May 20, 2002

STATE DISABILITY ADJUSTED LIFE EXPECTANCY: USING CENSUS DISABILITY DATA

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Abstract

Summary measures of population health usually combine one measure of length of life and one measure of health-related quality of life. We used the disability questions from the 1990 Census to create two estimates of Disability Adjusted Life Expectancy for the 50 United States for both males and females, at birth and at age 65. Variations in these measures across the States are presented. Advantages and disadvantages of using such secondary data for this purpose are discussed.

Key Words: Life Expectancy, Disability, Census, Summary Measures, DALE Population Health

Introduction: As more attention is focused on the performance of health systems domestically and globally, the potential for summary measures of health outcomes that can sit astride a family of measures has likewise increased. The concept of "Health Adjusted Life Expectancy" was first used in 1964 (Hillery and Saunders, 1968), but the first proposed method of calculation came later (Sullivan, 1971). A small number of researchers have continued to develop these methods (Robine and Ritchie, 1991, Robine, 1993), and occasional empiric work has utilized a summary measure as an outcome or a dependent variable (Katz et al., 1983, Valkonen and Sihvonen, 1997). From a policy perspective, the Years of Healthy Life measure was featured in the Healthy People 2000 document (USDHHS, 1991) and recently the WHO utilized Disability Adjusted Life Years in its controversial 2000 report (WHO, 2000). In 1997, the Institute of Medicine convened a panel to discuss the development and application of summary measures for population metrics (IOM, 1998), and concluded among other things that the USDHHS should "create a process to establish standards for population health metrics and assess the feasibility and practicality of a compatible set of health status measures that could be used for different descriptive and decision making purposes. With rare exceptions, little has been done since that time to move this research and policy agenda forward (Gold et al., 2002).

Among the many challenges that summary measures present is the nature of the data, which can be used for the health related quality of life (HRQoL) nonmortality component of the measure. In the YHL measure mentioned above, the matrix of self reported health status and activity levels depends on data from two national surveys that have a limited sample size(Erickson et al., 1995). The disability rates used in the WHO DALY calculations rely on subjective and expert assessment due to the data limitations in many nations. Primary data collection using instruments like the EuroQuol (Kind et al., 1994) would be more valid but are expensive to administer on a large population basis.

In order to avoid some of these limitations, in this study we utilized data available on disability status in the 1990 US census to estimate Disability Adjusted Life Expectancy for the 50 United States and the District of Columbia for 1989-91. We present these summary measures of state population health for two of several possible levels derived from census reported disability levels. We believe such estimates are one efficient way of measuring and comparing state health outcomes beyond mortality measures alone. When 2000 census data become available, this method should provide one way to measure trends in health outcome improvement across the states.

Methods: We calculated state life tables using the U.S. population distribution by age and sex as estimated by the 1990 census on one hand, and the three-year average of the deaths recorded for the three years 1989, 1990, and 1991 in Vital Statistics. We extracted the population data from the 5% Public Use Microdata Sample (PUMS 5%). We re-weighted the counts of population to get the complete count for each life table calculated, and recoded the variables of interest to match the standard life tables. Age was recoded from 0 to 90 years and over, as 0

years, 1 to 4 years, and in five-year intervals for age 5 to 90 years. The death statistics included an unknown age group. Although this unknown group was not large to have a significant impact on the end-result, we distributed them proportionally to the weight of each age group.

Misclassification of deaths by states is the most serious possible source of bias in the life tables at hand. The vital statistics data provide information about both the deceased state of residence and the deceased state of death. In order to gauge this source of bias, we calculated two sets of life tables. Comparison of the results showed a difference toward underestimation of life expectancy in some states, especially the District of Columbia. On the basis of this evaluation, we retained the set of life tables calculated using the state of residence tabulation as the baseline for the estimation of the Disability Adjusted Life Years. We calculated death rates by dividing the three-year average (1989-1991) deaths obtained from the vital statistics data for each age group of the conventional abridged life table. We then calculated the rest of the functions of the life table to get life expectancy at each age in the life table.

