutes or complements are identified as such. Factors that are zero or negative mean that that combination did not occur in the Harvard Study and so are not assigned to 3- and 4-year olds in the simulator. Factors of “1” mean that the deviation from the independence assumption was small. In these cases, the number of children with that care combination is often small too.

Calibrations of the Program Effects on Types of Childcare Arrangements

Several academic studies were used to calibrate the simulator for the effect of the program on parents’ choice of childcare arrangements–so called “switching” behavior. Three were structural models, two were observational studies, and one was a review of studies (see Table 10). The sizes of effects differed somewhat between the studies and the program characteristics also differed, but the studies were in rough agreement on the magnitude of the effects, with the largest positive effects on the use of center care. A plausible set of effect sizes from these studies were incorporated into the simulator by means of add factors applied to the threshold values for the probability of care models and the probability of out-of-pocket costs for licensed care alternatives. These add factors increased the probability of parents’ use of licensed care alternatives and of incurring out-of-pocket costs. These add factors and the methods used to operationalize “switching” behavior are presented in Table 9 and are further explained in the *Switching Behavior* section of the *Program Model*.

Calibration of the Program Effects on Labor Supply

Several studies estimated the effect of financial assistance programs on labor supply. Research focused on six studies: three were structural models, two were observational studies, and one was a review of studies. Several of these studies also commented on estimates of labor supply effects from other studies, so in all there were many sources of estimates. There was a wide variation in the effect sizes in the literature, from no effect to quite large effects. The widest variation in estimates appeared to be in observational studies. Also, the estimates of effect sizes in these observational studies appeared to fall over time, perhaps as the labor force participation of single parents was rising and so limited the size of the potential effects.

Rather than choose among these conflicting estimates, a simple labor supply model was estimated as described in the section on *Program Effects*. That model suggested a response close to the median of the estimates in the literature, and so was used instead of relying on outside estimates.

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Figure 1.
Flow of Households and Outputs in the Simulator

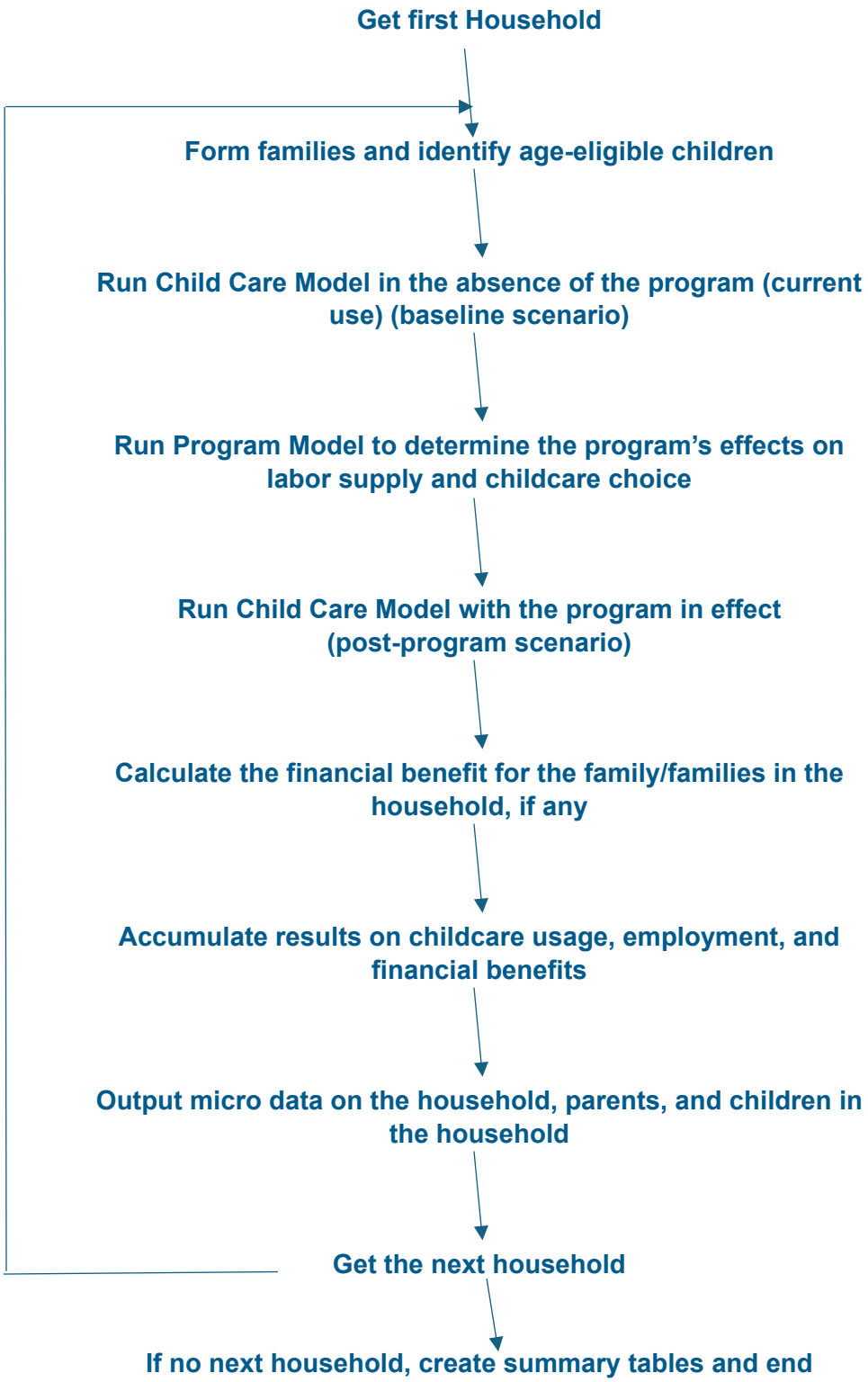

Table 1. Child Care Behavior Models by Type of Care, Model Number, and Model Name

