Preparing for the Next
INFLUENZA PANDEMIC

FluSurge

Software to Estimate the Impact of an Influenza Pandemic on Hospital Surge Capacity

FluSurge 1.0 Beta Test Version

CDC
SAFER • HEALTHIER • PEOPLE™

ACKNOWLEDGMENTS

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DISCLAIMER

The numbers generated through FluSurge are not to be considered predictions of what *will* actually occur during an influenza pandemic. Rather, they should be treated as estimates of what *could* happen.

Note: Influenza virus photo on the cover is an electron micrograph magnified 150,000 times over normal size. We thank Dr. Nancy J. Cox for providing this photo.

SYSTEM REQUIREMENTS

FluSurge uses the Windows* operating system (MS Windows 2000 or higher) and EXCEL (MS Office 2000 or higher). We recommend using a computer with at least a 486 Pentium processor and at least 128MB RAM. FluSurge requires up to 2 megabytes of storage space on the computer's hard drive.

*MS Windows and Office is a copyrighted product produced by Microsoft Corporation, WA. Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

Before loading and starting FluSurge, you must change Excel's security level. You must first do the following steps (see LOAD and START for details):

1). Open a blank Excel spreadsheet.

2). Click Tools and then click Macro, choose Security

3). Set Security Level to Medium.

4). Click OK.

5). Double click and open FluSurge file.

6). When asked to Disable Macros or Enable Macros, click Enable Macros.

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INTRODUCTION

Planning ahead in preparation for an influenza pandemic, with its potentially very high morbidity and mortality rates, is essential for hospital administrators and public health officials. To this end, FluSurge helps you estimate the impact of an influenza pandemic on your community. It has been designed to demonstrate the need to plan for a surge in demand for hospital services during the next pandemic, and to provide a method to estimate demand for these services, which can be used to plan the allocation of scarce resources.

Based on census data and estimates of hospital resources (staffed beds, staffed intensive care unit [ICU] beds, and mechanical ventilators) provided by you in a given area (e.g., a city, a state), FluSurge estimates the number of hospitalizations and deaths of an influenza pandemic (whose length and virulence are determined by you) and compares the number of persons hospitalized, the number of persons requiring ICU care, and the number of persons requiring ventilator support during a pandemic with existing hospital capacity.

BACKGROUND

Influenza pandemics can overwhelm a community, causing very serious public health, social, and economic problems. Approximately 110,000 hospitalizations per year are related to influenza (1). Researchers estimate that during the next influenza pandemic, 15% - 35% of the U.S. population will become clinically ill with the influenza virus (2, 3). Because this would create a large surge in demand for hospital-based services, pre-planning is extremely important to successfully reduce pandemic-related morbidity and

mortality, and to efficiently allocate scarce hospital resources. FluSurge can help local public health officials and hospital administrators better understand and prepare for the next influenza pandemic.

We ran FluSurge using metro Atlanta as an example to illustrate the impact of an 8-week influenza pandemic with a 25% gross clinical attack rate. In this example, the demand on hospital resources peaked in week 5, with a maximum of 287 hospital admissions per day. FluSurge estimated that during this week, 1,938 persons would be hospitalized, 407 would require use of the ICU, and 203 would need mechanical ventilation (these numbers, respectively, translate to 27% of all hospital beds, 54% of total ICU capacity, and 29% of all ventilators in metro Atlanta). Such an influenza pandemic would most likely result in 9,707 hospital admissions (ranging from 3,130 to 12,924) and 1,741 deaths (ranging from 782 to 3,120). (Note: Reductions in hospital capacity due to illnesses among healthcare workers were not taken into account in this first version of FluSurge.) These sample results from FluSurge illustrate how the next influenza pandemic may overwhelm existing hospital resources, given that hospitals increasingly operate at nearly full capacity. Public health officials and hospital administrators must plan for surges in demand for hospital services during the next pandemic.

METHODS

Microsoft Excel/Visual Basic was used to construct FluSurge. Part of FluAid 2.0 (4) was built into FluSurge and was used to estimate numbers of deaths and persons hospitalized due to an influenza pandemic. You need to provide estimates of your local

population in three age groups (0-17, 18-64, and 65+ years) and your available hospital resources (total staffed beds, ICU beds, and mechanical ventilators). You then select the duration of a pandemic (6, 8, or 12 weeks) and the gross clinical attack rate (15%, 25%, or 35%). Based on these data, FluSurge estimates numbers of persons hospitalized, bed capacity needed, ICU capacity needed, and ventilator usage over the course of the pandemic.