We used the Sullivan Method to adjust the conventional life table for disability. This method consists of applying disability rates calculated from cross sectional data to the person-years of the conventional life table. This calculation results into new estimates of the person-years lived in disability, and the complement of the later, the person-years lived free of disability. The calculation is then carried on to obtain Disability Life Years (DLY) and Disability Adjusted Life Years (DALY). We calculated “disability rates” using the Public Use Microdata Sample of the U.S. census 1990 that is exactly the same source of data we used for the life tables. We first tabulated the population by sex, life table age, and type of disability, which provided the numerators of the disability “rates”. The count of persons with disability divided by the total persons in the same class of age and sex resulted in the rate of disability used for adjusting.

The PUMS 1990 data provide data on disability in response to four questions. Two questions relate to daily living disability which includes limitations of mobility and personal care while two other address work-related disability in terms of whether the respondent had a condition that limited the nature and amount of work they could do or whether they had a conditions that prevented them from work entirely.

These four questions can be combined to create a number of levels of graded disability. We will elsewhere on the ways that these can be combined, and the issues that arise in comparing 1990 disability to that which will be available in the 2000 census, which had slightly different questions. For the purpose of this paper, we report data from only two disability categories, the most basic and the most severe. For the most basic (DALE1), the disability rate captures all persons who responded "yes" to any of the previous four questions. In other words, the DALE1 indicates the number of years a person will live, in average, with any type of disability if they are to live their whole life in the conditions of 1989-1991. Similarly, the most severe DALE2 represents those persons who answered yes to all 4 questions.

While the death rates are incidence rates, these disability rates are prevalence rates that merely measure the proportion of the population having a specific health condition. The U.S. Census 1990 provides disability data only for persons aged sixteen years and over for obvious reasons. Our disability rates start at fifteen years instead. We obtained this stretch of the data by doing a separate tabulation of the age group 16 to 19 years that provided us with four-year age group rates of disability. We applied this four-year age group disability rate to five-year person years of the life table to obtain disability, and disability free person-years for this age group.

TABLE 1

1990 LIFE EXPECTANCY AND TWO MEASURES OF DISABILITY ADJUSTED LIFE EXPECTANCY FOR MALES AND FEMALES AT BIRTH AND AT AGE 65

			Male- 0		Female - 0	(female-male)		Male- 65		Female – 65	(female - male)
LE	**National LE**		71.75		78.62	6.87		15.10		19.03	3.93
	High	HI	75.37	HI	81.36	5.99	HI	17.62	HI	21.01	3.39
	Low	MS	68.62	LA	76.67	8.05	WV	13.90	NV	17.64	3.74
	(high - low)		6.75		4.69			3.72		3.37	
DALE1	**National DALE**		70.16		75.88	5.72		13.78		16.35	2.57
	High	HI	73.75	HI	78.48	4.73	HI	15.98	HI	18.02	2.04
	Low	MS	66.79	LA	73.42	6.63	MS	12.29	LA	14.98	2.69
	(high - low)		6.96		5.06			3.69		3.04	
DALE2	**National DALE**		61.38		66.19	4.81		8.96		10.61	1.65
	High	HI	65.59	CT	69.81	4.22	HI	11.13	AZ	13.94	2.81
	Low	MS	56.00	MS	61.12	5.12	MS	6.20	MS	8.04	1.84
	(high - low)		9.59		8.69			4.93		5.90	

Results: Table 1 displays the summary results for 1990 life expectancy and two measures of Disability Adjusted Life Expectancy for males and females at birth and at age 65: The national mean life expectancy at birth for males is 71.75 and for females is 78.62, a difference of 6.87 years. The range across the 50 states is from 68.62 in Mississippi to 75.37 in Hawaii (a difference of 6.75 years); for females the range is from 76.67 in Louisiana to 81.36 in Hawaii (a difference of 4.69 years). For life expectancy at age 65 the national mean is 15.10 for males and 19.03 for females, a difference of 3.93 years. The range is from 13.90 in West Virginia to 17.62 in Hawaii for males (3.72 difference) and from 17.64 in Nevada to 21.01 in Hawaii for females (3.37 difference).

