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Who's at Risk When the Power Goes Out? The At-home Electricity-Dependent Population in the United States, 2012

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Abstract

Objectives—Natural and man-made disasters can result in power outages that can affect certain vulnerable populations dependent on electrically powered durable medical equipment. This study estimated the size and prevalence of that electricity-dependent population residing at home in the United States.

Methods—We used the Truven Health MarketScan* 2012 database to estimate the number of employer-sponsored privately insured enrollees by geography, age group, and sex who resided at home and were dependent upon electrically powered durable medical equipment to sustain life. We estimated nationally representative prevalence and used US Census population estimates to extrapolate the national population and produce maps visualizing prevalence and distribution of electricity-dependent populations residing at home.

Results—As of 2012, among the 175 million persons covered by employer-sponsored private insurance, the estimated number of electricity-dependent persons residing at home was 366 619 (95% confidence interval: 365 700-367 537), with a national prevalence of 218.2 per 100 000 covered lives (95% confidence interval: 217.7-218.8). Prevalence varied significantly by age group (χ^2 = 264 289 95, P < .0001) and region (χ^2 = 12 286 30, P < .0001), with highest prevalence in those 65 years of age or older and in the South and the West. Across all insurance types in the United States, approximately 685 000 electricity-dependent persons resided at home.

Conclusions—These results may assist public health jurisdictions addressing unique needs and necessary resources for this particularly vulnerable population. Results can verify and enhance the development of functional needs registries, which are needed to help first responders target efforts to those most vulnerable during disasters affecting the power supply.

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Keywords

disaster; emergency; preparedness; vulnerable population

Both natural and man-made disasters can result in disruptions to the power grid, a community's main energy source. Although a power outage, however brief, may be considered a nuisance to many, for certain medically fragile people, it has the potential to cause an acute decompensation that, depending on the severity and duration, may become life-threatening in a matter of hours. Outside the institutional setting, one particularly vulnerable population are those who depend on durable medical equipments (DMEs) that are electrically powered, such as ventilators and oxygen concentrators, in order to at a minimum sustain life for some and even maintain some degree of independence for others. This is a fully electricity-dependent population.

For transport and mobility, DMEs can be operated using batteries for a limited time. For oxygen concentrators, the battery life can be around 2 to 4 hours, and with backup external packs and used at the lowest settings, can be extended up to 12 hours. In the event of a power outage, these vulnerable persons will need to take immediate action to maintain power to their DME. Prolonged power outages can be life-threatening to individuals who rely on electricity-dependent DME and reside at home. Studies have shown increased health care utilization during power outages and, in particular, increased emergency department visits to obtain power for DME.[1-6] Previous studies have shown medically fragile individuals to be more likely to shelter in place and to be less prepared for disaster.[7,8] Upon mechanical device failure or when backup batteries fail, community-dwelling electricity-dependent individuals are likely to present to the emergency department, accounting for a large portion of avoidable admissions and potentially a large portion of power outage-associated morbidity and mortality.[1-4,6]

The year 2012 was an eventful year for natural disasters. Most notably, Hurricane Sandy caused extended power outages along the densely populated coastal Northeast/mid-Atlantic area from Delaware to Connecticut in late October 2012. At peak, 8 511 251 households were without power in 21 states.[9] It is important for public health officials to know how many and where electricity-dependent individuals reside within their jurisdictions in order to quickly and effectively communicate with them in advance of prolonged power outages.

Emergency planners have made some attempts to identify and estimate vulnerable populations and their risk factors. Such efforts have led to the development of registries identifying the electricity-dependent and those with functional needs.[10-12] However, these efforts have been limited to local efforts or to the Medicare eligible. In particular, DeSalvo et al[12] used Medicare data to identify community-dwelling electricity-dependent cardiopulmonary-compromised persons in New Orleans. They found that, while the insurance claims data were 93% accurate in identifying these vulnerable individuals, fewer than 2.5% were already present in the local special medical needs registry, indicating that the local registry severely underestimated the electricity dependent population.