LOAD AND START

Before loading and starting FluSurge, you must change Excel's security level. Because FluSurge uses Excel macro technology, you must first do the following steps:

1). Open a blank Excel spreadsheet.

2). Click Tools and then click Macro, choose Security

3). Set Security Level to Medium.

4). Click OK.

5). Double click and open FluSurge file.

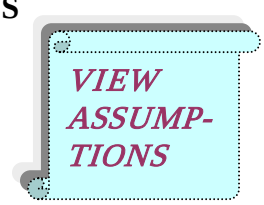
6). When asked to Disable Macros or Enable Macros, click Enable Macros.

You must open a blank Excel spreadsheet to change the security level. Changing security level with FluSurge opening won't make software work. In that menu item "Tools," scroll down until you reach the option labeled "Macros." A side bar of options associated with "Macros" will open up. From that sidebar, select the option labeled "Security." This will cause a little box titled "Security" to pop up. The first sheet in this box is titled "Security level." Select either "medium" (recommended) or "low." If you

select/ leave the security level at high, the macro (sets of commands) programming in FluSurge will be disabled and the software will not run.

Once you have selected the security level, click on the "OK" button. You are now ready to open FluSurge. If you selected "medium" security level, a pop-up box will appear and tell you that the spreadsheet you are opening (FluSurge) contains macros and ask you if you want to disable or enable the macros. You must select/ click on "Enable macros." If you select "disable macros" FluSurge will not work. Once you have selected "Enable macros," the software will quickly load and you are ready to click **START** to go to **Main Menu** and begin to run FluSurge.

ASSUMPTIONS

Clicking 

will lead you to FluSurge's underlying assumptions. These assumptions are as follows:

No. 1 Average length of hospital stay† for influenza-related illness is 7 days.

No. 2 Average length of ICU stay for influenza-related illness is 10 days.

No. 3 Average length of ventilator usage for influenza-related illness is 10 days.

No. 4 An average of 15% of admitted influenza patients will need ICU care.

No. 5 An average of 7.5% of admitted influenza patients will need ventilators.

*In future versions, you may be able to change all these assumptions, e.g., entering your own estimates of a patient's average length of stay in an ICU bed.

† How long will a patient stay in the hospital with an influenza-related illness? During an influenza pandemic, hospital administrators may have to reduce patients' length of stay in order to admit more patients.

DATA INPUT

1. Enter the population of the area you want FluSurge to work with, broken down into three age groups:

Age Group	Population
0-17 yrs	815,803
18-64 yrs	2,083,291
+ 65 yrs	231,899

The total population of the state or locality being modeled is divided into three age groups: school-aged children, working adults, and retirees. A set of previous numbers (Numbers you or previous users typed in last time) will automatically appear. All data you type in will be automatically saved when you exit FluSurge. To change the previous values, simply type over them.

You may wish to consult one of the following sources to get population estimates:

a. State estimates
   - Appendix I
   - U.S. Census Bureau (www.census.gov)

b. Regional estimates
   - Vital Statistics office

If the area of interest is outside the United States, contact the regional or national census office for population estimates.

2. Enter numbers of basic hospital resources:

Total staffed beds:	7,300
Staffed ICU beds:	759
Total number of ventilators:	691

A set of previous numbers will automatically appear. All data you type in will be automatically saved when you exit FluSurge. To change the previous values, simply type over them.

You may wish to consult the person coordinating the Health Resources and Services Administration's (HRSA) National Bioterrorism Hospital Preparedness Program for hospital resource information.

(Note: Future versions of FluSurge will take into account additional hospital resources.)

3. Choose the duration and gross clinical attack rate of the pandemic:

Duration:	8	**Attack rate:**	25%

Duration refers to the number of weeks you expect the pandemic to last; you may select 6, 8, or 12 weeks from the drop-down box. Gross clinical attack rate refers to the percentage of the population that becomes clinically ill due to influenza; a clinical case of influenza is one that causes some measurable economic impact, such as one-half day of work lost, or a visit to a physician's office. Default values (6, 8, or 12 weeks, and 15%, 25% or 35%) given here are taken from the work of Meltzer MI, Cox NJ, and Fukuda K (2, 3).

