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The Health Status of the USA States for the period 1989-1991 (Decennial Life Tables)

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Abstract: We apply the health state function theory to explore the health status of the USA States for the period 1989-1991. The data are from the official decennial life tables. We first use the New Hampshire data for the first application presented in the next figure and then we apply the same theory to 50 USA States and give comparative results.

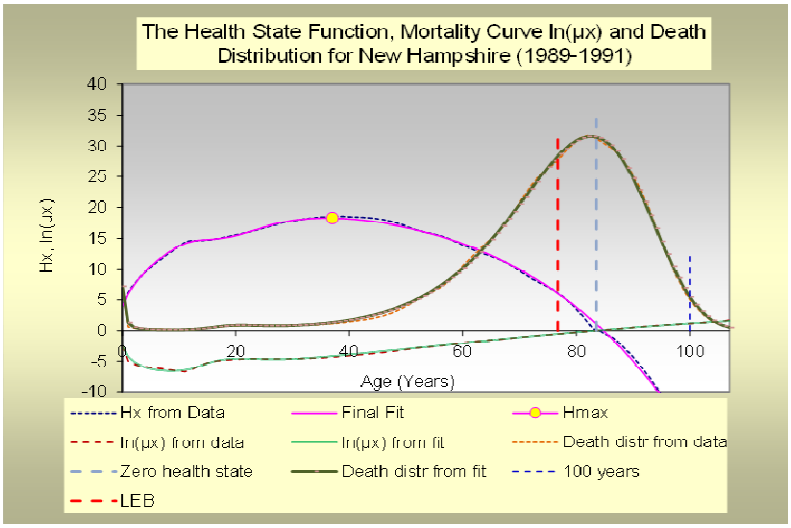

Figure 1. Main health state and mortality characteristics

Figure 1 above illustrates the main futures of the human health state and mortality theory. Three main graphs are present: the Death Distribution, the Health State Function and the Mortality Curve. The example used is for New Hampshire U.S. decennial life tables for 1989–91 provided by the US Department of Health and Human Services, National Center for Health Statistics, Centers for Disease Control and Prevention, Division of Vital

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Statistics. For the three graphs presented two main futures are given: the estimates from the data provided and the estimates after the fitting by using the SKI-1995 model and the related program in Excel provided in the http://www.cmsim.net website. The fitting is almost perfect.

From the data sets we form and present the death distribution (The scale of the graph is adapted). Few important futures are illustrated in the above graph. The related theory is presented in [1-5] .

1. The maximum number of deaths appear at 83.5 years of age
2. The death distribution around this year of age is of a non-symmetric bell-shaped form. The main task of future studies is to explore the mechanisms related to the form of this distribution and on how we can expand the region around of the peak of the deaths to the right.
3. A 33.3% of the total number of deaths appear in the age interval +-5 years from the maximum (78-88 years of age). This is 33.2% for USA 1990 data.
4. A 58.1% of the total number of deaths appear in the age interval +-10 years from the maximum (73-93 years of age). The related value for USA 1990 is 57.0%. This part of the death data, almost the 2/3 of the total deserves special attention. Any improvement by shifting the death distribution to the right will provide valuable help in millions of people.
5. The number of deaths from 100+ is only a 1.9% of the total number of deaths. (For USA 1990 is 1.1%). This is a very small amount distributed at the right hand part of the tail of the death distribution so that it is very difficult to collect any reliable information. That is why the studies on centenaries and super-centenaries face problems.
6. The number of deaths from 0-25 is only a 1.9% of the total number of deaths. It is similar to the number of deaths for 100+ years of age. This is 2.6% for USA 1990 data.