Electricity-dependent individuals account for a significant minority of the noninstitutionalized population; the Census Bureau reported that approximately 19% of the 2010 noninstitutionalized population were disabled; approximately 13% were severely disabled; and more than 4% of the population required assistance with at least 1 activity of daily living.[13] With advances in medical technology and an aging population, it is entirely likely that the electricity dependent will represent a growing portion of the US population whose needs must be anticipated by emergency planners.[13]

In 2013, 37.2 million people, 12.1% of the civilian noninstitutionalized population in the United States, had a disability. More than 10% of the working age population was disabled. Of those older than 65 years, 36.5% had a disability and 23.5% had an ambulatory disability.[14] It was not possible to determine the proportion of people with a disability that relied on DME requiring electricity. It would, therefore, facilitate national public health emergency preparedness to have an estimate of the size and location of the total population medically dependent on electricity.

This study estimated the national size and prevalence of the employer-sponsored privately insured population that relies on electricity-dependent DME and resides at home. Specifically, we considered those community-dwelling individuals with cardiopulmonary compromise who are dependent upon ventilators and oxygen concentrators. We developed prevalence estimates by age, sex, and geographic location. We further applied our prevalence estimates to the national population in order to approximate the total size of the community-dwelling electricity-dependent population for the United States and its regions.

This estimate can be used to help first responders target efforts to those most vulnerable as well as help preparedness planners better estimate the resources needed for an effective response that minimizes the impact of disasters affecting the power supply. Meeting these goals will help state, territorial, and local health departments address the functional needs of this vulnerable population, especially the ability to maintain independence, avoid separation from usual caregivers and support systems, and avoid direction to unnecessarily high levels of care.

Methods

This retrospective claims analysis utilized commercially available, deidentified data from Truven Health MarketScan*, Commercial Claims and Medicare Supplemental and Coordination of Benefits Databases for the year 2012. These data included health insurance claims across the continuum of care (eg, inpatient, outpatient, outpatient pharmacy, carve-out behavioral health care) as well as enrollment data from about 100 large employers and health plans across the United States that provided private health care coverage for more than 56 million employees, their spouses, and dependents. This administrative claims database includes a variety of fee-for-service, preferred provider organizations, and capitated health plans and is nationally representative of the employer-sponsored privately insured population, which comprises about 59% of the US population. Weights provided with

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Marketscan are used to adjust the convenience sample to reflect the demographics, for example, age, sex, and geographic distribution, of the national employer-sponsored privately insured population.

We identified community-dwelling individual cases with claims for life-sustaining electricity-dependent DME. Specifically, we included enrollees who incurred outpatient claims in 2012 related to either ventilators or oxygen concentrators that also incurred claims for health care services delivered in the patient's home. The diagnostic and procedural codes used for this identification are available from the authors upon request.

We extracted 2012 enrollment data for these electricity-dependent individuals residing at home. We applied associated weights to produce a nationally representative estimate of the US employer-sponsored privately insured community-dwelling electricity-dependent population. We generated descriptive and demographic statistics describing the electricity-dependent population and examined possible associations by demographic characteristics. Specifically, we generated χ^2 test statistics to determine whether the electricity-dependent population was uniformly distributed across age, sex, and geographic region. Confidence limits were calculated for the 95th percentile of the *t* distribution of the degrees of freedom based on the weighted totals.

Using data that were weighted to be representative of the employer-sponsored privately insured population, we estimated prevalence by age group, Metropolitan Statistical Area (MSA), state, and census region. We developed tables and maps of the electricity-dependent population by sex, age group, and geographic region. On the basis of these data, we developed prevalence estimates and maps of the employer-sponsored privately insured community-dwelling electricity-dependent population in the United States for 2012.

We applied the resulting prevalence estimates of employer-sponsored privately-insured DME-dependent persons to national and regional US population estimates for 2012 in order to approximate the total size of the electricity-dependent community-dwelling population in the United States.[15] We performed all statistical analyses using SAS software version 9.3 (SAS Institute, Cary, North Carolina). Maps were created using the ArcGIS version 10.2 (ESRI, Redlands, California).[16]

Results

Descriptive statistics on the electricity-dependent population in our database are presented in Table 1. We identified 121 297 individuals dependent upon electrically powered DME who resided at home in 2012 out of approximately 56 million covered lives. After applying weights, this figure represents 366 619 (95% confidence interval: 365 700, 367 537) employer-sponsored privately insured individuals who resided at home and were dependent upon electrically powered DME nationally among the employer-sponsored privately insured population of approximately 175 million in the United States in 2012.