Results

Click **Click to View Results** to see your final results, which are organized into two parts. The first part provides the total estimated number of persons needing hospitalization (or hospital admission) and total estimated deaths in different scenarios ("minimum," "most likely," and "maximum") due to influenza pandemic. This part also includes a graph and a table showing the weekly distribution of hospital admissions in three scenarios.

The second part of the results contains a graph showing the daily distribution of hospital patient admissions due to the influenza pandemic. There is also a table showing weekly and peak daily admissions, staffed bed capacity needed, ICU capacity needed, ventilator usage, and deaths from influenza. This table only includes estimates from the most likely scenario.

Results Part I

1. In the first part of your results, you will see a table, similar to the one below, showing the total estimated hospital demand and total deaths due to the influenza pandemic:

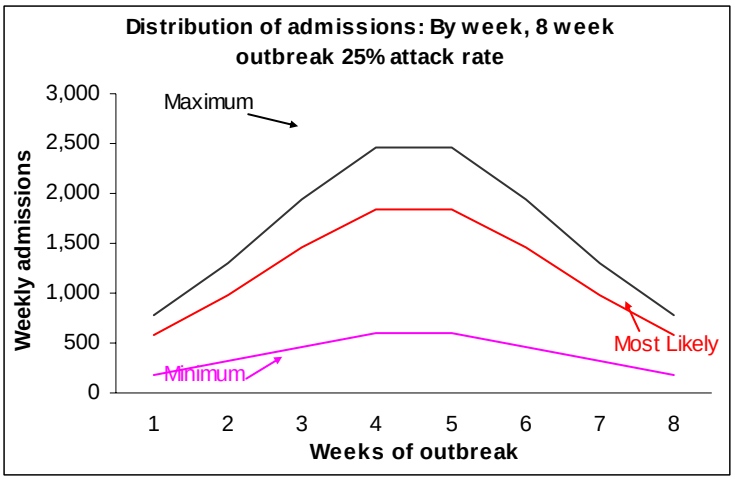
Influenza Pandemic Impact/Gross Attack Rate	**25%**
Total Hospital Demand	
Most Likely Scenario	*9,707*
Minimum Scenario	3,130
Maximum Scenario	12,924
Total Deaths	
Most Likely Scenario	*1,741*
Minimum Scenario	782
Maximum Scenario	3,120

The estimated number of hospital admissions is based on death rates and hospitalization rates provided by FluAid. Hospitalization rates are estimated to create

three scenarios of pandemic impact: minimum (the best case scenario), which estimates the fewest possible number of hospitalizations; mean (the most likely scenario), which estimates the number of hospitalizations most likely to occur; and maximum (the worst case scenario), which estimates the largest number of hospitalizations. Here, for example, an influenza pandemic with an 8-week duration and a 25% gross clinical attack rate will most likely result in 9,707 hospital admissions (ranging from 3,130 to 12,924) and 1,741 deaths (ranging from 782 to 3,120).

The estimates of hospital admissions, total bed capacity used, total ICU capacity used, total ventilators used, and deaths will markedly increase as the assumed gross clinical attack rate increases. These estimates of impact may also range widely over the three scenarios. For a given gross clinical attack rate, the extensive range between the minimum and maximum estimates is due to the uncertainty of how the next pandemic will spread through society, as well as to the lack of data regarding the impact of influenza in previous pandemics (2,3). Such uncertainty, and the resultant wide ranges in estimated impact, should serve as a warning to planners not to be overconfident in using a single estimate of impact when preparing their plans.

2. You will also see a graph and a table, like the one below, illustrating the weekly distribution of hospital admissions of influenza pandemic patients:



