Effects of Climate, Latitude, and Season on the Incidence of Bell’s Palsy in the US Armed Forces, October 1997 to September 1999

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Bell’s palsy is a relatively common disease characterized by the sudden onset of unilateral facial paralysis. Using a centralized surveillance system that contains demographic, military assignment, and medical encounter data of US military service members, the authors estimated rates, trends, and demographic correlates of risk of Bell’s palsy during a 2-year period. Poisson regression was used to estimate the independent effects of climate, season, and latitude. From October 1997 to September 1999, there were 1,181 incident cases of Bell’s palsy among US service members. The crude incidence rate was 42.77 per 100,000 person-years. Incidence rates increased with age and were higher among females, Blacks, Hispanics, married persons, and enlisted service members. Both climate (adjusted rate ratio for arid vs. nonarid climate = 1.34) and season (adjusted rate ratio for cold vs. warm months = 1.31) were independent predictors of risk of Bell’s palsy. Latitude was not a statistically significant predictor when demographic, climate, and season effects were taken into account. The results are consistent with hypotheses regarding viral etiologies (e.g., reactivation of herpes simplex) of Bell’s palsy. Am J Epidemiol 2002;156:32–9.

Bell palsy; climate; facial paralysis; military personnel; seasons

Abbreviation: HSV–1, herpes simplex virus type 1.

Bell’s palsy is the sudden onset of unilateral dysfunction of the seventh cranial nerve that results in the paralysis of the facial muscles on the affected side of the face. Although Bell’s palsy is a well-known and relatively common condition, its epidemiology is unclear. Estimates of the incidence of this disease in the United States range from 13 to 34 cases per 100,000 per year (1); worldwide, estimates range from 11.5 to 40.2 cases per 100,000 per year (2). Most studies have found comparable rates between males and females (3). Several studies have suggested that Bell’s palsy is more common among young and middle-aged adults (4), although others have documented rates that increased with age (3). Findings of associations between the risk of developing Bell’s palsy and seasonal (2, 5), geographic (4), racial/ethnic (2), and environmental (6) factors have been inconsistent.

There is an emerging consensus that most cases of Bell’s palsy are caused by reactivations of latent herpes virus type 1 (HSV–1) infections of geniculate ganglia of facial nerves (2, 3, 7–14). These reactivations lead to inflammation, swelling, compression, and, ultimately, dysfunction of affected facial nerves. It is unclear what stimuli most commonly trigger these reactivations.

Published studies estimating the incidence of Bell’s palsy, particularly in the United States, have generally focused on state or community samples (2, 15, 16). To our knowledge, there have been no studies of incidence of Bell’s palsy among members of military populations, although these groups can be particularly valuable for descriptive studies of this disease. For example, US military forces are widely dispersed over many geographic locations. These forces are large enough that statistically meaningful numbers of cases can occur in subgroups of interest in relatively short periods of time. Finally, all members have access to a worldwide system of health care in which most hospitalizations and outpatient visits are documented in standardized, automated records. Accordingly, for this study, we estimated incidence...
rates of Bell’s palsy overall and in demographic subgroups of active-duty US military personnel. In addition, we estimated the independent effects of climate, latitude, and season on the incidence of the disease.

MATERIALS AND METHODS

Data sources

All demographic and medical encounter data were taken from the Defense Medical Surveillance System. This electronic system is a collection of demographic, health risk, exposure, and medical encounter databases that are available for health surveillance of the active-duty military population. The Army Medical Surveillance Activity, under the US Army Center for Health Promotion and Preventive Medicine, routinely and systematically collects these data from multiple sources, maintains the system, and monitors the quality of the data. Personal identifiers permit the linkage of these separate databases, yielding a longitudinal picture of military careers. Medical encounter data available to this system include administrative records of hospitalizations and outpatient visits to military medical treatment facilities worldwide. Diagnoses for both hospitalizations and outpatient visits are assigned using the International Classification of Diseases, Ninth Revision, Clinical Modification.