Similar ranges are shown for the two DALE measures, with the expected lower levels reflecting the DALE "discounting" of life expectancy. The national mean DALE1 at birth is 70.16 for males and 75.88 for females, a difference of 5.72; at age 65, from 13.78 for males and 16.35 for females, a difference of 2.57. The ranges across the states in DALE1 are not substantially different than for life expectancy alone.

The DALE2 measure shows much lower absolute levels reflecting the mild nature of this disability estimation. The national mean for males is 61.38 and for females is 66.19, a discounting of almost 10 years for both genders. For DALE2 at age 65, the national mean for males is 8.96 and for females 10.61, reflecting less of a discounting for males (6.14) than females (8.42) from life expectancy alone. The magnitude of differences across the states from low to high are much higher than for life expectancy alone as well as for the DALE2 measure.

Figures 1 and 2 display the relationships between life expectancy and the two DALE measures for the 50 Figures 1 and 2 display the relationships between life expectancy and the two DALE measures for the 50 states.

The expected positive relationships are seen, with DALE1 being almost linear except for females at age 65 and all DALE2 groups showing the greater dispersion indicated above. One of the most important objectives of the research was to see how much more variance there is in a DALE measure as compared to LE alone. This is the case, most obviously for the less severe DALE2 measure. For example, there are 12 states with female life expectancy at age 65 from 19.0 to 19.5 (a range of 0.5), which have a range in DALE2 levels from 9.59 to 12.92 years (a range of 3.3 DALE years). For males at birth, there are 10 states with LE in the range of 70-71 which have a range in DALE2 of 57.17 to 62.27 (a range of 5.10 DALE2s). There is less dispersion in DALE1 because this is a rare condition, which translates into only a small discount of life expectancy.

FIGURE 1: Relationship between Life Expectancy at Birth and Disability Adjusted Life Expectancy at Birth in 1990 for the 50 United States (Distric of Columbia excluded)

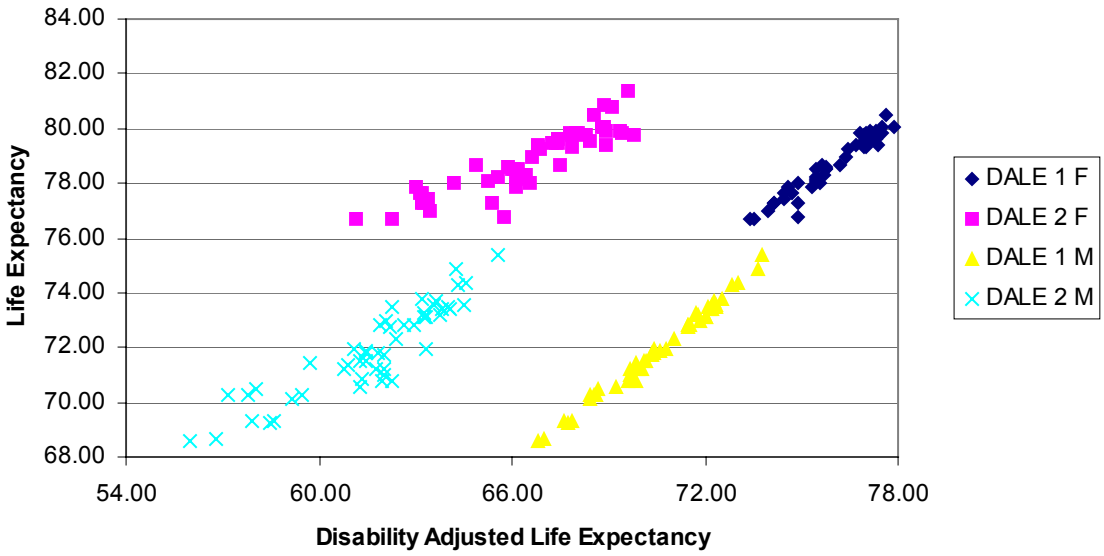
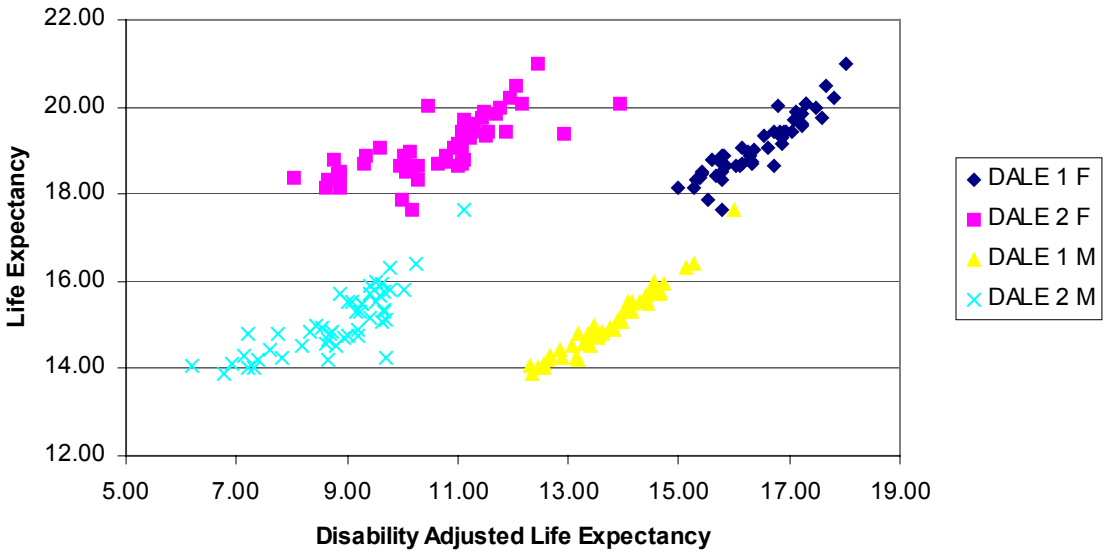


