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Why Markov Process Worklife Expectancy Tables are Usually Superior to the LPE Method[1]

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Abstract *Based on surveys of members of the National Association of Forensic Economics (NAFE), the predominant method for calculating worklife expectancy involves the use of Markov process statistical work-life expectancy tables, with the LPE method as a distant second, use of a fixed retirement date as a close third, and with median or mean years to final labor force separation a distant fourth. However, no paper has specifically addressed the reasons why the majority of forensic economists (or at least a majority of those completing NAFE surveys) apparently feel that statistical worklife tables compiled by standard Markov process models are superior to calculations based on the LPE version of Markov process models. A statement arguing that the LPE method is superior to standard statistical worklife expectancy tables has been published by Michael Brookshire and George Barrett (2009). This paper evaluates the claims made by Brookshire and Barrett, and explains why standard versions of Markov Process tables will usually be more accurate than the LPE version of the Markov process model when used in developing estimates of work-life expectancy for specific individuals.*

I. Introduction

Forensic economists use a variety of methods when projecting the period of time over which earnings losses resulting from personal injuries or wrongful deaths would have occurred. Those methods include use of statistical worklife expectancy tables, tables showing median or mean years to final labor force separation, the LPE method[2], assuming losses would continue until some fixed retirement date, or a combination of these methods. There are variations within each of these approaches, but the existing literature has been directed primarily to two approaches. The first approach involves using statistical worklife expectancy developed by use of standard versions of Markov process models, and the second approach

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involves use of the LPE version of the Markov process models. In a short section that has been published in the last few editions of *Determining Economic Damages* by Gerald D. Martin, Michael Brookshire and George Barrett (2009) argue that the LPE method for dealing with worklife expectancy is superior to method using Markov process models. Following Skoog and Ciecka (2004), this paper will argue that the LPE model is a version of the Markov process model, but a not very good version. The paper will then respond to the arguments made by Brookshire and Barrett, and explain why methods using Markov process tables are *usually* superior to LPE methods. This paper will nevertheless argue that there are unique instances when an LPE version of the Markov model may be superior to reliance on standard Markov process tables, but that such circumstances are rare.

In order to value loss of earnings, the number of years over which that loss of earnings will take place must somehow be measured. Some economists argue that an earnings loss damages calculation should be based on the number of years a worker *could* have worked and not the number of years a worker *would* have been expected to work, and therefore do not use work-life expectancy in measuring lost earnings. The key problem in this discussion is that while we have historical measures of how long workers *have* worked, we have no corresponding measures of how long those workers *could have* worked. While this short-circuits an extended discussion, there are no reliable measures of the length of the work-lives that workers could have worked. As a result, most forensic economists use measures based on historical records that provide insight into how long workers are likely to work, and not insight into how long they could work to the extent that there is any difference. A minority of forensic economists uses methods that assume workers could have worked to fixed retirement dates or to dates based on either mean or median ages of final labor force separation by either death or final retirement.

Over the years, a number of surveys have been conducted of members of the National Association of Forensic Economics (NAFE) asking questions about the methods used by forensic economists (Brookshire, Luthy and Slesnick 2009). While these surveys are not true scientific surveys, they provide the limited information that is available about the current practices of forensic economists. That information is provided in Table 1 of this paper for the years 1997, 2006, and 2009. By an increasingly overwhelming margin, the preferred approach is use of statistical tables compiled by Markov process methods. As of the most recent survey, 61.6 percent of respondents use statistical tables compiled by Markov process methods. The LPE method is a distant second with 8.1 percent, with 7.0 percent using fixed retirement dates , and another 2.9 percent using either median or mean years to final separation methods. An additional 20.3% use some combination of these methods.