The Life Expectancy at Birth (LEB) is estimated at 76.2 years of age (red line in the graph). LEB is the most popular indicator as it is used by actuaries and insurance companies to calculate the pension funds. However, LEB is a statistic indicator and the large public confuses this indicator with the year of the maximum number of deaths. LEB is always several years lower than the age year of the maximum death rate as is illustrated in the graph. For earlier time periods when infant mortality was extremely high LEB differs significantly from the age year of the maximum death rate. The use of the force of mortality μx and its logarithmic form $\ln(\mu x)$ do not help much as it provides a linear form for the age years higher than 30.

The theory of the health state of a population instead includes the empirical observations related to the health state starting from lower values at birth, increasing until maturity and then decreasing at higher ages. The theory includes many theoretical and technical details developed last decades and based on the

modern theory of the first exit time of a stochastic process from a barrier. Although the full knowledge of the theory requires high level mathematics and statistics the applications are feasible by using the Excel software provided in the http://www.cmsim.net website. The health state function *Hx* for New Hampshire is presented in the above figure 1. The main futures of the health state function are the following:

1. The health state function is zero at the age year of the maximum death rate.
2. The health state function provides a maximum at a specific age ranging from 30-45 years. The level of this maximum can be used to rank countries and regions. For New Hampshire it is 37 years of age at a level of 18.54. It is 37.52 years of age for USA in 1990 at a level of 17.56.
3. A more accurate estimate related to this maximum is the expected healthy age. For New Hampshire is 38.41 years of age. It is 38.97 years for USA in 1990.
4. Calculating the area under the health state function from zero age until the age of zero health state we have a clear estimate of the health condition of a population. The related number of the Total Health State is 1130 for New Hampshire (1989-1991) and 1110 for USA in 1990. Estimates for Sweden for a period of the last 250 years follow (Table I). The Total Health State improved and the Life Expectancy at Birth as well; the later increasing by 40.9 years of age in 250 years. Instead the age of the maximum death rate increased by only 12 years from 74 years in 1751 to 86 years in 2000. Contrary to the general opinion the maximum death rate of the population of Sweden was at the relatively high age of 74 years in 1751 almost 2 times more than the LEB years of age. This is an indication that the governing mechanisms for the human life duration are relatively stable and special attention is needed in organizing future studies.

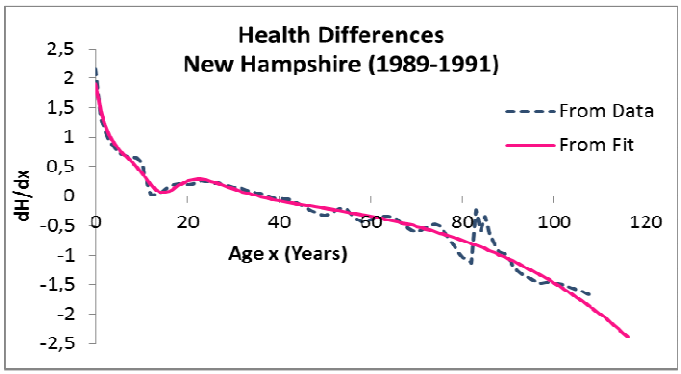

Figure 2. The health state differences as the first derivative of the health state function

5. A local maximum of the health state appears in 12 years of age from data sets (at 14.59 health level) and at 15 years of age from the fit curve (at 14.78 health level) as illustrated in Figure 1. As the case is very sensitive we estimate the Health State Differences presented in Figure 2. The level of health state achieved in this young age accounts for the 78.7% of the maximum health state. Furthermore Figure 2 provides a clear view of the course of health state changes in a population as a function of age. The changes expressed as the first derivative of the health state function (dH/dx) are positive but declining from birth until the end of the first decade or of the beginning of the second decade of the life span when it is close to zero thus providing a local maximum for H_x, then increases until a maximum (for New Hampshire is estimated at 23 years of age from the data sets and 22 from the fit curve) and then continuously decline passing from positive to negative values. The zero point is achieved at the year of the maximum health state.