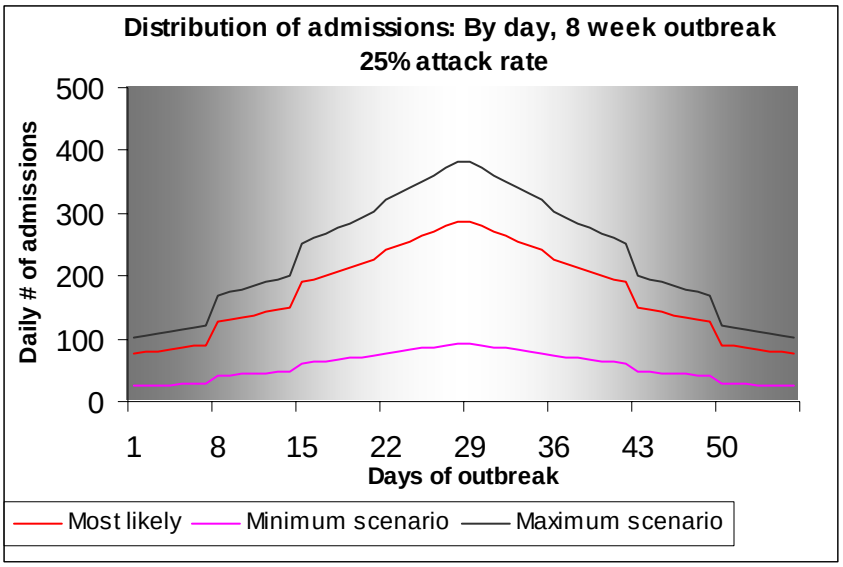
Hosp Adm./Week	1	2	3	4	5	6	7	8
Most Likely Scenario	582	971	1,456	*1,844*	*1,844*	1,456	971	582
Minimum Scenario	188	313	470	595	595	470	313	188
Maximum Scenario	775	1,292	1,939	2,456	2,456	1,939	1,292	775

The above weekly distribution of hospital admissions due to the influenza pandemic was based on an 8-week duration and a 25% clinical gross clinical attack rate. The peak number of hospital admissions arrived at the 4th and 5th week for all scenarios, with 1,844 patients admitted per week in the most likely scenario. This result ranged from 595 admissions in the minimum scenario to 2,456 admissions in the maximum scenario.

Results Part II

Click **Go to Next Page** to go to the second part of the results.

1. In the second part of your results, you will see a graph, similar to the one below, showing the daily distribution of hospital admissions of influenza pandemic patients:



This graph shows the daily distribution of numbers of people hospitalized due to an influenza pandemic with an 8-week duration and a 25% gross clinical attack rate. As this graph and the table below demonstrate, FluSurge estimates that the peak daily admission of influenza patients will reach 287 per day in the 4th and 5th weeks. This will result in a huge surge demand of hospital resources, as shown in the table below.

2. Next you will see a table, similar to the one below, showing the impact of the influenza pandemic on hospital resources:

Influenza Pandemic Impact / Weeks		1	2	3	4	5	6	7	8	9	10
Hospital admission	Weekly admission	582	971	1,456	1,844	1,844	1,456	971	582		
	Peak admission/day				287	**287**					
Hospital capacity	# of flu patients in hospital	582	971	1,456	1,844	1,938	1,784	1,380	910		
	Hospital capacity used	8%	13%	20%	25%	**27%**	24%	19%	12%		
ICU capacity	# of flu patients in ICU	87	185	285	376	407	396	314	217		
	ICU capacity used	12%	24%	37%	50%	**54%**	52%	41%	29%		
Ventilator capacity	# of flu patients on ventilators	44	93	142	188	203	198	157	109		
	% usage of ventilator	6%	13%	21%	27%	**29%**	29%	23%	16%		
Deaths	# of deaths from flu			104	174	261	331	331	261	174	104
	# of flu deaths in hospital			73	122	183	232	232	183	122	73

This table presents the results from the calculations using the data that you entered. It presents the estimates, by specified pandemic duration (e.g., 8 weeks) and gross clinical attack rate (e.g., 25%), of the impact of pandemic influenza on hospital resources. The hospital admission category includes the total number of weekly hospital admissions of influenza patients and peak admission per day. The hospital capacity category presents the maximum total number of influenza patients in the hospital and relevant hospital capacity needed. ICU capacity category shows the maximum total number of influenza patients in the ICU, and relevant ICU capacity needed. Ventilator capacity category provides the maximum total number of ventilators used and related percentage of use. Deaths category provides estimates of the total number of deaths and total number of influenza patients who would die in the hospital due to influenza pandemic in a week.