Table 1 – Methods Used to Deal With Worklife Expectancy in NAFE Surveys[3]

	1997	2006	2009
Statistical Markov Process Tables	45.0%	54.5%	61.6%
Mean or median years to final labor force separation	6.7%	4.5%	2.9%
LPE method	9.6%	10.9%	8.1%
Fixed Retirement Date or Age	8.4%	9.0%	7.0%
Combination of Methods	25.3%	21.2%	20.3%

Mean or median years to final separation methods are based on determining the number of years until final separation without regard to whether a worker would actually be expected to work all years to that age. Fixed date of retirement methods assume that there is some age at which retirement would ordinarily occur, often at a person's "full" Social Security retirement age or at age 70. Again this is without regard to whether a worker would actually be expected to work all of the years to that age. To that extent, those methods are based on a notion that the period of earning capacity over which an individual could have worked is longer than the period over which and individual would have been likely to work. Both standard Markov process statistical worklife expectancy tables and the LPE version of the Markov process model (henceforth "LPE method") are efforts to measure earning capacity as equivalent to expected earnings based on historical records. Each of those methods will be explained in turn in the next two sections of the paper, starting with the LPE method. The final section of the paper will deal with claims made by Brookshire and Barrett (2009) about the alleged superiority of the LPE method.

II. The LPE Method

The LPE method was first mentioned with that name in a 1983 paper by Brookshire and Cobb. This same method was explained, but without the name "LPE", by Baker and Seck in 1987, and with that name by Brookshire in 1987. The "L" in LPE stands for the probability that an average individual in a particular demographic category will be alive during any given year in the future. "P" stands for the probability, given that the individual is alive, that an average individual within in a particular demographic category will be a participant in the labor market during any given year in the future. "E" stands for the probability that an average individual within a demographic category who is both alive and a labor market participant will be employed in the labor market during any given year in the future.[4] When multiplied together the probabilities for the three factors determine the conditional probability that an average individual in a given demographic category will be alive, a participant in the labor market (defined as either having employment or actively seeking employment), and employed in the labor market. This joint probability is often referred to as "worklife probability."

Data required to prepare an LPE analysis start with the age of an individual who has either been injured or killed. An expert must then consult a life table for the purposes of calculating the appropriate "L" values. Life tables are structured to show the number of persons remaining alive at each age out of 100,000 persons born in the same year. For example, at age 55 there were 89,089 males still alive out of 100,000 males born 55 years earlier. That figure becomes a baseline for future survival probabilities. At age 56, the number of males remaining alive drops to 88,381. Thus the average probability that a 55 year old male would have survived to age 56 is 88,381 out of 89,089 possibilities, or 0.9921, or 99.21%. At age 57, the number remaining alive drops to 87,633, so that the probability that an individual who was alive at age 55 would still be alive at age 57 is 87,633 out of 89,089 possibilities, or 0.9837, or 98.37%. From year to year, the number of males remaining alive continues to decrease, but the probability remains based on 89,089, the number of males surviving to age 55 out of the original 100,000. By age 95, for example, the probability is equal to 5,808 divided by 89,089, or 0.065, or 6.5%. Even at age 100, 1,261 remain alive, which is 1,261 out of 89,089 possibilities, or 0.0142, or 1.42%.

An expert must then come up with data for "P" (participation rates) and "E" (employment rates). Brookshire and Barrett (2009) provide 2008 data in the form of unpublished Table 10 that is available from the U.S. Census Bureau, but these data are not available to someone searching for them on the web. The data in this table are also subject to significant problems. The P and E values in the unpublished Table 10 have only single percentages for all persons over the age of 65. As a result, using this table would force a researcher to assume that the P and E rates for persons in the age range from 95 to 100 are the same as for persons between the ages of 65 and 70. To get age breakdowns into smaller age cohorts between the ages of 65 and 100, one must go into the microdata to break out those rates. If this is not done, using 2008 data, a worker at age 95 who is still alive has a probability of 26.9% of being a participant in the labor market and a 96.7% chance of being employed.[5] For examples of how the three probabilities are combined, see Brookshire and Cobb (1984), Brookshire (1987) or Baker and Seck (1987).

III. Markov Process Statistical Worklife Expectancy Tables

The standard application of Markov process models in calculating work-life expectancy began in 1982 with the publication of Bulletins 2135 and 2157 by the Bureau of Labor Statistics (BLS). Prior to 1982, the BLS used what has sometimes been called "the original model." Some tables using the original model are still being produced by Richards and Donaldson (2009), but based on NAFE surveys those tables are not generally used. Other tables included in Richards and Donaldson (2009) are based on the standard Markov process model. The essential innovation in Markov process (increment-decrement) models is the use of transitional probabilities based, in most instances, on year-to-year transitions between the "active" state and the "inactive" state in the labor market. (See Foster and Skoog (2005) for a more technical introduction to assumptions made in a Markov model.)