TABLE I

Estimates for Sweden			
Year	Max Death Rate	Life Expectancy at Birth	Total Health State
1751	74	38.7	737
1800	71	32.9	646
1850	73	44.5	724
1900	79	51.9	866
1950	80	71.0	1076
2000	86	79.6	1291

The above figures 3A and 3B illustrate the estimates for the Total Health State (THS) and the Life Expectancy at Birth (LEB) for the US States for the period 1989-1991 (Decennial Life Tables). Observing the rank of the particular States we found clear connections between THS and LEB. The States presenting highest Total Health State show high Life Expectancy at Birth as well.

The Life Expectancy at Birth versus the Total Health State for the US States (1989-1991) is presented in figure 4 along with the linear trend line with equation: $y = 0{,}0283x + 44{,}061$. The relationship is evident. It is further demonstrated in the next comparative Table II. The US States are classified according to Life Expectancy at Birth and in the next column the Total Health State ranking appears. The last column indicates how many places moved up or down every State. 6 States are exactly classified. 17 States change only one position up or down. 9 States moved to 2 places up or down, 6 States moved to 3 places, 5 states moved to 4 places up or down, whereas 2 States moved to 5 places and 2 to 6 places. The remaining three States are New Hampshire (8 places down), Alaska (9 places up) and Florida (10 places up). USA with 1110 for the THS will be ranked between Maine (1113) and New Jersey (1106) in a place between 25 and 26 in the middle of the US States. Instead according to LEB (75.24 years) USA should be ranked in place 35 of 50 States with Illinois.