- Weekly admission: The total number of influenza patients admitted into hospital during each pandemic week.
- Peak admission/day: The peak number of daily hospital admissions of influenza patients and the week in which the peak occurs.
- # of flu patients in hospital: The maximum daily number of influenza patients hospitalized in a relevant week. The maximum number of influenza patients in the hospital in a week is greater than the weekly admission after the peak, because we assume a 7-day stay in general wards (10-day stay in the ICU and 10-day use of a ventilator). For example, patients admitted toward the end of week 4 will still be in the hospital during week 5.

- Hospital capacity used: The proportion of all staffed hospital beds that would be occupied by influenza patients. For example, 1,938 influenza patients in the hospital equivalent to 27% of the hospitals' total capacity, that is, 27% of total staffed beds will be required. Many hospitals do not have such surplus capacity available. (Note: Reductions in hospital capacity due to illnesses among healthcare workers were not taken into account in this first version of FluSurge.)
- # of flu patients in ICU: The maximum daily number of influenza patients requiring ICU care in a relevant week.
- ICU capacity used: The proportion of all staffed ICU beds that would be occupied by influenza patients. For example, 407 influenza patients in the ICU is equivalent to 54% of the ICU's total capacity.
- # of flu patients on ventilators: The maximum daily number of influenza patients requiring ventilator support in a relevant week.
- % usage of ventilator: The proportion of all mechanical ventilators that would be used by influenza patients. For example, 203 influenza patients using ventilators equivalent to 29% usage of the total ventilators available.
- # of deaths from flu: The total number of influenza patients died during each pandemic week. Here, we assume that death starts at the 3rd week.
- # of flu deaths in hospital: The total number of influenza patients died in hospitals during each pandemic week.

Therefore, in this case, an 8-week influenza pandemic with a 25% gross clinical attack rate will consume 27% of the total hospital capacity, 54% of the total ICU

capacity, and 29% of total ventilators during the pandemic's peak (the 5th week). Moreover, two weeks later, 331 people would die, and 232 of these deaths would occur in the hospital.

TECHNICAL NOTES

Note I. Total Hospital Admissions

Total hospitalizations and total deaths are estimated using FluAid. We assume 70% of deaths happen in hospital. Therefore, Total hospital admissions (*in FluSurge*) = Total hospitalizations (*in FluAid*) + 70% * Total deaths (*in FluAid*). In later versions, you may also be able to change this 70% rate (percentage of deaths assumed to be hospitalized).

Note II. Distribution of Hospital Admissions

Because FluAid only provides estimates of total hospitalizations and total deaths of an influenza pandemic, we have to distribute total number of hospitalizations and total number of deaths into different weeks. We first assumed an approximate normal distribution for weekly distribution of hospital admission and death of influenza patients. Then, within each week, we assumed a 3% daily increase in case arriving compared to previous day before the peak and a 3% daily decrease in case arriving compared to previous day after the peak. Therefore, you are expected to see some little bumps in the daily distribution graph. In later versions, you may also be able to change the daily increase (decrease) rate (3%). In this way, you can change the shape of the daily distribution.

PRINTING

In order to print your results on a single page, you must change the printing page setup to Landscape format. To do so,

1). Click File and then choose Page Setup.

2). In the Orientation section, change Portrait to Landscape.

3). Click OK.

EXIT

Click **Return to Main Menu** to go to the **Main Menu** if you want to change any data you typed in, or to select a different pandemic duration and/or gross clinical attack rate. Click **Close** in the **Main Menu** to close all programs and go to the front page. Click **EXIT&SAVE** to save input data and results while exiting FluSurge.

CONTACT

For additional help or feedback, please email your comments or questions to Xinzhi Zhang M.D., Ph.D. (xzhang4@cdc.gov).

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Appendix I:

No. 20. Resident Population by Age and State: 2000

[In thousands, except percent (281,422 represents 281,422,000). As of April. Includes Armed Forces stationed in area]