In both the original model and a standard Markov model, an individual is defined as "active" if he is either employed or actively seeking employment. An individual is defined as "inactive" if he is not employed and not actively seeking employment. However, this differentiation is limited to the point at which data are being collected. As compared with an LPE model, making this distinction divides larger populations into "active" and "inactive" populations and produces data for each of these smaller populations. Not surprisingly, worklife expectancies for "active" populations are greater than for corresponding "inactive" populations. The difference between the original version of this model and the standard Markov process version is that "transition probabilities" are developed to take into account that individuals may go back and forth between the "active" and "inactive" states. Compiling standard Markov process tables involves calculating rates of transitions back and forth between the two states, and calculating estimated worklife expectancies on the basis of those calculated transition rates. Most explanations provided in published Markov process worklife expectancy tables contain extensive mathematical specifications for how this is done, but the essence is fairly simple. A worker who is "active" in time period 0 has some chance of transitioning to the "inactive" state in time period 1 and then transitioning back to "active" in time period 2. The probabilities of transitions between states are estimated from the survey data and then applied in calculations of expected worklife. Since (P) in an LPE model does not take into account whether a person was "active" or "inactive" last year, this is not done in the LPE approach.

Most existing Markov Process tables that are being used by forensic economists rely on a "two state, first order" process. Technically, a Markov process model is a first order model in that it only looks back one year. However, multiple periods can at least be envisioned and will be referred to as second order models, third order models, and so forth. A two state model means that transitions between the active and inactive states are incorporated into the measurement of worklife expectancy. First order means that the model only looks back one year to distinguish between states. One of the existing sets of published tables defines “non participation” to include unemployed individuals who are actively seeking work (Millimet et al. 2003), while other tables define the “active” state to include both persons who are employed or actively seeking employment. All of the models currently being employed are “first order” models in that they look back only one year in measuring transitions.

While a “second” order model only goes back two years, the process exponentially increases the number of transitions to be measured as follows: A transition rate between active and inactive statuses this year for persons who were “active” during both of the last two years; a transition rate for persons who were active last year but inactive the year before; a transition rate for persons who were inactive last year, but active the year before; and a transition rate for persons who were inactive in each of the past two years. In such a model, there are eight transition rates, of which four are independent. A “third order” model goes back three years and requires 16 transition rates, of which 8 rates are independent. To capture differences based on a ten year time horizon, a two state model would require measuring 1,024 (2 to the 10^{th} power) independent transition rates and would certainly run into the problem that data would provide insufficient sample sizes for reliable estimates for most of those transition rates. A three state model would require 118,098 independent transition rates unless it was argued that the transition rates for participation and employment (from each initial state) affected each other (as they very likely do), in which case the number would vastly increase.

Since only first order worklife expectancy tables have been compiled, economic experts are limited to first order models The following Markov process worklife expectancy studies are currently available and in use, all of which provide worklife expectancies by age, education, and sex:

(1) Bureau of Labor Statistics, Bulletin 2254, published February 1986 and based on 1979-80 data. This is a two state, first order study.

(2) Millimet et al., *Journal of Econometrics*, published 2003 and based on pooled data from 1992 to 2000. This paper presents two-state and three-state first order models. In the three-state model, the authors do not count the time spent in the inactive and unemployed

states as adding to the cumulative total of worklife years.

(3) Ciecka, Donley and Goldman, *Journal of Legal Economics*, published 1999-00 and based on 1997-98 data. This is a two state, first order study.

(4) Ciecka, Donley and Goldman, *Journal of Legal Economics*, published 2000-01 and based on 1997-98 data with more educational categories. This is a two state, first order study.

(5) Skoog and Ciecka, *Journal of Legal Economics*, published 2001 and based on 1997-98 data with detailed educational categories and greater detail about statistical variation. This is a two state, first order study.

(6) Skoog and Ciecka, *Journal of Forensic Economics,* published 2004 and based on 1997-98 data with explanation for how various types of studies relate to each other.

(7) Krueger, *Journal of Forensic Economics*, published 2004 and based on pooled data from 1998 to 2004. This is a two state, first order study.