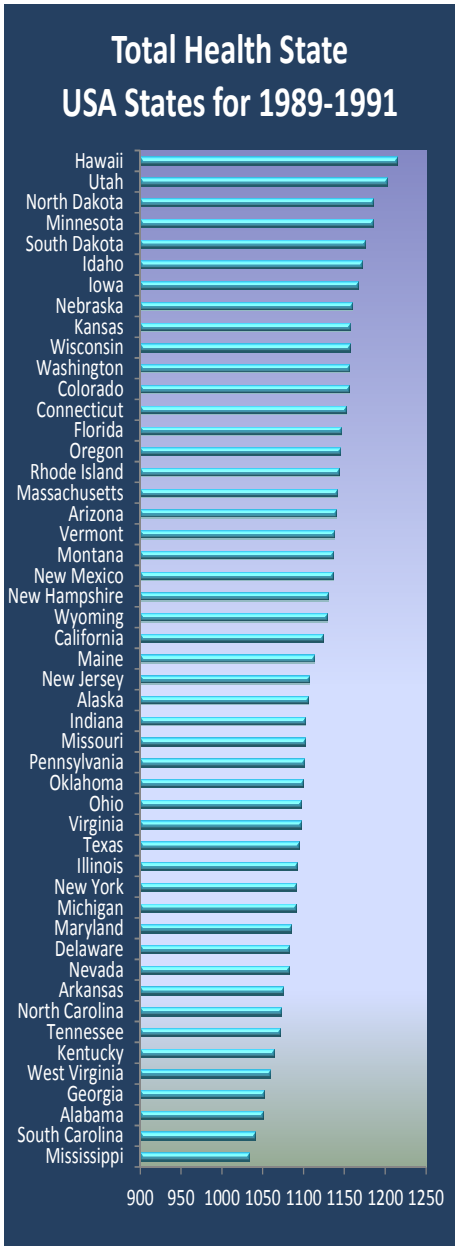

Fig. 3A. Total health state estimates

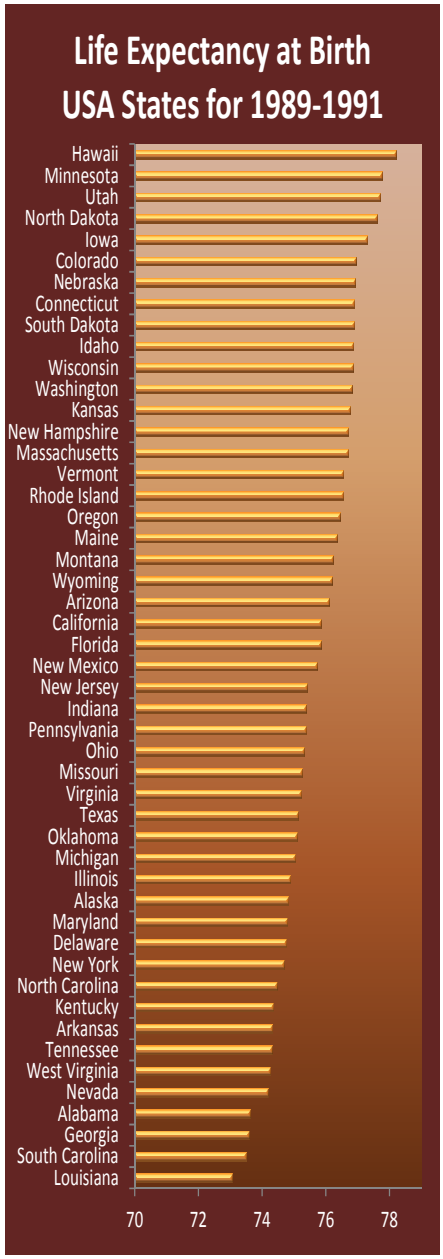

Fig. 3B. Life expectancy at birth estimates

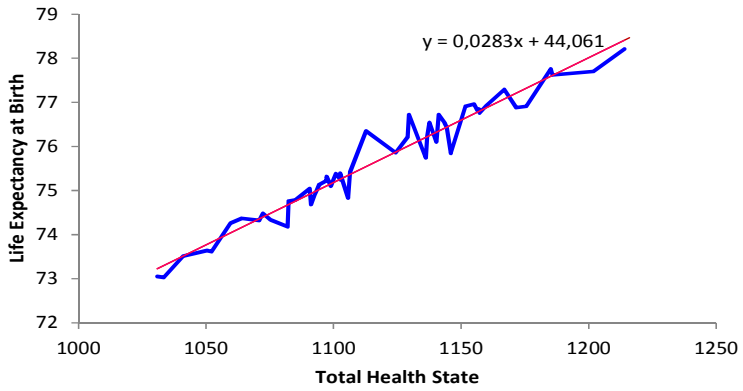

Fig. 4. The LEB versus THS for 50 USA States

6. The most important futures of the Health State Function of a Population is the estimation of the Loss of Health Life Years (LHLY) and then the calculation of the Healthy Life Expectancy (HLE) as the difference between the Life Expectancy at Birth (LEB) and LHLY that is HLE=LEB-LHLY. There are three special cases. In the most important we estimate the loss of healthy life years under severe causes and we calculate the healthy life expectancy at birth (HLEB) under severe causes. The method used is analyzed in the 5th chapter of the book on "The Health State Function of a Population" (Skiadas & Skiadas, 2012) and it is applied to the World Health Organization (WHO) member states for the years 1990, 2000 and 2009. The application for USA States (1989-1991) is presented in figure 5A. Minnesota is ranked first with 71.93 years and Louisiana with 67.44 healthy life years is in the last place. The gap is 4.49 healthy life years. Minnesota, Hawaii, Utah, Connecticut, Iowa, North Dakota, Wisconsin, New Hampshire, Nebraska and Massachusetts form the first decade whereas West Virginia, Kentucky, Nevada, Georgia, New York, Arkansas, Alabama, South Carolina, Mississippi and Louisiana are the last ten states in the rank.