		Probability of Using		Weekly Hours		Probability of Out-of-Pocket Costs		Weekly Out-of-Pocket Costs	
Type of Care (Age Restriction)	**Description and Age Restriction, if Any**	**#**	**Name**	**#**	**Name**	**#**	**Name**	**#**	**Name**
Head Start	Head Start, <6 yrs old	1	pcare01	15	hours01	28	pay01	37	weekly_cost01
Public Pre-K	Public Pre-K, <6 yrs old	2	pcare02	16	hours02	29	pay02	38	weekly_cost02
ECE Center	Early care center, <6 yrs old	3	pcare03	17	hours03	30	pay03	39	weekly_cost03
ECE Center Drop-In/Single Use	Early care center (drop-in, single activity, not inc. in ECE Center), <6 yrs old	4	pcare04	18	hours04	31	pay04	40	weekly_cost04
Other Organization	Other organization (inc. children >5 yrs old)	5	pcare05	19	hours05	32	pay05	41	weekly_cost05
Other Organization Drop-In/Single Use	Other organization (drop-in, single activity, not inc. in oth_center, includes children>5 yrs old)	6	pcare06	20	hours06	33	pay06	42	weekly_cost06
Family Provider	Family-based care outside the home	7	pcare07	21	hours07	34	pay07	43	weekly_cost07
In-Home, No Prior Relationship	In-home provider, no prior relationship to family	8	pcare08	22	hours08	35	pay08	44	weekly_cost08
Individual, Paid, Prior Relationship	Individual, paid, prior relationship to family	9	pcare09	23	hours09	36	pay09	45	weekly_cost09
Individual, Unpaid	Individual, unpaid	10	pcare10	24	hours10				
K-8 (in school)	Kindergarten through 8th grade (in school)	11	pcare11	25	hours11				
Irregular	Irregular ECE, usually < 5 hours/week	12	pcare12	26	hours12				
Other/Unknown Setting	Other, can't assign to one of the other types	13	pcare13	27	hours13				
Parental Care or K-8 (in school) Only	Parental or K8 only, not mutually exclusive of K-8	14	pcare14						

Table 2. Relationship of Simulator Child Care Types and NSECE Types of Care

Model #	Provider	Description	NSECE Type of Care	Age Restriction	Pay Information	Usually 5+ hours/week
1	headstart	Head Start, <6 yrs old	4	<72 months of age	yes	yes
2	pubprek	Public Pre-K, <6 yrs old	4	<72 months of age	yes	yes
3	ec_center	Early care center <6 yrs old	4	<72 months of age	yes	yes
4	ec_center_ds	Early care center (drop-in, single activity, not inc. in ec_center)	4	<72 months of age	yes	yes
5	oth_org	Other organization (inc. children >5 yrs old)	5	none	yes	yes
6	oth_org_ds	Other organization (drop-in, single activity, not inc. in oth_center, includes children>5 yrs old)	5	none	yes	yes
7	family_prov	Family-based care outside the home	1	none	yes	yes
8	in_home_npr	In-home provider, no prior relationship	1	none	yes	yes
9	indiv_paidpr	Individual, paid, prior relationship	2	none	yes	yes
10	indiv_unpaid	Individual, un-paid	3	none	no	yes
11	k8	Kindergarten through 8th grade	6, plus school and kindergarten providers in Types of Care 4 and 5	>=5 years old for Type of Care 6. May include younger children for Type of Care 4 and 5	no	yes
12	irregular	Irregular ECE, usually < 5 hours/week	7	none	no	no
13	other_uk	Other, can't assign to 1-12	8	none	no	NA
14	parental_k8	Parental or K8 only, not mutually exclusive of k8	NA	none	NA	NA

Table 3. Provider Type by Type of Care (Frequencies)

Provider Type		Type of Care: Usually >=5 hours per week — Individual provider: Individual paid, no prior relationship	Individual paid, prior relationship	Individual, unpaid	Organizational provider: Center-based care, <72 months of age	Other organizational care	K-8 Schooling	< 5 hours/week: Irregular ECE, < 5 hours/week	All other setting unknown	Total
	other/unknown	0	0	0	970	558	2,083	271	213	4,095
	headstart	0	0	0	223	0	0	9	0	232
	public pre-k	0	0	0	304	0	0	9	0	313
	kindergarten	0	0	0	92	3	358	6	2	461
	school (1-8)	0	0	0	11	0	2,957	62	0	3,030
	drop-in	7	0	2	17	242	136	97	0	501
	single activity	10	0	10	50	384	692	204	10	1,360
In-home care	in-home, no prior relationship	163	0	45	0	0	0	40	0	248
In-home care	in home, prior relationship	0	520	2,420	0	0	0	512	0	3,452
In-home care	in home, prior relationship unknown	0	0	20	0	0	1	0	37	58
	other prior relationship	0	483	2,481	0	0	0	1,688	0	4,652
	other individual/ family-based care	375	0	160	0	0	7	61	0	603
	Total	555	1,003	5,138	1,667	1,187	6,234	2,959	262	19,005

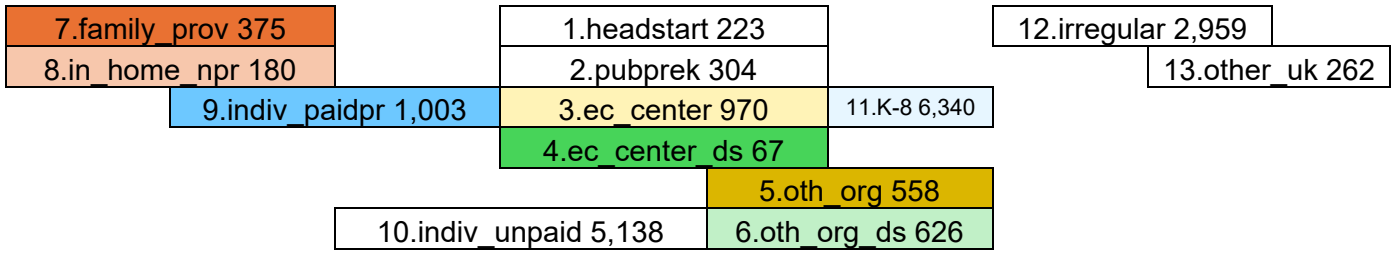

Table 4. Model Estimation Code, Output Files, and Sample Sizes

				Sample Size				Probability Distribution of Errors		Sample Size	
Model #	**Model Name**	**Do File**	**Log File**	**PrCare**	**Hours**	**PrPaid**	**Weekly Amt**	**Univarate**	**Bivarate**	**Univarate**	**Bivarate**
01	headstart	headstart.do	headstart.log	7,640	202	193	44	univariate_hours01.csv	bivariate_hours01.csv	159	43
02	pubprek	pubprek.do	pubprek.log	7,864	286	245	72	univariate_hours02.csv	bivariate_hours02.csv	214	72
03	ec_center	ec_center.do	ec_center.log	7,640	867	848	640	univariate_hours03.csv	bivariate_hours03.csv	227	640
04	ec_center_sds	ec_center_sds.do	ec_center_sds.log	7,864	230	90	34	univariate_hours04.csv	bivariate_hours04.csv	198	32
05	oth_org	oth_org.do	oth_org.log	15,537	495	485	221	univariate_hours05.csv	bivariate_hours05.csv	276	219
06	oth_org_ds	oth_org_ds.do	oth_org_ds.log	15,537	508	468	249	univariate_hours06.csv	bivariate_hours06.csv	259	249
07	family_prov	family_prov.do	family_prov.log	15,537	333	284	284	univariate_hours07.csv	bivariate_hours07.csv	49	284
08	in_home_npr	in_home_npr.do	in_home_npr.log	15,537	150	147	113	univariate_hours08.csv	bivariate_hours08.csv	37	113
09	indiv_paidpr	indiv_paidpr.do	indiv_paidpr.log	15,537	538	646	343	univariate_hours09.csv	bivariate_hours09.csv	195	343
10	individ unpaid	individ unpaid.do	individual unpaid.log	15,979	3,081			univarate_hours3.csv		3,081	
11	k-8	k-8.do	k-8.log	9,457	5,667			univariate_hours6.csv		5,667	
12	irregular	irregular.do	irregular.log	15,979	1,098			univariate_hours7.csv		1,098	
13	setting unknown	setting unknown.do	setting unknown.log	15,979	1,335			univariate_hours8.csv		1,335	
14	parental or k8	care all types.do	care all types.log	15,979							

Note: Location A for models 01-09, Location B for models 10-14.