(8) Krueger, Skoog and Ciecka, published 2006 and based on pooled data from 1998 to 2004. This is a three state Markov model with worklife expectancies for full-time employed, part-time employed and inactive males and females by education.

For male worklife expectancies, there is surprisingly little difference among the studies. Millimet et al. shows somewhat smaller worklife expectancies, as should be expected, because the study includes reduction for unemployment. For female worklife expectancies, however, the 1986 BLS study shows significantly lower worklife expectancies than any of the more recent studies, all of which contain data that is significantly more recent than the BLS study. This is also as expected given the growth in female labor force attachment between 1979-80 and 1997-98. Because much of the difference between male and female worklife expectancy can be explained by the greater role of females in stay-at-home child care and elder care, some forensic economists use male worklife expectancies for females when females have shown consistent labor force attachment.

IV. Why the LPE Approach is a Version of the Markov Model

One of the arguments being made in this paper is that the LPE approach is not in stark contrast with the standard Markov process model used by the majority of forensic economists in the NAFE surveys, but is instead a specific version of Markov process model. Both standard Markov models and the LPE version of that model use the same approach with respect to "L" in the LPE model. There is no difference in how "L" is treated between the two versions of the model. The reason for this is that transitions go only in one direction, from being alive to being dead. The PE portion of the model uses an implicit definition of "inactive" that matches the version of the Markov process model used by Millimet et al (2003) as "non earning either because of non participation or because of unemployment." Thus, in effect, the two states in the LPE method are not "active" and "inactive" as in most standard Markov models, but "earning" and "non earning" measured by PE and one version of the Millimet et al. (2003) version of the Markov model. The question is about how transitions between those states are being measured. In effect, the transition rate in the LPE version of the model is implicitly defined as equal to the average PE rate for the whole population being considered. In other words, in each year the probability of being in the "earning" versus "non earning" states is average for the whole population at the age the individual reaches in that year without regard to what might have been true in the previous year. Thus, the LPE model assumes that the labor force state (earning versus non-earning) at the time of an injury has no effect on the model's assumption about the earnings of that individual in the future.

V. Consideration of Arguments by Brookshire and Barrett in Favor of the LPE Method

Brookshire and Barrett (2009) argue that LPE methods are superior to standard Markov Process models for purposes of measuring earnings loss in most circumstances for two reasons. (They argue that standard Markov process tables are superior for individuals aged 50 or older, for a reason to be discussed below.) Their first reason is that LPE tables include unemployment as a factor influencing lost earnings. Their second reason is that data upon which an LPE analysis is made can be more current than data required for a study that relies upon a statistical worklife expectancy table. The second reason is clearly true. As of today, an LPE study would be based on the current 2004 U.S. Life Tables and could be based on information that included participation and employment information from 2008. The most current Markov Process tables would be found in the Krueger (2004) study, which includes pooled data from 1998 through 2004.

The first reason Brookshire and Barrett offer is, however, incorrect. It is actually an advantage of using statistical worklife expectancy tables that unemployment is not factored into the analysis rather than a disadvantage. With an LPE approach, an analysis must be based on the average unemployment rate for a given age and demographic category. For example, if an expert was using unpublished Table 10 to determine the employment rate for a male high school graduate (no college) at age 45, the expert would find an employment rate of 94.9%, implying an unemployment rate of 5.1%. However, not all male high school graduates with no college are equally vulnerable to unemployment. The expert might know, for example, that the injured man had not experienced unemployment at any time during the past ten years and would not be likely to face unemployment at any time in the near future. If so, using the average unemployment rate for this individual would exaggerate the probable impact of unemployment on his earnings loss. Further, the LPE method would have us multiply the LPE probability by the person's wages. However, the impact of unemployment is already embedded in the person's annual earnings history that was used to forecast future income losses. For this to be done accurately, one would have to determine the individual's past earnings on the basis of what those earnings would have been if the individual had never been unemployed. If that is not done, the impact of unemployment will be counted twice.