FIGURE 2: Relationship between Life Expectancy at Age 65 and Disability Adjusted Life Expectancy at Age 65 in 1990 for the 50 United States (Distric of Columbia excluded)



Discussion: These results show that data from the 1990 census can be used to create Disability Adjusted Life Years for the 50 United States and D.C. They should be useful as one summary measure of population health outcomes to compare States as well as to track change over time, such as from 1990-2000 when that data becomes available. A primary advantage is that it is a reliable nonmortality measure easily available from a secondary source, and does not require new primary data collection such as are required for other health related quality of life modifiers of life expectancy.

The DALE1 measure is one reflection of the total disability burden on life expectancy for the nation and its states, since this includes anyone who answered positively to all of the four Census questions. Nationally, 4,518,614 persons or 1.82% of the adult population aged 16 years and over were in this category, and therefore it is a fairly small percentage which produces the reductions from life expectancy 2.2% for males and 3.5% for females at birth, 8.7% for males and 14% for females at age 65. The range across the states is fairly similar to life expectancy, and therefore does not provide much additional new information on relative state health outcome performance.

The DALE2 measure is different since it is calculated based on those individuals who responded positively to any of the four disability questions. Nationally, 29,868,521 persons were in this category, or 12% of the adult population aged 16 years and over. It is this mild disability that shows more variance from life expectancy and across the states, and these differences require more analysis to understand their meaning and their socioeconomic or medical care determinants. Further work is needed to determine the relative contribution to DALE1 scores of all of the combinations of individuals represented by their responses to the four questions.

One hypothesis of the study was that there would be a greater range in DALEs across states than life expectancy, i.e. that life expectancy and disability would not be perfectly correlated. As has been seen, this does not appear to be the case for the DALE1 more severe measure, although some is seen for the DALE2 less severe measure. The fact that DALE1 can include a positive response to all four disability categories could favor the more prevalent minor disability conditions and the DALE derived from it would be distributed in a manner similar to life expectancy. For DALE2, the state range across men at birth increases from life expectancy by 2.84 (9.59-6.75), while for females at birth it increases by 4.0 (8.69-4.69); for DALE2 at age 65, the difference increases 1.21 for men and 2.53 for women. While these latter are not unimportant, they do not reach the differences reported by Williams, where the five-year difference in male life expectancy across British social classes increased to nine quality adjusted life years when the EuroQuol measure was used to discount life expectancy in his calculations (Williams and Culyer, 1997).