Note: For probability of care models for types 10-14, see "care all types.do" and "care all types.log"

A = C:\Users\a.clayton-matthews\Dropbox\ACM\Projects\Professional\2023\Early Education\Models

B = C:\Users\a.clayton-matthews\Dropbox\ACM\Projects\Professional\2022\Early Education\Models\Hours

Table 5. Behavioral Model Independent Variables

Row	Variable Name	Abbreviation in Stata	Description
1	lnincome	lnincome	logarithm of household income
2	zero_income	zero_income	indicator for household income <= zero
3	nchildlt6_1	nchildlt6_1	indicator for 1 child in family <6 years old
4	nchildlt6_2	nchildlt6_2	indicator for 2+ children in family <6 years old
5	pov_density_high	pov_densit~h	indicator for > 20% of PUMA population below federal poverty level (FPL)
6	pov_density_low	pov_densit~w	indicator for <=13.9% of PUMA population below FPL
7	urban_density_high	urban_dens~h	indicator for urban density of PUMA population >=.85
8	urban_density_low	urban_dens~w	indicator for urban density of PUMA <.3
9	midwest	midwest	indicator for Midwest region of U.S.
10	south	south	Indicator for South region of U.S.
11	west	west	Indicator for West region of U.S.
12	incpov_ratio	incpov_ratio	income poverty ratio of child
13	single_parent	single_par~t	indicator for single parent family
14	a12	a12	indicator for 15 months <= age <33 months
15	a13	a13	indicator for 33 months <= age <48 months
16	a14	a14	indicator for 48 months <= age <60 months
17	a15	a15	indicator for 60 months <= age <69 months
18	a16	a16	indicator for 69 months <= age
19	older	older	age in years -9; =0 if age<9
20	pworking1	pworking1	indicator for 1 working parent
21	pworking2	pworking2	indicator for 2 working parents
22	lnwklyhour_wst	lnwklyhour~t	logarithm of parents' weeklly hours of work, school, and training; = 0 if wst=0
23	girl	girl	indicator for girl
24	condition	condition	indicator for child having a disability
25	blacknh	blacknh	child is Black, Non-Hispanic
26	asiannh	asiannh	child is Asian, Non-Hispanic
27	hisp	hisp	child is Hispanic
28	race2plus	race2plus	child has 2 or more races
29	raceother	raceother	child has another race (not including White, Nonhispanic)
30	ntypescare2	ntypescare2	child has two or more different types of care
31	k8care	k8care	child has a K-8 type of care
32	ntypes_x_k8	ntypes_x_k8	interaction of ntypescare2 and k8care
33	_cons	_cons	constant = 1

Note: Reference categories are:

	no children <6 years old
	medium poverty density
	medium urban density
	northeast region
	age < 15 months
	no working parents
	boy
	White Non-Hispanic
	child has 1 or no non-parental care types
	child does not have K-8 type of care

Table 6. Model Estimated Parameters

Model number	1	2	3	4	5
Simulation Type	Head Start	Public Pre-K	ECE Center	ECE Center Drop-In/Single Use	Other Organization
Model name	pcare01	pcare02	pcare03	pcare04	pcare05
lnincome	0.0519862	0.08857973	0.36128695	-0.06815405	0.52969615
zero_income	1.1955585	0.46864733	3.1216871	-1.5145589	6.5548197
nchildlt6_1	0	0	0.2535652	0	0
nchildlt6_2	0	0	0	0	0
pov_density_high	0	0	-0.19220518	-0.67170346	0.07552917
pov_density_low	0	0	0.22539731	-0.48785434	-0.19642246
urban_density_high	0	0	0.01701444	0	0
urban_density_low	0	0	-0.43924707	0	0
midwest	-0.40797805	-0.0853766	-0.44829591	-0.03914748	-0.01061756
south	-0.61406215	0.20428338	-0.22879657	-0.11229407	-0.09489331
west	-0.69697686	-0.76945125	-0.5715954	0.30465282	0.24185521
incpov_ratio	-0.46247629	0	0	0	0
single_parent	0.60339829	0	1.0859279	0.6304077	1.1895723
a12	2.1065645	-0.54701085	0.57099889	0.53353324	1.0374783
a13	3.8264474	1.300919	0.91328827	3.1038853	0.82479629
a14	4.452558	2.7202616	1.1393055	5.2150037	1.5692491
a15	3.9449235	2.8577843	0.37493353	6.3971148	1.7668013
a16	2.3287324	-0.21998745	-0.52693387	5.3208887	2.9694658
older	0	0	0	0	-0.28454129
pworking1	0.39295708	0	0.66775173	0.84541281	-0.23956369
pworking2	0.93466192	0	1.6561279	1.3016356	0.44517345
lnwklyhour_wst	0	0	0.16883319	0	0.34967353
girl	0	0	0	0	0
condition	0	0	0.16292649	0	0
blacknh	0.93062397	0	0.02200404	0	0
asiannh	-0.96073691	0	0.47173459	0	0
hisp	-0.29659516	0	-0.56238923	0	0
race2plus	0.5621574	0	0.12636044	0	0
raceother	-1.196926	0	-0.45821224	0	0
ntypescare2	0	0	0	0	0
k8care	0	0	0	0	0
ntypes_x_k8	0	0	0	0	0
_cons	-7.4311123	-5.7990889	-8.1253015	-8.2158715	-13.201735

Model Estimated Parameters (cont.)