State	Total	Under 5 years	5 to 17 years	18 to 24 years	25 to 34 years	35 to 44 years	45 to 54 years	55 to 64 years	65 to 74 years	75 to 84 years	85 years and over	Percent 65 years and over
U.S.	281,422	19,176	53,118	27,143	39,892	45,149	37,678	24,275	18,391	12,361	4,240	12.4
AL	4,447	296	827	440	603	686	600	416	317	196	67	13.0
AK	627	48	143	57	89	114	95	45	23	11	3	5.7
AZ	5,131	382	985	514	743	769	628	442	364	235	69	13.0
AR	2,673	182	499	262	353	398	350	257	198	129	46	14.0
CA	33,872	2,487	6,763	3,366	5,229	5,485	4,332	2,614	1,888	1,282	426	10.6
CO	4,301	298	803	430	664	737	614	339	226	142	48	9.7
CT	3,406	223	618	272	452	581	481	309	232	174	64	13.8
DE	784	52	143	75	109	128	104	72	56	35	11	13.0
DC	572	33	82	73	102	88	75	50	36	25	9	12.2
FL	15,982	946	2,701	1,331	2,084	2,485	2,069	1,559	1,452	1,024	331	17.6
GA	8,186	595	1,574	838	1,299	1,354	1,080	661	436	262	88	9.6
HI	1,212	78	218	115	171	191	171	107	85	58	18	13.3
ID	1,294	98	271	139	169	193	170	108	76	52	18	11.3
IL	12,419	877	2,369	1,211	1,812	1,984	1,627	1,041	772	536	192	12.1
IN	6,080	423	1,151	615	831	961	817	530	395	266	92	12.4
IA	2,926	188	545	298	363	445	393	257	212	159	65	14.9
KS	2,688	189	524	276	349	420	354	220	176	129	52	13.3
KY	4,042	266	729	402	568	643	557	373	274	173	58	12.5
LA	4,469	317	902	474	601	692	586	379	283	175	59	11.6
ME	1,275	71	231	104	158	213	193	123	96	64	23	14.4
MD	5,296	353	1,003	451	749	916	755	470	321	211	67	11.3
MA	6,349	397	1,103	579	927	1,063	873	546	428	316	117	13.5
MI	9,938	672	1,924	932	1,362	1,598	1,368	863	643	434	142	12.3
MN	4,919	330	957	470	673	824	666	405	296	213	86	12.1
MS	2,845	204	571	311	382	425	362	246	186	115	43	12.1
MO	5,595	370	1,058	536	739	888	742	507	393	264	99	13.5
MT	902	55	175	86	103	142	135	85	63	43	15	13.4
NE	1,711	117	333	174	223	264	226	142	116	83	34	13.6
NV	1,998	146	366	180	307	322	269	190	132	70	17	11.0
NH	1,236	76	234	103	160	221	184	110	78	51	18	12.0
NJ	8,414	564	1,524	677	1,189	1,435	1,159	754	575	402	136	13.2
NM	1,819	131	378	178	234	282	246	159	118	71	23	11.7
NY	18,976	1,239	3,451	1,765	2,757	3,074	2,553	1,688	1,276	861	311	12.9
NC	8,049	540	1,425	807	1,213	1,287	1,085	724	534	330	105	12.0
ND	642	39	121	73	77	98	85	53	46	34	15	14.7
OH	11,353	755	2,133	1,057	1,520	1,805	1,566	1,009	790	541	177	13.3
OK	3,451	236	656	357	452	524	454	316	242	156	57	13.2
OR	3,421	223	624	328	471	527	507	304	219	161	57	12.8
PA	12,281	728	2,194	1,094	1,560	1,948	1,705	1,132	969	712	238	15.6
RI	1,048	64	184	107	140	170	142	89	74	58	21	14.5
SC	4,012	265	745	408	561	625	550	373	270	165	50	12.1
SD	755	51	152	78	91	115	98	62	53	39	16	14.3
TN	5,689	375	1,024	549	816	903	787	533	383	239	81	12.4
TX	20,852	1,625	4,262	2,199	3,162	3,322	2,611	1,598	1,143	692	238	9.9
UT	2,233	209	509	317	327	300	238	143	102	67	22	8.5
VT	609	34	114	57	75	102	94	57	41	27	10	12.7
VA	7,079	462	1,276	679	1,037	1,201	999	632	432	273	87	11.2
WA	5,894	394	1,120	559	841	975	846	497	337	241	84	11.2
WV	1,808	102	301	172	229	272	270	185	148	97	32	15.3
WI	5,364	342	1,026	521	706	876	732	458	355	252	96	13.1
WY	494	31	98	50	60	79	74	45	31	20	7	11.7

Source: U.S. Census Bureau, "Demographic Profiles: Census 2000"; <http://www.census.gov/Press-Release/www/2001/demoprofile.html>.