Climate data were obtained from the Idaho State Climate Services of the University of Idaho. Researchers from this division obtained precipitation, temperature, and elevation data from the Oregon Climate Service and used a geographic information system to create climate zone grids based on the Köppen climate classification system (17, 18). The Köppen system, originally developed in the early 1900s, is a widely recognized and commonly used climate classification system (19, 20). The system groups land areas into climatic categories based on characteristics (e.g., extremes, ranges, central tendencies) of temperature, precipitation, and aridity (21). We downloaded the climate zone grids from the Idaho State Climate Services website and mapped them to ZIP codes within the continental United States (22). For our analyses, we used the Köppen classification of “dry climate” as our single indicator of climate, since it could be directly applied to all regions of the continental United States and was not highly correlated with other factors under investigation (i.e., latitude and season).

Case definition

For this study, all hospitalization and outpatient records were searched to identify visits that resulted in a primary diagnosis of Bell’s palsy (International Classification of Diseases, Ninth Revision, Clinical Modification code 351.0) between October 1, 1997 and September 31, 1999. Incident cases were defined as those active-duty service members whose first Bell’s palsy diagnosis occurred during the study period.

Data analysis

Crude incidence rates per 100,000 person-years were calculated overall and for demographic subgroups. Adjusted incidence rates, controlling for gender, age group (17–24, 25–29, 30–39, and 40–65 years), self-reported race/ethnicity (Black, Hispanic, White/other), marital status (married, unmarried), grade (enlisted, officer), service (Army, Navy, Air Force, Marines), and region (outside the continental United States, North, Southeast, and Southwest/South Central) were estimated through a series of backward-elimination Poisson regression analyses. Adjusted rate ratios and corresponding 95 percent confidence intervals were computed for each demographic subgroup.

To assess the relations of climate, latitude, and season to the incidence of Bell’s palsy, we restricted analyses to active-duty personnel who were assigned to the continental United States during some or all of the study period. A climate classification (arid or nonarid) was assigned to each case based on ZIP code at the time of first diagnosis (figure 1). Three bands of latitude (based on assignment ZIP codes) were defined such that each band included approximately one third of the total person-time of exposure to risk during the study period. Finally, each case was characterized by season of onset on the basis of the month in which Bell’s palsy was first diagnosed. Seasons were classified as “warm” (May through September), “cold” (November to March), and “transitional” (April and October). Seasonal variations in incidence of Bell’s palsy were assessed by comparing month-specific rates with the crude overall rate. Poisson regression was used to estimate the independent effects of climate, latitude, and season on the incidence of Bell’s palsy while controlling for the potentially confounding effects of demographic characteristics. Analyses were conducted using ORACLE version 8 (Oracle Corporation, Redwood Shores, California) and SAS version 8 (SAS Institute, Inc., Cary, North Carolina).

RESULTS

Overall

There were 1,181 incident cases of Bell’s palsy identified among active-duty military service members during the 2-year surveillance period (table 1). The crude incidence rate was 42.77 cases per 100,000 person-years. The incidence rate of Bell’s palsy was slightly higher for females than for males (crude rate ratio = 1.12). The incidence rate, which increased with age, was twice as high for those in the oldest age group compared with those in the youngest age group. Blacks and Hispanics had higher rates did than those in the White/Asian/Native American group (crude rate ratio = 1.35 and 1.54, respectively). Incidence rates were higher among married service members compared with their unmarried counterparts (crude rate ratio = 1.64) and among enlisted personnel compared with officers (crude rate ratio = 1.26). Finally, rates were higher among Air Force and Navy personnel (crude rate = 46.20 and 45.46 per 100,000 person-years, respectively) than among soldiers (Army) or Marines (crude rate = 40.28 and 36.51 per 100,000 person-years, respectively).

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Incidence rates of Bell’s palsy varied by geographic region. In general, the rates were higher in the southern regions of the United States compared with the northern region and with areas outside the continental United States.

Simultaneous adjustment for demographic characteristics and geographic region did not substantially change the relations revealed by analysis of the crude rates (table 1).

Continental United States

To examine the relations between climate, latitude, and season to the incidence of Bell’s palsy, further analyses were restricted to those personnel assigned to the continental United States during the study period. The demographic characteristics of this subpopulation were almost identical to those of the active-duty military (data not shown). There were, however, relatively fewer Navy personnel assigned to the continental United States. The overall crude incidence rate of Bell’s palsy in the subpopulation was 46.67 per 100,000 person-years.