TABLEII

LEB and THS rankings for US States					
Rank	Life Expectancy at Birth		Total Health State		Places +up / -down
1	78,22	Hawaii	Hawaii	1214	0
2	78,10	Minnesota	Utah	1202	1
3	77,95	Utah	North Dakota	1186	1
4	77,76	North Dakota	Minnesota	1185	-2
5	77,63	Iowa	South Dakota	1176	4
6	77,47	Colorado	Idaho	1172	4
7	77,34	Nebraska	Iowa	1167	-2
8	77,34	Connecticut	Nebraska	1160	-1
9	77,28	South Dakota	Kansas	1157	4
10	77,27	Idaho	Wisconsin	1157	1
11	77,19	Wisconsin	Washington	1156	1
12	77,19	Washington	Colorado	1155	-6
13	77,17	Kansas	Connecticut	1152	-5
14	77,15	New Hampshire	Florida	1146	10
15	77,06	Massachusetts	Oregon	1144	3
16	77,03	Vermont	Rhode Island	1143	1
17	76,96	Rhode Island	Massachusetts	1141	-2
18	76,79	Oregon	Arizona	1140	4
19	76,77	Maine	Vermont	1138	-3
20	76,58	Montana	Montana	1137	0
21	76,58	Wyoming	New Mexico	1136	4
22	76,29	Arizona	New Hampshire	1130	-8
23	76,00	California	Wyoming	1129	-2
24	75,91	Florida	California	1124	-1
25	75,86	New Mexico	Maine	1113	-6
26	75,82	New Jersey	New Jersey	1106	0
27	75,81	Indiana	Alaska	1106	9
28	75,78	Pennsylvania	Indiana	1103	-1
29	75,76	Ohio	Missouri	1103	1
30	75,70	Missouri	Pennsylvania	1101	-2
31	75,67	Virginia	Oklahoma	1099	2
32	75,57	Texas	Ohio	1097	-3
33	75,55	Oklahoma	Virginia	1097	-2
34	75,44	Michigan	Texas	1094	-2
35	75,24	Illinois	Illinois	1093	0
36	75,23	Alaska	New York	1091	3
37	75,19	Maryland	Michigan	1091	-3
38	75,02	Delaware	Maryland	1085	-1
39	74,90	New York	Delaware	1082	-1
40	74,90	North Carolina	Nevada	1082	5
41	74,89	Kentucky	Arkansas	1075	1
42	74,82	Arkansas	North Carolina	1072	-2
43	74,72	Tennessee	Tennessee	1071	0
44	74,64	West Virginia	Kentucky	1064	-3
45	74,22	Nevada	West Virginia	1060	-1
46	74,02	Alabama	Georgia	1052	1
47	73,99	Georgia	Alabama	1050	-1
48	73,93	South Carolina	South Carolina	1041	0
49	73,50	Louisiana	Mississippi	1034	1
50	73,45	Mississippi	Louisiana	1031	-1

7. The estimates of the Healthy Life Expectancy at Birth under all causes are also presented. This is an indicator including severe, moderate and light causes for loss of healthy life years (Figure 5B). As it is expected the related indicator for the Healthy Life Expectancy at Birth (HLEB) under all causes provides lower values for the expected healthy years of age than the previous one. However, it is an important estimator for the health policy planers especially when estimate the expenses for the health care system. New Hampshire (63.00 years), Maine, Vermont, Iowa, Nebraska, Minnesota, Massachusetts, Wisconsin, Colorado and Washington are the first ten with the highest healthy life years. The lower ten positions are covered by Arkansas, Louisiana, South Carolina, Arizona, Georgia, Alabama, New Mexico, Mississippi, New York and Florida (57.12 years). The gap from the first to the last one is 5.88 life years. For USA 1990 the HLEB (severe causes)) is 68.69 years higher than Missouri (69.54 years) and lower than Florida (69.71 years) in a place between 28 and 29.