Model number	6	7	8	9	10
Simulation Type	Organization Drop-In/Single Use	Family Provider	In-Home, No Prior Relationship	Individual, Paid, Prior Relationship	Individual, Unpaid
Model name	pcare06	pcare07	pcare08	pcare09	pcare10
lnincome	0.25995014	-0.03817195	0.7238662	-0.03467123	-0.03526121
zero_income	0	0.14895301	0	-2.6444477	-0.50074908
nchildlt6_1	-0.41449611	0	0.11285231	0	-0.32111365
nchildlt6_2	-0.97536704	0	-0.57614635	0	-0.32239892
pov_density_high	0	-0.05114718	-0.59018193	-0.3799936	-0.05900798
pov_density_low	0	0.31811112	-0.77061837	-0.09471141	-0.15698041
urban_density_high	0	0	0.7710104	0	-0.14027756
urban_density_low	0	0	-0.28211854	0	0.16840719
midwest	0.2811763	0.56970567	0.11342706	0	-0.21528557
south	0.48066681	-0.2925028	-0.85391422	0	-0.37170912
west	0.74306772	-0.06916703	-1.0904974	0	-0.19916605
incpov_ratio	0	0	0	0	0
single_parent	1.0003704	2.1082711	1.8606728	1.4496739	1.9576022
a12	0.31904766	0.34152878	-0.49279481	0.46742037	0.24043357
a13	0.81858426	0.48031925	-0.58462685	0.02893995	0
a14	1.2228355	-0.39851522	-0.0735726	-0.22458234	0
a15	-0.06939639	-0.53726243	-1.8837539	-0.16412526	0
a16	-0.38382252	-1.0584271	-1.1055686	-0.93091139	-0.45262559
older	-0.06787319	-0.43728492	-0.45553953	-0.28523283	-0.0615442
pworking1	0.38391924	0.98336194	1.9275436	0.17320024	0.70088695
pworking2	1.213851	2.8488805	3.4609057	1.6456046	2.1242996
lnwklyhour_wst	0.14662895	0.37637833	0.40326464	0.22672033	0.18330171
girl	0.31874184	0	0	0	0
condition	0	0	0	0	0.3085974
blacknh	-0.08068661	-0.78123928	-0.41110581	0.46028594	0.06117369
asiannh	0.05219108	-1.815986	-1.6455908	-0.27810185	0.01334221
hisp	-0.40925441	-0.24435786	-0.69091723	0.77508769	-0.16212262
race2plus	0	0.24543061	0	-0.10451235	0.15162383
raceother	0	0	0	-0.00774821	0.30392506
ntypescare2	0	0	0	0	0
k8care	0	0	0	0	0
ntypes_x_k8	0	0	0	0	0
_cons	-7.9462032	-6.8452739	-15.705531	-4.7216921	-2.7395429

Model Estimated Parameters (cont.)

Model number	11	12	13	14
Simulation Type	K-8 (in school)	Irregular	Other/Unknown Setting	Parental Care or K-8 (in school) Only
Model name	pcare11	pcare12	pcare13	pcare14
lnincome	0.06977641	0.15507365	0.18605555	-0.13049257
zero_income	0	2.7305033	2.4253425	-1.43955
nchildlt6_1	0	-0.31122436	0.58428816	0
nchildlt6_2	0	-0.49609371	0.9567894	0
pov_density_high	0	0	0	0
pov_density_low	0	0	0	0.025843
urban_density_high	0.12691741	-0.37042278	0	0.14871574
urban_density_low	-0.1295995	-0.37003373	0	0.04235814
midwest	-0.36670016	0.53937766	-0.22610855	0.06708621
south	-0.33089558	0.13044917	-0.219879	0.23367552
west	-0.21741398	0.61974713	-0.07605347	0.16091319
incpov_ratio	0	0	0	0
single_parent	0.36606281	-0.20855357	1.0728796	-1.615976
a12	0	0	0.08672233	-0.4173949
a13	0	0	0.43231507	-0.67755182
a14	0	0	0.77682881	-1.1634379
a15	-2.080238	0	0.81131869	-0.77844857
a16	0	0	1.2882205	0.36814814
older	-0.10538348	-0.1308932	0.01808063	0.12767672
pworking1	-0.37237714	0.31872321	0.3272158	-0.6277699
pworking2	0.14748695	0.20963994	1.0295263	-2.014657
lnwklyhour_wst	0.22591788	0.0210236	0.1883703	-0.23661742
girl	0.13624404	0	0	0.08223132
condition	0	0.23242679	0	-0.27274216
blacknh	0	-0.34151414	0.22524473	-0.22290912
asiannh	0	0.11504077	0	-0.15406978
hisp	0	-0.50590594	0	0.15963923
race2plus	0	0.10123386	0.33571105	-0.42494015
raceother	0	-0.42987673	0.65054121	-0.07318186
ntypescare2	0	0	0	0
k8care	0	0	0	0
ntypes_x_k8	0	0	0	0
_cons	-0.53376917	-4.0375191	-7.3330339	3.5712381

Model Estimated Parameters (cont.)

Model number	15	16	17	18	19
Simulation Type	**Head Start**	**Public Pre-K**	**ECE Center**	**ECE Center Drop-In/Single Use**	**Other Organization**
Model name	hours01	hours02	hours03	hours04	hours05
lnincome	-0.00163993	-0.01734513	-0.010374	-0.07989903	0
zero_income	0.2996702	0.00090551	-0.02054099	-0.35271052	-1.9069575
nchildlt6_1	0	0	0	0	0
nchildlt6_2	0.00017269	-0.23311249	0	-0.22275454	0
pov_density_high	0	0.12741433	0	0	0
pov_density_low	0	-0.11613042	0	0	0
urban_density_high	0	0.0419737	0	0.03814501	0.2089181
urban_density_low	0	0.26556468	0	-0.26381697	0.5866222
midwest	0	0.20540205	-0.13360499	-0.4329882	-0.2496741
south	0	0.34445833	0.03753006	-0.24093966	0.03096486
west	0	0.31344311	-0.00723469	-0.4471774	-0.05730848
incpov_ratio	0	0	0	0	0
single_parent	0.14826346	0.26592817	0.79335913	0.37227116	0
a12	0.08274243	0	0.15665311	-1.1075586	0.36438735
a13	-0.23267985	0	-0.07582147	-2.3284245	0.06609254
a14	-0.20177293	0	-0.11897663	-0.1642592	0.4864138
a15	-0.28103008	0	-0.47094979	0.03305357	-0.58563245
a16	0.21221033	0	-0.09227065	0.22889939	0.0226365
older	0	0	0	0	0
pworking1	-0.14972493	0.16753041	0.25346562	0	0
pworking2	-0.09641622	0.34950426	0.90158318	0	0
lnwklyhour_wst	0.0901684	0	0	0.10192787	0
girl	0	-0.11493227	0	-0.1991413	0
condition	0	0	0	0	0
blacknh	0.20463876	0.3143301	0	0	0
asiannh	0.21020383	-0.20163418	0	0	0
hisp	-0.00706123	0.05620828	0	0	0
race2plus	0.15048584	0	0	0	0
raceother	0.07830695	0	0	0	0
ntypescare2	-0.24661313	-0.2382577	-0.45540967	-0.4762671	-0.49316588
k8care	0	0	0	0	-0.32716825
ntypes_x_k8	0	0	0	0	0.31511391
_cons	3.2471582	2.9787226	2.8000056	4.3135311	2.8952968

Model Estimated Parameters (cont.)