The opposite would be true for a worker in a seasonal industry who was regularly unemployed 20% of each year. Using a 5.1% unemployment rate for that individual would significantly underestimate the impact of unemployment on that individual's earnings. If the expert used a Markov process worklife expectancy table, the expected earnings of the first individual could be assessed based on the assumption of 0% unemployment, while the expected earnings of the second individual could be assessed based on the assumption of 20% unemployment. To be sure, if unemployment was not separately considered, a model that took unemployment into account would be superior to a model that did not take unemployment into account. However, nothing prevents an expert from separately considering the impact of unemployment when using a statistical worklife expectancy table. Because use of the standard Markov process statistical worklife expectancy table allows an expert to make unemployment assumptions appropriate to the experience of a worker, it is a more flexible instrument than a model that forces an expert to use an average unemployment rate for an individual whose employment record is not equal to that average. For this reason, what initially appears to be an advantage is, in reality, a disadvantage.

Brookshire and Barrett (2009) further state that:

> We clearly feel that the LPE technique is superior to other methods for reasons already discussed. This is not true, however, in cases of persons age 50 or older. Here, an increment-decrement-type approach should be added to the worklife analysis. Such tables make a worklife prediction contingent on whether a 56-year old, for example, was participating at the date of injury or death. They are generally superior to LPE tables for this reason alone, unless LPE tables are somehow adjusted.

There is no good reason why this statement applies to persons older than 50, but not persons younger than 50. No explanation is provided for why the age of a person being 50 or greater makes the advantage of considering if a worker was active or inactive at the time of injury or death override the advantages that the data in an LPE method is more current and the authors' incorrectly assumed advantage that an LPE method allows consideration of unemployment. In almost all instances, use of a Markov process worklife expectancy table is superior to use of an LPE approach for exactly the reason stated by Brookshire and Barrett for persons over the age of 50.

VI. Why Standard Markov Process Worklife Tables are *Usually* Superior to LPE Approaches

The ability to consider whether or not an individual was active or inactive usually provides more information than is lost with a Markov process table that is based on data that is older than the data used in an LPE approach. The data that can be used with an LPE approach is more current than data that is used in standard Markov models, but current data can be misleading if used without averaging over a past period to capture different stages of the business cycle. Markov process worklife expectancy tables provide a more flexible way to consider worklife expectancy issues and usually incorporate more information in a way that usually allows for a more reliable projection of lost earnings. Throughout this paper, the term "usually" has been used to describe the difference. That is because there are circumstances in which use of a Markov process model would result in an outcome that is less reliable than use of the LPE method. Understanding what creates the exception to the general superiority of the

Markov process approach also illustrates why the Markov process approach is generally superior.

The information that is added by a Markov process model compared to an LPE approach is information about whether a worker was active or inactive at the time of injury or death. Studies have shown that there is a significant difference between the average expected worklives of those who were active compared with those who were inactive. However, knowing only that a worker was active or inactive at the moment of injury or death can be misleading. Suppose, for example, that a worker had been inactive in the labor market for the past ten years, but recently returned to the labor market and was employed at the time of his injury. In a first order Markov process model (without expert adjustment), that worker would have the same worklife expectancy as a worker who had been active and fully employed in the labor market for the past ten years. While it is true, on average, that workers who were active in the labor market at the time of injury or death have longer expected worklives than persons who were inactive in the labor market at the time of injury or death, that trend may not be the case for a specific individual. The worker who was out of the labor market for the past ten years, but active at the moment of injury should probably be treated as an inactive worker rather than an active worker. Treating that worker as an active worker would probably exaggerate that worker's loss of earnings. In an LPE model, all workers are treated as equally likely to be active or inactive at the moment of injury or death. Thus, it would probably be more accurate to use the LPE model with that individual than to use a Markov process model without adjustment.

An economic expert, however, is always wise to gather as much information about the plaintiff or decedent's work record as possible. An economic expert who knows that an individual had been inactive for the past ten years, but had become active just before his injury or death could adjust his calculations to take that fact into account. The expert could point out that the person was active at the time of injury or death, but that the ten year hiatus in labor market involvement may have made the worker more like an inactive worker than an active worker. The expert could provide the jury with calculations based on both inactive and active worklife expectancies, and let the jury make its own decision about which assumption was more reasonable. With such an adjustment, the expert's testimony would be more complete if the expert provided calculations based on a Markov process worklife expectancy table than with an LPE approach. In the final analysis, the accuracy and reasonableness of testimony depends more on how methods are used than features inherent to the method.