8. A comparative study is presented in Table III including the estimates for the healthy life expectancy at birth under severe and under all causes of disabilities for the USA States from 1989-1991. The rankings differ significantly in the two estimates. The main reason is that by estimating all causes of disabilities (severe, moderate and light) the light causes responsible for the loss of several life years of age are higher or lower in places with special characteristics for the way of living. The main positive changes (+up) were for West Virginia (+25), Delaware (+24), Kentucky (+23), Alaska (+22), Maine (+14), Vermont (+14), Indiana (+13), Ohio (+11) and Virginia (+10). The main negative changes (-down) were for Hawaii (-35), Connecticut (-23), Florida (-22), Arizona (-21), Utah (-21), Kansas (-16), New Mexico (-16), North Dakota (-15), California (-14), South Dakota (-11) and Rhode Island (-10). For USA 1990 the HLEB (all causes)) is 59.37 years higher than South Carolina (59.23 years) and lower than Louisiana (59.41 years) in a place between 42 and 43.

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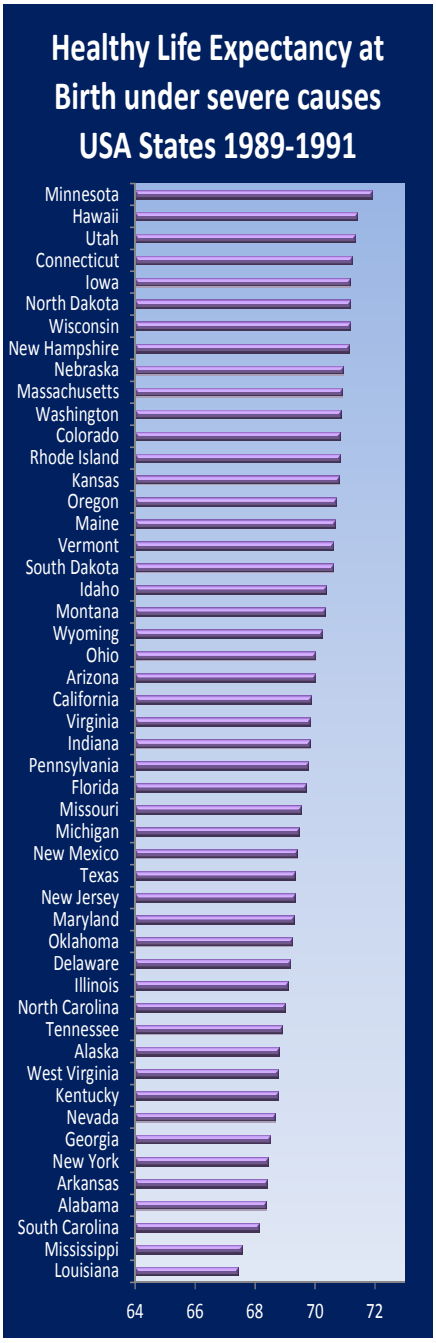

Fig. 5A. HLEB (severe causes)