Model number	20	21	22	23
Simulation Type	Organization Drop-In/ Single Use	Family Provider	In-Home, No Prior Relationship	Individual, Paid, Prior Relationship
Model name	hours06	hours07	hours08	hours09
lnincome	0.00585364	0.07786301	0.03128232	-0.02306796
zero_income	0	1.2344327	0	-0.4039375
nchildlt6_1	-0.39306966	0.6420276	0.32670622	0
nchildlt6_2	-0.52535431	0.59423996	0.00477074	0
pov_density_high	0	0	0	0
pov_density_low	0	0	0	0
urban_density_high	0	0.41771154	0	0
urban_density_low	-0.29359477	0.12559034	0	0
midwest	0.03326779	-0.17999911	-0.31384748	-0.08865474
south	-0.04034312	0.01844346	-0.22386874	-0.16268672
west	-0.30694917	-0.19944687	-0.13978194	-0.06373567
incpov_ratio	0	0	0	0
single_parent	0.61863812	0.4828276	0	1.1967871
a12	-0.01598647	0.23844668	0	0
a13	0.05853205	-0.04798179	0	0
a14	0.14786396	0.15227042	0	0
a15	-0.29172138	0.15808486	0	0
a16	-0.54944591	-0.03023217	0	0
older	-0.12303536	-0.33088321	0	0
pworking1	-1.6783385	0	-1.6561457	-2.3841228
pworking2	-1.6920327	0	-1.6817617	-2.0515767
lnwklyhour_wst	0.51148279	0.29993615	0.39883617	0.72031532
girl	0	0	-0.29854997	0
condition	0.45270035	0	0.53612922	-0.40897049
blacknh	0.48497746	0	0	0.39729204
asiannh	0.14545144	0	0	0.52004082
hisp	0.07466451	0	0	0.09850909
race2plus	0.06956704	0	0	0.15173335
raceother	-0.2469499	0	0	0
ntypescare2	-0.48594358	-0.4067874	-0.65119866	-0.64060486
k8care	-0.27127292	-0.58452054	-1.0974806	-0.99894299
ntypes_x_k8	-0.19502437	-0.12877776	-0.06378831	0.75203724
_cons	3.0403401	0.46156243	3.1249489	2.5508761

Model Estimated Parameters (cont.)

Model number	24	25	26	27
Simulation Type	Individual, Unpaid	K-8 (in school)	Irregular	Other/Unknown Setting
Model name	hours10	hours11	hours12	hours13
lnincome	-0.02613069	0	-0.11256442	0.00725271
zero_income	-0.20147065	0	-1.8440745	0.20721331
nchildlt6_1	0	0	0	0.05684672
nchildlt6_2	0	0	0	0.22464109
pov_density_high	0	0	0	0
pov_density_low	0	0	0	0
urban_density_high	0	0	0	0
urban_density_low	0	0	0	0
midwest	0	-0.04496183	0.05499413	-0.23460131
south	0	0.0383952	-0.12087191	-0.16157055
west	0	-0.09501315	-0.27923045	-0.44439626
incpov_ratio	0	0	0	0
single_parent	0.31481244	0.05784406	0.33708014	0
a12	0	0	-0.02141588	-0.56631435
a13	0	0	0.15822617	-0.50805719
a14	0	0	0.07737448	-0.29385405
a15	0	-0.1713194	0.62886086	-0.14518067
a16	0	0	0.80210738	0.15874083
older	0.0323211	0	0.08632538	0.10243776
pworking1	-0.91576543	0	0	-0.68212645
pworking2	-1.2526722	0	0	-0.92989567
lnwklyhour_wst	0.20849603	0.01101823	0	0.11592593
girl	0	0	0	0
condition	0	0	-0.31458369	0
blacknh	0.10405208	0	0	0.22915588
asiannh	-0.01747428	0	0	0.22936666
hisp	0.00821095	0	0	0.2882556
race2plus	0	0	0	0.20040746
raceother	0	0	0	-0.17243561
ntypescare2	-0.64460877	-0.16544853	-0.217549	-1.0019711
k8care	-0.88259881	0	-1.2228019	-1.423195
ntypes_x_k8	0.54691495	0	0.32689313	0.33963298
_cons	3.6337928	3.4944404	3.1333747	3.5614097

Model Estimated Parameters (cont.)

Model number	28	29	30	31	32
Simulation Type	Head Start	Public Pre-K	ECE Center	ECE Center Drop-In/Single Use	Other Organization
Model name	pay01	pay02	pay03	pay04	pay05
lnincome	1.4390729	1.3803564	0.11402569	1.8155102	0.66148439
zero_income	0	0	0	0	8.931328
nchildlt6_1	0	0	0	0	0
nchildlt6_2	0	0	-0.41185039	0	0.5529429
pov_density_high	0	-1.9506075	0	0	0
pov_density_low	0	-0.03029627	0	0	0
urban_density_high	0	0	0	0	0
urban_density_low	0	0	0	0	0
midwest	0	0	0	-2.9100231	0
south	0	0	0	-0.2899904	0
west	0	0	0	0.30158349	0
incpov_ratio	0	0	0	0	0
single_parent	5.0537853	2.372975	0	0	0.96823493
a12	0	3.055707	0	0	-2.2727674
a13	0	1.15088	0	0	-0.71983298
a14	0	1.0241423	0	0	-1.0572904
a15	0	0.55952896	0	0	-1.4895306
a16	0	0	0	0	-2.3752253
older	0	0	0	0	-0.52257103
pworking1	1.5789206	-6.570163	-1.1928557	0	0
pworking2	4.9550546	-6.220836	-0.4713387	0	0
lnwklyhour_wst	0.3393503	2.0257428	0.61621423	-0.45471822	0.46106813
girl	0	0.66135179	-0.52603341	0	-0.36260274
condition	0	-2.3578209	-1.9911692	0	0
blacknh	0	0	-0.63759895	0	-0.74348764
asiannh	0	0	0	0	1.8350275
hisp	0	0	-0.57643055	0	-0.28904274
race2plus	0	0	0	0	0
raceother	0	0	0	0	0
ntypescare2	0	-1.9810051	-0.78476906	1.1787539	0
k8care	0	0	0	0	0
ntypes_x_k8	0	0	0	0	0
_cons	-22.78054	-17.99052	0.16207579	-18.607194	-6.5623767

Model Estimated Parameters (cont.)