The most important advantage of using Markov process tables for dealing with worklife expectancy lies in the flexibility of that method. Tables do not exist that would allow an expert to find different worklife expectancies for workers based on how many of the past ten years the worker was active or inactive in the labor market, or in what order the years fell. (A worker who was inactive in the labor market for the first five of the ten years, but then consistently active thereafter would probably have a different worklife expectancy from a worker who was active every other year for the same ten year period.) Ultimately, worklife expectancy is an average and should be presented to a jury as an average. A statement indicating that an average means (approximately) that half of all workers would have more years of worklife than the average and half of all workers would have fewer years than that average should be included in all reports of experts using Markov process statistical worklife expectancy tables.

This author typically adds three years to worklife expectancy when using Markov process models. In other words, if a worker has a worklife expectancy of 15 years, tables would provide loss figures for up to at least 18 years. Emphasis is put on 15 years as the average for a person of the same age and sex and with the same education as the injured person or decedent, but the point that no individual is an average is emphasized so that a jury understands how to add or subtract years based on that average in either direction. With an LPE approach, a projection is typically made to at least age 75, with various annual probabilities being shown in earnings loss tables. Such calculations do not take into account whether or not a worker was active at the moment of injury or death, or whether the worker was employed or not. The calculations are based on average Participation and Employment rates for all persons in the demographic category. LPE earnings loss tables are complex, hard for a jury to follow, and very hard for a jury to adjust in light of information that a jury has heard about the Plaintiff's or decedent's work activity prior to the incident at litigation. In addition, truncating an LPE calculation at age 75 or some other age short of 100, adds an undetermined amount of inaccuracy to a calculation.

Endnotes

1. Portions of this paper were previously published in the author's paper, "Markov Process Work-Life Expectancy Tables, the LPE Method for measuring Worklife Expectancy, and Why the Gamboa-Gibson Worklife Expectancy Tables are Without Merit," *The Rehabilitation Professional*, 2009, 17(3):111-126. The author thanks Timothy Field, editor of *The Rehabilitation Professional* for permission to include those portions in the current paper. The author also thanks James Ciecka, Gerald Martin, Michael Nieswiadomy, and Gary Skoog for suggestions about improving the text of this paper.

2. "L," "P" and "E" stand for "Life, Participation, and Employment." Thus the acronym "LPE" in the "LPE method" stands for the fact that the probability that a living adult at each age will have an average probability of remaining alive based on a standard life table, an average probability of being a participant in the labor market if alive, and an average probability of being employed in the labor market if alive and a participant in the labor market.

3. This table is taken from Brookshire, Luthy and Slesnick (2009). The first category, labeled "Statistical Markov Process Tables", is the sum of categories (a) "BLS Tables" at 5.8% in 2009 and (b) "tables published in economics journals" in the discussion of Question 31 of the 2009 survey. Early BLS tables were not Markov process tables, but tables in the last BLS Bulletins to provide work-life expectancy tables were Markov process tables. To prepare this table, I have made the assumption that persons selecting Markov process tables utilized tables in Bulletins 2235 or 2254, which were Markov process tables. Similarly, I have assumed that "tables as published in economics journals" were Markov process tables even though a few "mean or median years to final separation" tables have also been published in economics journals. Since option (c) in the survey was "median or mean years to final labor force separation" I assumed that persons using those tables as their primary method would have chosen (c), not "tables published in economics journals." This table was previously published in Ireland (2009).

4. Technically, this is not true. The use of an unemployment rate to reduce the earnings for a given year by, say, 3%, implies that there is a 3% chance that an individual will be unemployed for that whole year, not that the individual will be unemployed for 3% of that year. The LPE method assumes that a 3% chance of unemployment for a whole year is equivalent to assuming that an individual will be unemployed for 3% of the year. The

same is true of participation rates.

5. BLS's "Table 10, Employment status of the civilian noninstitutional population by educational attainment, age, sex, and Hispanic or Latino and Non-Hispanic Ethnicity," which is an unpublished table. PDFs of all the tables can be downloaded at http://www.valueeconomics.com/data.html. That site also provides an Excel spreadsheet that contains the population, labor force and employment data needed to calculate both the P and E in LPE. The 2008 version of the BLS unpublished Table 10 is also available in Martin (2009), pages 12-50 and 12-51. Sometimes, LPE tables include more refined information by age that can only be found in microdata available through the BLS.

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