Fewer than 1% of the electricity-dependent were ventilator patients, while more than 99% were dependent upon oxygen concentrators. Electricity-dependent persons were fairly evenly distributed by sex but more than three-fourths were older than 65 years. Cases and proportions rose significantly with each age group (χ^2 = 264 289.95, $P < .0001$) (Table 1).

The highest proportion of electricity-dependent persons was identified in the South (~39%). While the North Central region had the largest proportion of rural living electricity-dependent individuals (~28%), the largest number living in rural settings was in the South (~32 300 cases) due to the larger population concentrated in that region.

More than three-fourths of the electricity-dependent population lived in MSAs, which for purposes of this study we defined as urban. Those individuals residing outside of MSAs were categorized as living in rural areas and comprised nearly 23%. The largest concentration of electricity-dependent persons resided in the South, followed by the West census region. We found that the distribution of electricity-dependent individuals varied significantly by region (χ^2 = 12 286.30, $P < .0001$) and rural versus urban (χ^2 = 28 311.79, $P < .0001$) (Table 1 and Figure).

Table 2 presents prevalence by age group and by region. The national community-dwelling electricity-dependent prevalence estimate was 218.23 cases per 100 000 lives (95% confidence interval: 217.7-218.8) based on employer-sponsored privately insured people. After the first year of life, prevalence rose by an order of magnitude in each age group and was highest among the oldest age group at 2185.3 cases per 100 000 covered lives (95% confidence interval: 2178.1-2192.4).

As presented in Table 2, the Figure, and Appendices A and B (see Supplemental Digital Content Appendix, available at http://links.lww.com/JPHMP/A177 and http://links.lww.com/JPHMP/A178), prevalence varied considerably across regions, states, and MSAs. Electricity-dependent prevalence was highest in the South and West regions, where it did not differ significantly. Prevalence was lowest in the Northeast. Five of the 10 highest prevalence MSAs were in the West, while 4 were in the South. The Figure shows that the states with highest prevalence of at-home electricity-dependent population were Wyoming, Colorado, and Montana. Prevalence in 28 states exceeded the national prevalence of 218.2 cases per 100 000 lives.

The Figure presents electricity-dependent prevalence by state and by MSA, weighted to be representative of the privately insured in the United States. Ranges used in the figure are based on the quintiles of the prevalence and population distributions. Prevalence estimates by MSA are presented in the Appendix B (see Supplemental Digital Content Appendix, available at http://links.lww.com/JPHMP/A178). While prevalence is highest in Wyoming, Colorado, and Montana, because of population concentrations, the largest numbers of electricity-dependent individuals resided in California, Florida, Michigan, New York, and Texas. Note that while Florida was an average prevalence state, it included some of the highest prevalence MSAs. Arizona presented similarly. This may reflect the concentration of retirees in certain MSAs in these states.

Table 3 presents national and regional estimates of the size of the electricity-dependent population overall and for the employer-sponsored privately insured. The total national population number was calculated by applying our national prevalence estimate, 218.2 per

100 000, to the national Census population estimate. This yielded a national electricity-dependent population estimate of more than 685 000. Similarly, regional population numbers were calculated by applying our regional prevalence estimates to regional Census population estimates. Regional electricity-dependent population estimates ranged in size from approximately 101 000 in the Northeast to approximately 284 000 in the South.

Discussion

The success of medical care has advanced life expectancy in the United States to age 78.8 years and as a result has fostered an expanding population that is both chronically ill and aging—and is a concern to public health, health care, and emergency management.[17,18] In the case of a widespread emergency, whether natural or man-made, a growing and aging population means that increasing numbers of residents with disabilities and special needs will reside within the community and require specialized resources.[13] Disasters do not have to be large-scale events with a damaged infrastructure, but simply the loss of electrical power covering large geographic areas and persisting beyond a few hours could have a significant impact on select groups. This is the unique challenge for the electricity-dependent population that live in the community outside of institutional settings, a group that will always need ready access to electrical power to keep their DMEs running. This study provides the first national prevalence estimates (by age and by region) per 100 000 insurance-covered lives of those on electrically powered DMEs by using aggregate claims data.