We also note that this study shows that the traditional advantage that females have over males in longevity is not true for disability free life expectancy. This finding runs against the conclusion of the 2000 WHO report which says that women have a longer life expectancy and a longer healthy life expectancy than men(WHO, 2000). This contradiction is not surprising given the way of defining disability WHO used, which included weights based on “expert opinion”. The prevalence-based definition we are using is free of this type of biases.

Using a single health related quality of life modifier of life expectancy has certain advantages, perhaps the major one being that valuing multiple components is not necessary. On the other hand, it loses the richness of some individual valuation such as is possible with other approaches. For example, in the Years of Healthy Life measure a measure of disability is combined with

individual self reported health status to create the modifier of life expectancy (Erickson et al., 1995). The DALE values here trade off the availability of secondary data from a much larger population for a potentially richer DALE estimation.

There are several limitations of this work. This approach gives useful results only on widespread health conditions such as DALE2 in the present paper. Being fairly rare, more severe conditions are difficult to analyze using this method because of the small variation as shown with DALE1. The method is based on adjustment of a period life table. Therefore the well-known cohort effect problem cannot be captured through this method, and the assumption of the same force of mortality for the disabled and the non-disabled may not always work. Using the prevalence rates of disability, which reflect a single state approach, has its limitations. Whether the advantages enumerated in the text counter-balance these limitations is in itself an interesting research question that deserves exploration.

An immediate future research topic should be extending this exercise to comparison cross time, in order to assess progress accumulated on the international, national, and state levels. It is also fairly easy to gain more depth through application of methods of decomposition known to demographers in order to set apart the contributions of specific age groups, health conditions, and mortality components to the level of DALE. A comparative approach of population health requires indices that can be estimated for all populations of interest to the investigator. The universality and comprehensiveness of the census data speaks to the preference for prevalence based disability-adjusted life expectancy. This same source is a minefield of data on the socio-economic conditions of the populations. It offers the advantage of having the same sources for the denominators of any explanatory variable one needs to construct. This is a strong invitation to population health and health services researchers to take advantage of the census to move the

research from the descriptive level such as this and other papers on DALE operated to the building explanatory models.

Disclaimer. The data utilized in this paper were made available in part, by the Inter-University Consortium for Political and Social Research. The data for the mortality-detail file 1989-1991 were originally collected by the NCHS. Neither the collectors of the original data nor the Consortium bear any responsibility for analysis or interpretation presented here.

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APPENDIX 1

LIFE EXPECTANCY (LE), DISABILITY FREE LIFE EXPECTANCY (DFLE), AND PERCENT OF LIFE EXPECTANCY IN BASELINE DISABILITY (PCT), GENDER AND STATE OF RESIDENCE

UNITED STATES 1989-1991

FEMALES AT AGE ZERO

STATE	*LE*	*DFLE*	*PCT*	*STATE*	*LE*	*DFLE*	*PCT*
D.C.	73.3	60.5	17.4				
Louisiana	76.7	62.3	18.8	New Mexico	79.3	66.9	15.6
Mississippi	76.7	61.1	20.3	Oregon	79.3	66.8	15.7
Nevada	76.8	65.7	14.4	Montana	79.3	67.9	14.5
Tennessee	77.0	63.4	17.6	Maine	79.4	66.8	15.9
Delaware	77.3	65.4	15.4	Vermont	79.4	68.9	13.2
Georgia	77.3	63.3	18.1	Rhode Island	79.5	67.4	15.1
Alabama	77.3	63.2	18.3	Florida	79.5	67.4	15.2
South Carolina	77.4	63.4	18.1	Washington	79.5	67.2	15.4
Kentucky	77.7	63.1	18.7	New Hampshire	79.5	68.4	14.0
West Virginia	77.7	63.2	18.6	Idaho	79.6	67.4	15.3
Maryland	77.9	66.1	15.0	Connecticut	79.8	69.8	12.5
Arkansas	77.9	63.0	19.1	Massachusetts	79.8	68.3	14.4
North Carolina	78.0	64.2	17.7	Colorado	79.8	67.9	14.9
Illinois	78.0	66.5	14.7	Alaska	79.8	67.8	15.1
Michigan	78.1	65.2	16.4	Arizona	79.8	69.4	13.1
New York	78.2	66.1	15.4	Kansas	79.9	68.0	14.8
Ohio	78.2	65.6	16.1	Utah	79.9	68.1	14.8
Pennsylvania	78.3	66.5	15.2	North Dakota	79.9	69.3	13.2
Texas	78.5	66.0	16.0	Wisconsin	79.9	68.9	13.8
Indiana	78.5	66.1	15.9	Nebraska	80.1	68.8	14.1
Virginia	78.6	66.2	15.8	Wyoming	80.1	68.9	14.0
Missouri	78.6	65.9	16.2	Iowa	80.5	68.6	14.8
New Jersey	78.6	67.5	14.2	Minnesota	80.8	69.1	14.4