Model number	33	34	35	36
Simulation Type	Organization Drop-In/Single Use	Family Provider	In-Home, No Prior Relationship	Individual, Paid, Prior Relationship
Model name	pay06	pay07	pay08	pay09
lnincome	0.80793072	0	0	0.03066556
zero_income	0	0	0	0
nchildlt6_1	0	0	0	0.43515127
nchildlt6_2	0	0	0	0.91621917
pov_density_high	0	0	0	0
pov_density_low	0	0	0	0
urban_density_high	0	0	0	0
urban_density_low	0	0	0	0
midwest	-1.2504811	0	0	-0.10563957
south	-0.64658715	0	0	-0.34901391
west	-0.73207966	0	0	-0.01651309
incpov_ratio	0	0	0	0
single_parent	1.3739338	0	0	-2.298918
a12	0.54857775	0	0	-0.15840434
a13	0.20510767	0	0	0.24236972
a14	-0.50061376	0	0	0.86078848
a15	-1.242633	0	0	0.09205959
a16	-0.85975288	0	0	0.73743276
older	-0.09901562	0	0	0.75396568
pworking1	0.5880904	0	0	0
pworking2	1.9388103	0	0	0
lnwklyhour_wst	0	0	0	0
girl	0	0	0	0
condition	0	0	0	0
blacknh	-0.60504791	0	0	0
asiannh	1.8047381	0	0	0
hisp	-0.51550696	0	0	0
race2plus	0	0	0	0
raceother	0	0	0	0
ntypescare2	0	0	0	-1.5311421
k8care	0	0	0	-0.99533489
ntypes_x_k8	0	0	0	0.17921733
_cons	-8.7575082	12	3.7467333	2.3148059

Model Estimated Parameters (cont.)

Model number	37	38	39	40	41
Simulation Type	Head Start	Public Pre-K	ECE Center	ECE Center Drop- In/Single Use	Other Organization
Model name	weekly_cost01	weekly_cost02	weekly_cost03	weekly_cost04	weekly_cost05
lnincome	0.34752847	0.38452643	0.13426716	0.48213326	0.49974309
zero_income	0	0	1.4285471	0	5.8913452
nchildlt6_1	0	0	0	0	0
nchildlt6_2	0	-0.37491495	0	0	0
pov_density_high	-0.50999327	-0.81243123	-0.05261194	0	0.28031864
pov_density_low	0.50491818	0.36399758	0.22017442	0	0.58767096
urban_density_high	0	0	0.22427988	0	0
urban_density_low	0	0	-0.34788467	0	0
midwest	-0.02900435	0.44938232	-0.3845882	-1.3100536	-0.83321773
south	-0.34227256	0.77037879	-0.3288101	-0.5282733	-0.35252799
west	-0.10498451	1.1202725	-0.16406592	-1.6373746	-0.37460187
incpov_ratio	0	0	0	0	0
single_parent	0	0.75263307	0.29037692	-0.7911125	0
a12	0	0	-0.03200422	0	0.2296715
a13	0	0	-0.27311783	0	-0.19574853
a14	0	0	-0.28584573	0	0.49510515
a15	0	0	-0.39586096	0	-1.0227269
a16	0	0	-1.1767201	0	-0.22775175
older	0	0	0	0	-0.17412201
pworking1	0	0	0.17584092	0	0
pworking2	0	0	0.67976197	0	0
lnwklyhour_wst	0	0.40881493	0	0	0.14586339
girl	0	0	0	0	0
condition	0	-1.4457864	0	0	0.44085002
blacknh	-0.32153208	0.57979773	-0.13916141	0	0
asiannh	0	0.07743564	0.34147257	0	0
hisp	-0.25498946	0.76490812	0.11693256	0	0
race2plus	0.62938819	0	0.05541181	0	0
raceother	0	0	0	0	0
ntypescare2	-1.8461708	-0.34833054	-0.17530312	-0.73572256	0
k8care	0	0	0	0	0
ntypes_x_k8	0	0	0	0	0
_cons	1.0567236	-2.4662292	2.9328526	0.66083009	-2.1833338

Model Estimated Parameters (cont.)

Model number	42	43	44	45
Simulation Type	Other Organization Drop In/Single Use	Family Provider	In-Home, No Prior Relationship	Individual, Paid, Prior Relationship
Model name	weekly_cost06	weekly_cost07	weekly_cost 08	weekly_cost09
lnincome	0.17377044	0.20052969	0.59114977	0.07602765
zero_income	0	1.4854945	0	1.0734134
nchildlt6_1	0	0	0.95459693	0
nchildlt6_2	0	0	0.34113029	0
pov_density_high	0	-0.03201367	0	-0.05644162
pov_density_low	0	0.30213317	0	0.43144944
urban_density_high	0	0.39527646	0	0.29456261
urban_density_low	0	0.14805677	0	-0.32220297
midwest	-0.92430579	-0.53707422	-0.91400145	-0.02914107
south	-0.00845411	-0.29028615	-0.49755206	-0.16439868
west	-0.29992994	-0.49755261	-0.65703415	-0.1935104
incpov_ratio	0	0	0	0
single_parent	0.9017237	0	-0.98965324	0.50558308
a12	-0.65236539	0	0	-0.32501426
a13	-0.65597969	0	0	-0.41732399
a14	-0.48467969	0	0	-0.49417743
a15	-0.963772	0	0	-0.42930859
a16	-1.200861	0	0	-0.96990958
older	-0.07044596	0	0	-0.17236155
pworking1	-1.605254	0	-3.9619842	0
pworking2	-1.0464763	0	-5.3575484	0
lnwklyhour_wst	0.34143511	0.20643043	0.80710462	0.18055091
girl	0	0	0	0
condition	0	-0.36107641	0	0.3179567
blacknh	-0.11756415	0	0	-0.16945118
asiannh	0.47224897	0	0	0
hisp	-0.07800054	0	0	0.31915004
race2plus	0	0	0	0
raceother	0	0	0	0
ntypescare2	0	0.03048854	-0.59795409	-0.05008428
k8care	0	-1.1807501	-0.67597308	0.01848904
ntypes_x_k8	0	0.03334769	0.16136107	-0.45425748
_cons	2.6908322	1.7088007	-0.04619632	2.6945296

Table 7. Model Coefficients for the Program Models

	prworking female	prworking male	annual hours female	annual hours male	wage income female	wage income male	subsidy
lths_hhm	-0.412567	-0.52395	-0.229861	-0.0909242	-0.35475	-0.230695	-0.0572313
somecol_hhm	0.442381	0.140745	-0.0355799	0.0686703	0.13763	0.178225	0.0280822
ba_hhm	0.708961	0.759785	-0.00208843	0.0853867	0.557937	0.600169	0.186742
ma_hhm	1.12987	0.788594	0.123824	0.0669202	0.828361	0.839456	0.300213
prof_hhm	1.54354	1.30796	0.238556	0.123292	1.18653	0.933338	0.313172
blacknh_hhm	0.330849	-0.220748	0.12605	-0.0811375	0.0681592	-0.437574	-0.0802073
hisp_hhm	-0.00104948	-0.180712	0.0565346	-0.0277593	-0.0747306	-0.276051	0.122596
asiannh_hhm	-0.562093	-0.165133	0.0758381	-0.1025	0.0839094	-0.205611	-0.0171982
othernh_hhm	-0.113782	-0.195425	0.1185	-0.0544304	-0.0648494	-0.243035	-0.0250359
agep_hhm	0.0781057	0.224118	0.0539821	0.0705174	0.0991583	0.135059	0
agesq	-0.00114426	-0.00294192	-0.00065823	-0.00087321	-0.00104004	-0.00149622	0
nchildlt6_1	-0.368871	-0.10033	0.0438562	-0.0422938	0.0877912	-0.0373056	1.20187
nchildlt6_2	-0.671958	0.0275425	-0.12265	-0.0140027	0.0389232	0.00230881	1.63034
spouse	-0.312284	0.727247	0.109	0.164121	0.199301	0.436745	0.435623
working_spouse	0.136953	0.179146	-0.0850417	-0.0364684	-0.0819984	-0.158123	0
_cons	-0.290588	-2.65639	6.14212	6.11614	7.78348	7.65161	7.05785