Emergency planners in the public and health care sectors are already anticipating the steadily growing and aging population.[18] United States Census projections anticipate that those aged 65 years and older will comprise nearly 17% of the total population by 2020 and nearly 21% by 2030.[15] Senior Americans are the demographic more likely to be beset by chronic diseases that consume more medical resources and also hampered by one or more disabilities that can affect mobility and/or self-care.[17] This suggests that the electricity-dependent population will grow steadily in the near future and faster in areas with large concentrations of elderly populations.

Although a power outage, however brief, may be considered a nuisance, it has the potential to cause medical decompensation that may be life-threatening. In the national estimate, more than 99% of the DMEs under study are oxygen concentrators, a device that enables people with certain cardiopulmonary diseases the ability to move about, and even travel, without being tethered to a canister or tank of oxygen. However, a concentrator is limited by its battery life when not plugged into an energy source. There are a number of oxygen concentrators available, differing in size, weight, battery life, and functions. At the lowest settings, most will last 3 to 4 hours (selected models up to 6 hours), but there are a few models that can last 8 or more hours with an additional battery. However, planners cannot assume that all patients using a concentrator use the minimal setting, and higher settings will shorten battery life significantly. Those using higher settings are also more likely to decompensate faster and need medical intervention sooner.

As many emergency preparedness planners and directors continue to develop their emergency operation plans for the next disaster, one small part is populating a list of the special populations that are medically dependent, such as special needs children, medically disabled and immobile persons, hemodialysis recipients, and so forth. However, there still do not appear to be fully populated, functional registries in place that allow identification of such vulnerable people, so that in times of disaster, they can be contacted and assisted. Because this is patient-identified health care information, all health providers have to adhere to the Health Insurance Portability and Accountability Act privacy rules. Although public health has exemptions to investigate and intervene in the best interests of the community, providers are still reluctant to work with public officials for fear of violating privacy rules and incurring severe penalties.

It is unclear to what extent the people with DMEs are prepared for disaster. There have been numerous surveys of states and communities looking into whether they have enough food, water, emergency supplies (such as batteries) and medications. While it has been shown that the medically vulnerable are more likely to shelter in place and have medication on hand, they are generally less prepared for emergencies.[7,8] No studies specifically consider at-home preparedness for those with DMEs, such as home generators and other alternate power sources, extra batteries for their DME, and/or an evacuation plan with possible destinations with the necessary resources.

This study includes several limitations. We do not consider the universe of electricity-dependent individuals. Our prevalence estimates are based on privately insured individuals. The smallest geographic area for which we produce prevalence estimates is the MSA. Marketscan data for 2012 did not include county-level information and, therefore, county-level estimates could not be produced.

We consider only those dependent upon oxygen concentrators and/or mechanical ventilators. The population dependent on electrically powered DME does include a wider range of individuals such as those receiving hemodialysis and peritoneal dialysis. However, dialysis patients have a longer range of time to acquire treatment in the case of power outage, measured in days rather than hours. Those receiving hemodialysis are typically treated at clinics that have organizational emergency procedures in place in the event of extended power outage. Peritoneal dialysis can be accomplished manually without electrically powered DME. The number of peritoneal dialysis patients in our sample was very small and did not provide sufficient numbers to achieve statistical precision.

Our prevalence estimates are based on the employer-sponsored privately insured and those Medicare-eligible individuals who are covered by employer-sponsored supplemental insurance. As such, Marketscan is a convenience sample. It has been well documented that health status and health care utilization vary by insurance status and coverage.[19-22] In general, less insurance coverage has been associated with poorer health outcomes. Because prevalence can vary across insurance types, the application of our prevalence estimates to the general US population may result in biased national estimates. The resulting estimate of total national cases may, therefore, underestimate the true size of the population and should be considered only an approximation.

While prevalence estimates of numbers of electricity-dependent people can be made down to the state and MSA level, these geographic areas are still broad and prevalence is likely to vary within as well as between these geographic areas. Indeed, our results indicate that prevalence varies within and between regions and states and varies between MSAs. Public health officials, emergency planners, and health care providers involved in disaster planning should not assume that prevalence estimates for their state or MSA can be readily applied to different geographic units, such as counties and cities. Accordingly, resource requirements to meet the needs of this vulnerable population will vary across jurisdictions, and national and state budgets aimed at addressing these resource needs should reflect that variation. It is worth noting that the current Public Health Emergency Preparedness grant system includes a funding stream dedicated to the emergency readiness of cities, the Cities Readiness Initiative, which could be leveraged to anticipate the needs of vulnerable populations within MSAs.