Oklahoma	78.7	64.9	17.6	South Dakota	80.9	68.9	14.8
California	78.9	66.7	15.6	Hawaii	81.4	69.6	14.4

FEMALES AT AGE 65 YEARS

STATE	*LE*	*DFLE*	*PCT*	*STATE*	*LE*	*DFLE*	*PCT*
Nevada	17.6	10.2	42.3	New York	19.0	11.1	41.7
Delaware	17.9	10.0	44.2	California	19.1	10.9	42.6
Louisiana	18.2	8.6	52.6	Oklahoma	19.1	9.6	49.7
Tennessee	18.2	8.9	51.2	Oregon	19.2	11.0	42.5
D.C.	18.3	10.0	45.4	Washington	19.3	11.2	41.7
Kentucky	18.3	8.6	52.8	Massachusetts	19.3	11.5	40.4
Maryland	18.3	10.3	43.9	Connecticut	19.4	12.9	33.4
Mississippi	18.4	8.0	56.2	Colorado	19.4	11.1	42.9
West Virginia	18.4	8.9	51.9	New Mexico	19.4	11.2	42.3
Georgia	18.5	8.8	52.2	Rhode Island	19.4	11.3	41.9
Ohio	18.5	10.1	45.7	Montana	19.4	11.6	40.5
Alabama	18.5	8.9	52.1	Wisconsin	19.4	11.9	38.8
Virginia	18.6	9.9	46.6	Idaho	19.6	11.2	42.8
Vermont	18.7	11.0	41.0	Utah	19.6	11.3	42.3
Indiana	18.7	10.3	45.0	Kansas	19.7	11.1	43.6
Michigan	18.7	10.2	45.4	Wyoming	19.8	11.4	42.2
South Carolina	18.7	9.3	50.1	Nebraska	19.9	11.7	41.1
Pennsylvania	18.7	10.6	43.1	Iowa	19.9	11.5	42.4
New Jersey	18.7	11.1	40.7	Minnesota	20.0	11.8	41.1
Illinois	18.8	10.8	42.5	Alaska	20.0	10.5	47.8
Arkansas	18.8	8.8	53.2	Arizona	20.1	13.9	30.5
New Hampshire	18.8	11.1	40.9	North Dakota	20.1	12.2	39.5
North Carolina	18.9	9.3	50.5	Florida	20.2	12.0	40.8
Maine	18.9	10.8	42.9	South Dakota	20.5	12.1	41.1
Texas	18.9	10.0	46.9	Hawaii	21.0	12.5	40.6
Missouri	19.0	10.1	46.7				