Source: Simulation output, [log 2023 09 22 1024.xlsx]

Table 8. Mean Elasticities from the Labor Supply Model

Mean Extensive Elasticity by Educational Attainment and Sex			
	Male	**Female**	**Either**
Less than HS	0.3005	0.2280	0.2475
HS	0.1111	0.6040	0.4775
Some college	0.1172	0.0935	0.0979
BA	0.0602	0.2159	0.1902
MA	0.2482	0.1271	0.1496
Prof	0.3132	0.1256	0.1753
Any	0.1600	0.2708	0.2469
Mean Extensive Elasticity by Race/Ethnicity and Sex			
	Male	**Female**	**Either**
Hispanic	0.1948	0.3061	0.2819
WhiteNH	0.1333	0.2543	0.2281
BlackNH	0.1682	0.2654	0.2395
AsianNH	0.2161	0.2781	0.2668
OtherNH	0.2020	0.2990	0.2798
Any	0.1600	0.2708	0.2469
Mean Intensive Elasticity by Educational Attainment and Sex			
	Male	**Female**	**Either**
Less than HS	0.3668	0.6069	0.5341
HS	0.3644	-0.2369	-0.0882
Some college	0.0321	0.0652	0.0592
BA	-0.0677	0.4321	0.3384
MA	0.5892	0.2823	0.3309
Prof	0.5892	0.2823	0.3590
Any	0.2225	0.1767	0.1862
Mean Intensive Elasticity by Race/Ethnicity and Sex			
	Male	**Female**	**Either**
Hispanic	0.2656	0.1457	0.1697
WhiteNH	0.2142	0.1875	0.1926
BlackNH	0.1525	0.1245	0.1318
AsianNH	0.2907	0.2577	0.2670
OtherNH	0.1981	0.1298	0.1470
Any	0.2225	0.1767	0.1862

Table 9. Threshold Add Factors (negative values increase probability)

	Threshold #	Add Factor
Pr(Care): 01 Head Start	1	0
Pr(Care): 02 Public Pre-K	2	0
Pr(Care): 03 ECE Center	3	-0.515
Pr(Care): 04 ECE Center Drop-in/Single Use	4	-0.02
Pr(Care): 05 Other Organization	5	-0.02
Pr(Care): 06 Other Org. Drop-in/Single Use	6	-0.02
Pr(Care): 07 Family Provider	7	-0.036
Pr(Care): 08 In-Home, No Prior Relationship	8	0.063
Pr(Care): 09 Individual, Paid, Prior Relationship	9	0.073
Pr(Care): 10 Individual, Unpaid	10	0.073
Pr(Care): 11 K-8	11	0
Pr(Care): 12 Irregular	12	0.073
Pr(Care): 13 Other/Unknown Setting	13	0.073
Pr(Care): 14 Parental Care or K-8 Only	14	0.067
Pr(Pay): 01 Head Start	15	0
Pr(Pay): 02 Public Pre-K	16	0
Pr(Pay): 03 ECE Center	17	-0.2
Pr(Pay): 04 ECE Center Drop-in/Single Use	18	-0.2
Pr(Pay): 05 Other Organization	19	-0.2
Pr(Pay): 06 Other Org. Drop-in/Single Use	20	-0.2
Pr(Pay): 07 Family Provider	21	-0.2
Pr(Pay): 08 In-Home, No Prior Relationship	22	0
Pr(Pay): 09 Individual, Paid, Prior Relationship	23	0

Source: Simulation output, [log 2024 05 20 0823.xlsx]

Table 10. Sources of Calibration Information

Author(s)	Year	Title	Labor Supply	Program Effects on Type of Child Care Used	Number and Types of Childcare Arrangements	Type of Study or Information
Borowsky, Brown, et al.	2022	An equilibrium model of the impact of increased public investment in early childhood education	x	x		Structural model
Berlinsky, Ferreyra, et al.	2020	Child care markets, parental labor supply, and child development	x	x		Structural model
Griffen	2019	Evaluating the effects of childcare policies on children's cognitive development and maternal labor supply	x	x		Structural model
Herbst	2023	Child care in the United States: Markets, policy, and evidence	x	x		Review of studies
Jones, Lesaux, et al.	2018	Early learning study at Harvard: Household survey full report			x	Survey
Jones, Lesaux, et al.	2020	Exploring the role of quality in a population study of early education and care			x	Survey
Landivar, Scarborough, et al.	2021	Do high childcare costs and low access to Head Start and childcare subsidies limit mothers' employment? A state-level analysis	x			Observational study
Massachusetts Department of Early Education and Care (EEC)	2023				x	Administrative data
Massachusetts Department of Elementary and Secondary Education	2023				x	Administrative data
Massachusetts Head Start Association	2023				x	Administrative data
Pilarz	2018	Childcare subsidy programs and childcare choices: Effects on the number and type of arrangements		x		Observational study
Tekin	2005	Childcare subsidy receipt, employment, and childcare choices of single mothers	x	x		Observational study
U.S. Census Bureau, American Community Survey	2021	American Community Survey, Massachusetts PUMS, 2015-19			x	Survey

Table 11. Probability of Care Add Factors

Type of Child Care	Model Name	Model #	Add factor
Head Start	pcare01	1	0.3246
Public Pre-K	pcare02	2	1.261
ECE Center	pcare03	3	0.4723
ECE Center Drop-In/Single Use	pcare04	4	0.3357
Other Organization	pcare05	5	0.3685
Other Organization Drop-In/Single Use	pcare06	6	0.3413
Family Provider	pcare07	7	0.6921
In-Home, No Prior Relationship	pcare08	8	0.1517
Individual, Paid, Prior Relationship	pcare09	9	-0.2921
Individual, Unpaid	pcare10	10	-0.3267
K-8 (in school)	pcare11	11	0.1418
Irregular	pcare12	12	0
Other/Unknown Setting	pcare13	13	0
Parental Care or K-8 (in school) Only	pcare14	14	-0.7917

Table 12. Multiplicative Factors for 3 and 4-Year Olds by Type of Care in Harvard Study