Despite being approximations, these findings can inform public health agencies and emergency management agencies in anticipating and approximating the resource needs to protect this particularly vulnerable population during a prolonged power outage. Jurisdictions with high prevalence might consider devoting resources to establishing and promoting temporary emergency power stations for use by the electricity-dependent population during extended power out-ages. By routing individuals dependent on electricity-driven DME toward these temporary power stations during emergencies, avoidable emergency department visits and hospitalizations can be reduced and emergency department crowding may be alleviated.

Further research will examine the health care utilization of those who have experienced prolonged power outages and assess the health care burden attributable to those power outages. We will also estimate the size of the community-dwelling publically insured electricity-dependent population and examine how electricity-dependent prevalence varies by insurance coverage and type.

A national estimate of the community-dwelling population dependent on electricity-driven medical devices can help public health emergency preparedness planners anticipate the resources needed for first responders to target and prioritize efforts aimed at those most vulnerable to disasters affecting the power supply. The comprehensive geographic identification via insurance claims data of community-dwelling people dependent on electricity-driven medical devices can be used to enhance the development of functional needs registries. These registries can in turn help first responders target efforts to those most vulnerable as well as help planners better estimate the resources needed for an effective response that minimizes the impact of disasters affecting the power supply. Meeting these goals will help state, territorial, and local health departments address the functional needs of this vulnerable population, especially the ability to maintain independence, avoid separation from usual caregivers and support systems, and avoid direction to unnecessarily high levels of care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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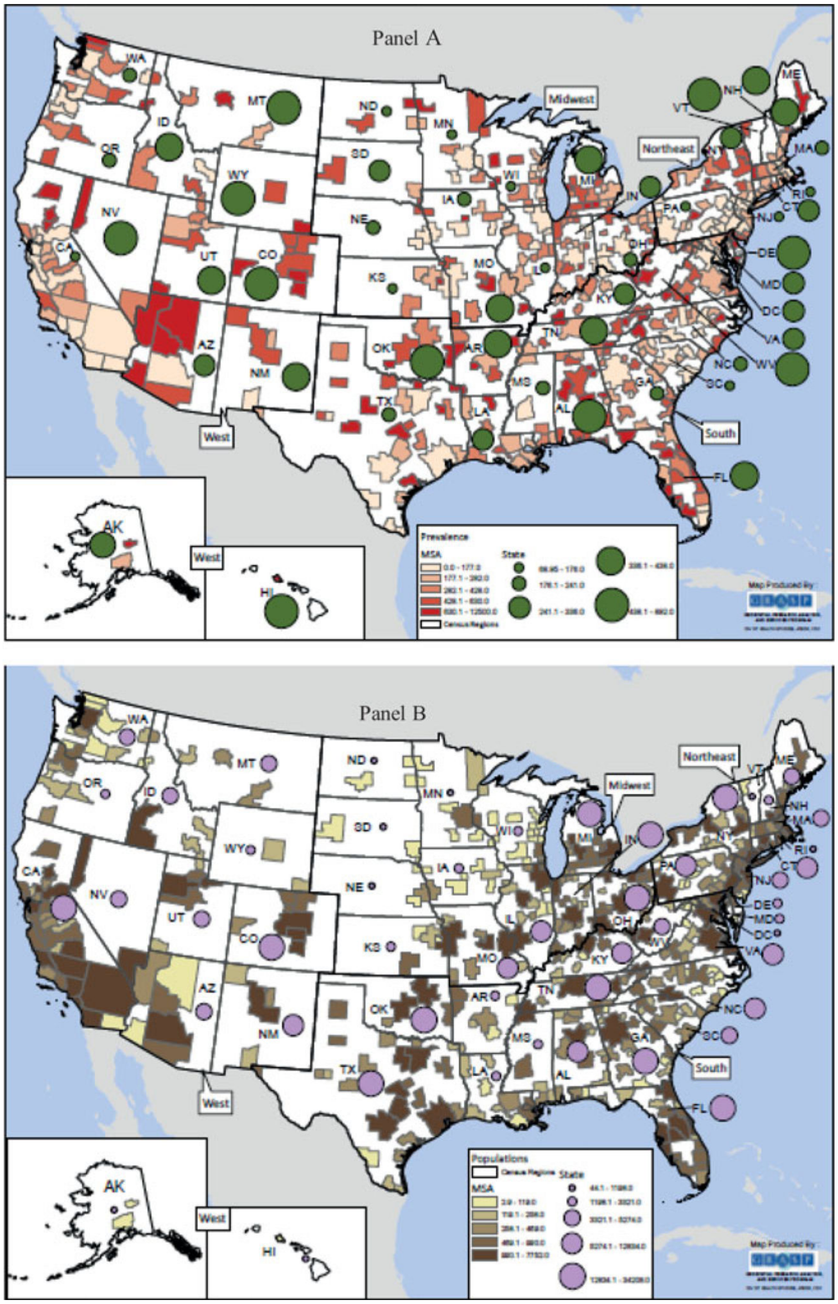