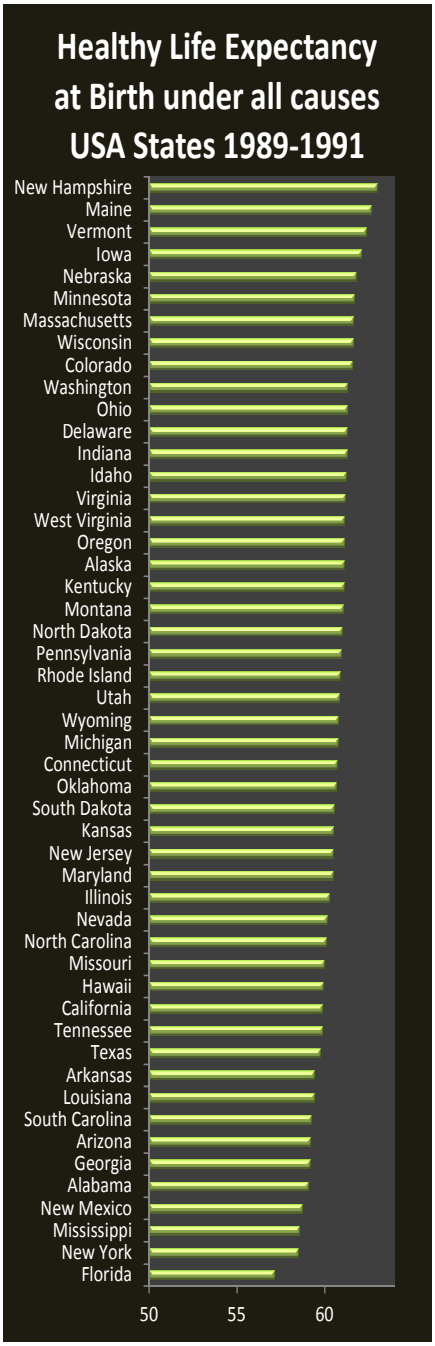

Fig. 5B. HLEB (All causes)

TABLE III

Healthy Life Expectancy rankings for US States					
Rank	Healthy Life Expectancy at Birth (severe causes)		Healthy Life Expectancy at Birth (all causes)		Places +up / -down
1	71,93	Minnesota	New Hampshire	63,00	7
2	71,42	Hawaii	Maine	62,67	14
3	71,35	Utah	Vermont	62,36	14
4	71,24	Connecticut	Iowa	62,12	1
5	71,18	Iowa	Nebraska	61,80	4
6	71,18	North Dakota	Minnesota	61,69	-5
7	71,17	Wisconsin	Massachusetts	61,65	3
8	71,14	New Hampshire	Wisconsin	61,64	-1
9	70,95	Nebraska	Colorado	61,60	3
10	70,90	Massachusetts	Washington	61,29	1
11	70,86	Washington	Ohio	61,29	11
12	70,86	Colorado	Delaware	61,29	24
13	70,84	Rhode Island	Indiana	61,28	13
14	70,82	Kansas	Idaho	61,24	5
15	70,72	Oregon	Virginia	61,20	10
16	70,67	Maine	West Virginia	61,12	25
17	70,61	Vermont	Oregon	61,11	-2
18	70,60	South Dakota	Alaska	61,10	22
19	70,37	Idaho	Kentucky	61,10	23
20	70,35	Montana	Montana	61,04	0
21	70,25	Wyoming	North Dakota	61,01	-15
22	70,00	Ohio	Pennsylvania	60,96	5
23	70,00	Arizona	Rhode Island	60,90	-10
24	69,88	California	Utah	60,84	-21
25	69,83	Virginia	Wyoming	60,78	-4
26	69,83	Indiana	Michigan	60,75	4
27	69,80	Pennsylvania	Connecticut	60,71	-23
28	69,71	Florida	Oklahoma	60,67	7
29	69,54	Missouri	South Dakota	60,55	-11
30	69,49	Michigan	Kansas	60,49	-16
31	69,39	New Mexico	New Jersey	60,48	2
32	69,35	Texas	Maryland	60,48	2
33	69,33	New Jersey	Illinois	60,29	4
34	69,30	Maryland	Nevada	60,13	9
35	69,23	Oklahoma	North Carolina	60,07	3
36	69,18	Delaware	Missouri	59,97	-7
37	69,10	Illinois	Hawaii	59,93	-35
38	69,01	North Carolina	California	59,88	-14
39	68,90	Tennessee	Tennessee	59,87	0
40	68,80	Alaska	Texas	59,77	-8
41	68,77	West Virginia	Arkansas	59,42	5
42	68,77	Kentucky	Louisiana	59,41	8
43	68,68	Nevada	South Carolina	59,23	5
44	68,50	Georgia	Arizona	59,18	-21
45	68,44	New York	Georgia	59,16	-1
46	68,40	Arkansas	Alabama	59,10	1
47	68,38	Alabama	New Mexico	58,72	-16
48	68,15	South Carolina	Mississippi	58,53	1
49	67,57	Mississippi	New York	58,50	-4
50	67,44	Louisiana	Florida	57,12	-22