Type of Care in Harvard Study	Complement or Substitute	Combination Factor
Community center-based care only (CCC)		1.475
Head Start only (HS)		1.48906
Public school prekindergarten only (PSP)		3.66875
Family child care only (FCC)		2.101
Unlicensed care by a relative only (URC)		0.740625
Unlicensed care by a non-relative only (UNC)		1.37305
CCC, HS	Substitute	-3
CCC, PSP	Substitute	0.24375
CCC, FCC	Substitute	0.48457
CCC, URC	Complement	0.6625
CCC, UNC	Complement	1.15625
HS, PSP	Complement	0.5
HS, FCC	Substitute	0.733008
HS, URC	Substitute	0.45
HS, UNC	Substitute	1
PSP, FCC	Substitute	1
PSP, URC	Complement	2.4875
PSP, UNC	Complement	4.55
FCC, URC	Substitute	0.537891
FCC, UNC		1
URC, UNC	Substitute	0.648633
CCC, HS, PSP	Substitute	-3
CCC, HS, FCC	Substitute	-3
CCC, HS, URC	Substitute	-3
CCC, HS, UNC	Substitute	-3
CCC, PSP, FCC	Substitute	-3
CCC, PSP, URC	Substitute	0.201563
CCC, PSP, UNC	Substitute	-3
CCC, FCC, URC	Substitute	0.0799072
CCC, FCC, UNC	Substitute	-3
CCC, URC, UNC	Substitute	0.625781
HS, PSP, FCC		1
HS, PSP, URC		1
HS, PSP, UNC		1
HS, FCC, URC		1
HS, FCC, UNC		1
HS, URC, UNC		1
PSP, FCC, URC	Complement	5
PSP, FCC, UNC		1

Table 12. Multiplicative Factors for 3 and 4-Year Olds by Type of Care in Harvard Study (cont'd)

Type of Care in Harvard Study	Complement or Substitute	Combination Factor
PSP, URC, UNC	Complement	0.959375
FCC, URC, UNC	Substitute	-3
CCC, HS, PSP, FCC		1
CCC, HS, PSP, URC	Substitute	-3
CCC, HS, PSP, UNC		1
CCC, HS, FCC, URC		1
CCC, HS, FCC, UNC		1
CCC, HS, URC, UNC		1
CCC, PSP, FCC, URC	Substitute	-3
CCC, PSP, FCC, UNC		1
CCC, PSP, URC, UNC	Substitute	-3
CCC, FCC, URC, UNC		1
HS, PSP, FCC, URC		1
HS, PSP, FCC, UNC		1
HS, PSP, URC, UNC		1
HS, FCC, URC, UNC		1
PSP, FCC, URC, UNC		1
CCC, HS, PSP, FCC, URC		1
CCC, HS, PSP, FCC, UNC		1
CCC, HS, PSP, URC, UNC		1
CCC, HS, FCC, URC, UNC		1
CCC, PSP, FCC, URC, UNC		1
HS, PSP, FCC, URC, UNC		1
CCC, HS, PSP, FCC, URC, UNC		1
Unknown alone		0
Irregular alone		1
Irregular & Unknown		1
Parental care only		1

Exhibit 1.
[Exhibit 5.1] Types of Care: Non-parental and Parental Care

Type of Care	Definition	Examples
1. Individual, No prior relationship, Paid	An individual with whom the respondent had no prior personal relationship receives payment for caring for the child and cares for the child at least 5 hours weekly.	A family child care provider or a babysitter who was previously unknown to the family.
2. Individual, Prior relationship, Paid	An individual with whom the respondent had a prior personal relationship receives payment for caring for the child and cares for the child at least 5 hours weekly.	A grandparent who receives payment from the parents for the care s/he provides, or a family member who receives a child care subsidy for caring for a child.
3. Individual, **Unpaid**	An individual who does not receive payment for caring for the child, but provides care at least 5 hours weekly. The individual may or may not have a prior personal relationship with the respondent, although in almost all cases there was such a prior relationship.	A grandparent who cares for her grandchild without receiving payment, or an adult sibling who lives in the same household and looks after a younger sibling after school.
4. Center-based ECE	This type of care corresponds to the providers in the Center-Based Provider Sample. It includes all Head Starts, Public Pre-Kss, community-based child care, or any other care that is not drop-in or single activity, and occurs at least 5 hours weekly. This type of care is reserved for children under age 72 months.	Head Starts, Public Pre-Ks, or community-based child care for 5 or more hours a week and for children 5 years and under.
5. Other Organizational ECE	This type of care includes any regular organizational care not included in type of care 4 above.	After-school care to school-age children, drop-in or single-activity care or lessons, church child care during services, recreational activities, etc.
6. K-8 schooling	Not a type of ECE. Elementary schooling kindergarten through grade 8 during the school day, whether in a public or private setting. The same organization may also provide type of care 5 above outside of the school day. This type of care is reserved for children aged 60 months or above.	Public or private K-8 schools.

Type of Care	Definition	Examples
7. Irregular ECE	Provider cares for child fewer than 5 hours weekly, may otherwise meet the requirements for any of categories 1 through 5 above.	Any individual or organization that cares for child for fewer than 5 hours per week. Same examples as types of care 1 through 5, as long as they occur for 4 or less hours per week.
8. All other setting unknown	Regular ECE setting, but we have inadequate information to assign the provider to one of the categories 1-6.	Regular ECE setting that we were not able to match to types 1-6, generally due to incomplete or inconsistent information.
9. Parental Care	Used only in the child calendar to indicate time slots not assigned to a non-parental care provider.	

Source: National Survey of Early Care and Education Project Team (2021). *2019 National Survey of Early Care and Education (NSECE) User's Guide – Household*, pp. 167-8.

About the Early Education Leaders Institute

The Early Education Leaders Institute at the University of Massachusetts Boston provides the leadership development opportunities and infrastructure that early educators need to support thriving children and families. Founded in 2016, we drive systems change by cultivating effective leaders who reflect and represent their communities—through workforce and leadership development, research, and partnerships that strengthen the larger early education ecosystem. We are nationally recognized as a model of excellence, and we make high-quality early care and education a reality for more children and families while supporting the professional growth of a diverse workforce of early educators. Get involved or learn more by visiting **umb.edu/earlyedinstitute**.

About the Center for Women in Politics and Public Policy

The Center for Women in Politics and Public Policy, established in 1994, aims to promote diverse women's leadership to achieve more just, equitable, and responsive public and institutional policies and meaningful inclusion. Through its innovative educational programs, policy-relevant research, and public forums, it works to ensure that the voices, expertise, and experiences of all women are valued and included in civic discourse and the policymaking process. The center collaborates across sectors to build a prosperous economy that increases access and opportunity for all, particularly low-wage workers and women of color. All center initiatives and research utilize an anti-racist approach and explore the intersection of gender, race/ethnicity, class, and other identities on policymaking and politics. The center is part of the McCormack Graduate School of Policy and Global Studies in the College of Liberal Arts at the University of Massachusetts Boston. Visit **umb.edu/cwppp** for more information.

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