FIGURE.

National Employer-Sponsored Privately Insured Electricity-Dependent Residing at Home in the United States, Prevalence per 100 000 Covered Lives and Population, 2012[a]

[a]Prevalence by state and Metropolitan Statistical Area (MSA) are displayed in Panel A. Distribution of electricity-dependent populations by state and MSA are displayed in Panel B. Prevalence and population estimates are based on Truven Health MarketScan® data, 2012.

TABLE 1

Demographic Characteristics of Sample of Community-Dwelling Privately Insured Electricity-Dependent in the United States, 2012[a]

	N	Weighted N	95% Confidence Interval		Weighted Percent
DME					
Ventilator	1040	3143	2943	3343	0.86
Oxygen concentrator	120 257	363 475	362 539	364 411	99.14
Sex					
Male	54 825	184 663	183 418	185 908	50.50
Female	66 472	181 020	179 837	182 203	49.50
Age group, y					
<1	311	885	786	984	0.24
1-17	1073	3072	2888	3257	0.84
18-49	5766	16 944	16 506	17 382	4.63
50-64	18 833	58 535	57 752	59 318	15.97
65+	95 314	287 183	285 949	288 416	78.33
Urbanicity[b]					
Rural[b]	27 189	83 946	82 933	84 958	22.90
Urban	94 108	282 673	281 524	283 822	77.10
Census region					
Northeast	20 526	57 998	57 164	58 833	15.82
North Central	28 245	74 461	73 592	75 330	20.31
South	40 283	142 300	141 086	143 514	38.81
West	32 095	91 421	90 431	92 411	24.94
Unknown	148	438	358	518	0.12
Total	121 297	366 619	365 700	367 537	100.00

Abbreviation: DME, durable medical equipment.

[a]Estimates based on data from Truven Health MarketScan data from 2012.

[b]Rural: Residing outside of Metropolitan Statistical Area.

TABLE 2

Prevalence of Community-Dwelling Electricity Dependent by Age Group and by Region in the United States, 2012[a]

	Prevalence[a] per 100 000 Covered Lives	
	Point Estimate	**95% Confidence Interval**
Age group		
<1 y	31.0	27.6-34.4
1-17 y	9.0	8.4-9.5
18-49 y	21.8	21.3-22.4
50-64 y	146.9	145.0-148.7
65+ y	2,185.3	2178.1-2192.4
Region		
Northeast	180.8	178.3-183.3
North Central	190.4	188.3-192.6
South	241.9	239.9-243.9
West	242.0	239.5-244.5
Overall mean	218.2	217.7-218.8

[a]Estimates based on data from Truven Health MarketScan data, 2012.

TABLE 3

Estimated Community-Dwelling Electricity-Dependent Population in the United States, 2012

	All Persons[a]		Employer-Sponsored Privately Insured[b]		
	Total Cases	**95% Confidence Interval**	**Cases**	**95% Confidence Interval**	**% Total Cases**
United States	685 482	683 810-687 153	366 619	365 700-367 537	53.48
Northeast	100 963	99 569-102 355	57 998	57 164-58 833	57.44
North Central	128 215	126 782-129 647	74 461	73 592-75 330	58.08
South	283 855	281 536-286 173	142 300	141 086-143 514	50.13
West	178 102	176 271-179 931	91 421	90 431-92 411	51.33

[a] Applies prevalence estimates to US Census 2012 national and regional population estimates.

[b] Prevalence estimates based on national and regional data from Truven Health MarketScan data, 2012.