Male: Age 65

STATE	*LE*	*DALE 2*	*PCT*	*STATE*	*LE*	*DALE 2*	*PCT*
D.C.	61.8	52.7	14.7	Florida	71.9	61.5	14.5
Mississippi	68.6	56.0	18.4	New Jersey	71.9	63.3	12.0
Louisiana	68.7	56.8	17.4	New Mexico	71.9	61.1	15.1
South Carolina	69.3	58.5	15.6	California	72.3	62.4	13.7
Alabama	69.4	57.9	16.5	Montana	72.8	62.2	14.5
Georgia	69.4	58.6	15.5	Maine	72.8	61.9	15.0
Tennessee	70.1	59.2	15.6	Rhode Island	72.8	62.6	14.0
North Carolina	70.3	59.5	15.4	South Dakota	72.9	62.9	13.6
Arkansas	70.3	57.8	17.8	Oregon	73.0	62.1	15.0
West Virginia	70.3	57.2	18.7	Wyoming	73.1	63.3	13.4
Kentucky	70.5	58.1	17.6	Vermont	73.1	63.3	13.5
New York	70.6	61.3	13.2	Massachusetts	73.2	63.8	12.9
Alaska	70.8	62.3	12.0	Kansas	73.2	63.3	13.6

Arizona	70.8	62.0	12.5	Nebraska	73.4	63.8	13.0
Nevada	70.9	61.4	13.4	New Hampshire	73.4	64.1	12.7
Illinois	71.0	62.0	12.6	Idaho	73.5	62.3	15.3
Maryland	71.2	61.8	13.2	Wisconsin	73.5	64.0	12.9
Texas	71.2	60.8	14.6	Connecticut	73.5	64.5	12.3
Delaware	71.2	62.0	12.9	Colorado	73.5	63.6	13.6
Missouri	71.4	60.9	14.7	Iowa	73.7	63.6	13.7
Oklahoma	71.4	59.7	16.4	Washington	73.8	63.2	14.3
Michigan	71.5	61.3	14.3	North Dakota	74.3	64.3	13.4
Virginia	71.5	61.5	14.1	Minnesota	74.4	64.6	13.2
Pennsylvania	71.7	62.0	13.5	Utah	74.9	64.3	14.1
Indiana	71.8	61.9	13.8	Hawaii	75.4	65.6	13.0
Ohio	71.8	61.4	14.5				

Male: Age 65

STATE	*LE*	*DALE 2*	*PCT*	*STATE*	*LE*	*DALE 2*	*PCT*
D.C.	13.8	7.9	43.1	Vermont	14.9	8.6	42.7
West Virginia	13.9	6.8	51.4	Texas	15.0	8.4	43.6
Louisiana	14.0	7.2	48.6	New Jersey	15.1	9.6	36.2
Georgia	14.0	7.3	47.8	New York	15.1	9.7	35.9
Mississippi	14.1	6.2	55.9	New Hampshire	15.2	9.4	37.8
Kentucky	14.1	6.9	51.0	Massachusetts	15.3	9.7	36.7
Tennessee	14.2	7.4	47.8	Nebraska	15.3	9.2	40.2
Alaska	14.2	8.7	38.9	Rhode Island	15.3	9.2	39.7
Arizona	14.3	9.7	32.0	Wisconsin	15.3	9.7	36.9
South Carolina	14.3	7.8	45.3	Iowa	15.5	9.3	40.1
Alabama	14.3	7.1	50.1	Oregon	15.5	9.3	40.2
North Carolina	14.4	7.6	47.3	Montana	15.5	9.5	38.5
Delaware	14.5	8.8	39.3	South Dakota	15.5	9.0	42.0
Virginia	14.5	8.2	43.8	Kansas	15.5	9.1	41.6
Indiana	14.6	8.6	40.9	Minnesota	15.7	9.6	38.7
Ohio	14.6	8.7	40.9	Wyoming	15.7	9.4	39.9
Pennsylvania	14.7	8.9	39.2	Idaho	15.7	8.9	43.5
Illinois	14.7	9.2	37.5	Colorado	15.8	9.7	38.8
Maryland	14.8	9.0	38.9	California	15.8	9.8	38.1
Oklahoma	14.8	7.8	47.6	Connecticut	15.8	10.0	36.5
Maine	14.8	8.7	41.2	North Dakota	15.9	9.4	40.7
Arkansas	14.8	7.2	51.4	Washington	16.0	9.6	39.6
Michigan	14.8	8.7	41.1	New Mexico	16.0	9.5	40.3
Missouri	14.9	8.3	43.9	Utah	16.3	9.8	40.1
Nevada	14.9	9.2	38.2	Florida	16.4	10.2	37.6