Climate. Crude incidence rates were approximately 33 percent higher among those assigned to arid regions of the United States compared with those who were assigned to nonarid regions of the country (figure 1 and table 2).

Latitude. Crude incidence rates were approximately 15 percent higher among those assigned to the southern latitude band of the United States compared with those assigned to the middle and northern latitude bands (figure 1 and table 2).

Season. Crude incidence rates during the colder months of the year (November to March) were consistently higher than the upper 95 percent confidence bound of the overall rate, while the crude incidence rates during the warmer months of the year (May to September) were consistently lower than the lower 95 percent confidence bound of the overall rate (figure 2). Crude incidence rates during transitional months (October and April) were within the 95 percent confidence bounds of the overall rate.

Multivariate analysis. After simultaneous adjustment for demographic characteristics, climate, latitude, and season, both climate (adjusted rate ratio for arid vs. nonarid climate = 1.34) and season (adjusted rate ratio for cold vs. warm months = 1.31) were found to be significant independent predictors of Bell’s palsy risk (table 2). Latitude was not found to be a significant predictor of Bell’s palsy risk when demographic, climate, and season effects were taken into account (table 2). Adjusted rate ratios for demographic subgroups were similar to those for the US Armed Forces as a whole, with the exception that females had significantly higher incidence rates than did males (adjusted rate ratio = 1.26, 95 percent confidence interval: 1.05, 1.51) (data not shown).

DISCUSSION

In this study, we observed a Bell’s palsy incidence rate of 42.77 per 100,000 person-years among active-duty members of the US Armed Forces. Studies in nonmilitary US populations have reported rates of 13 to 34 cases per 100,000 per year (1, 2). There are several potential explanations for the relatively high rate observed in this study. First, case ascertainment may have been more complete in this than in other studies, since US service members have unlimited access to “free” health care, and almost all care in fixed military medical treatment facilities worldwide is documented in the Defense Medical Surveillance System. Second, we may have included misdiagnoses of other conditions (e.g., Ramsay Hunt’s syndrome, a facial palsy that is caused by reactivation of the varicella zoster virus (23)), since we relied on administrative data to identify cases. Finally, incidence rates may be higher in military than in nonmilitary populations.
If most cases of Bell’s palsy are indeed caused by reactivated herpes virus infections, then persons with prior HSV–1 infections should be at higher risk of Bell’s palsy than others in the same populations. In addition, persons with Bell’s palsy should be demographically similar to those with latent HSV–1 infections when populations are uniformly exposed to competent triggers of HSV–1 reactivation. In this study, Bell’s palsy rates increased with age; were slightly higher among females than among males; and were relatively high among Hispanic, intermediate among Black non-Hispanic, and low among White non-Hispanic service members. In studies of various nonmilitary US populations, prevalences of antibodies to HSV–1 (indicative of prior infections) generally increased with age; were higher in females than in males; and were relatively high among Hispanics, intermediate among African Americans, and low among White non-Hispanics from the same populations (24–29). Thus, our findings are consistent with the hypothesis that reactivated

### TABLE 1. Incident cases of Bell’s palsy in US Armed Forces, October 1997 to September 1999

<table>
<thead>
<tr>
<th></th>
<th>Incident cases</th>
<th>Person-years</th>
<th>Crude rate per 100,000 person-years</th>
<th>Adjusted*,† rate ratio</th>
<th>95% confidence interval</th>
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</thead>
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<tr>
<td><strong>Total</strong></td>
<td>1,181</td>
<td>2,761,496</td>
<td>42.77</td>
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<td><strong>Gender</strong></td>
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<tr>
<td>Female</td>
<td>182</td>
<td>386,479</td>
<td>47.09</td>
<td>1.16</td>
<td>0.98, 1.36</td>
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<td>Male</td>
<td>999</td>
<td>2,374,995</td>
<td>42.06</td>
<td>1.00</td>
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<td><strong>Age group (years)</strong></td>
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<td></td>
<td></td>
<td></td>
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<td>17–24</td>
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<td>1,062,505</td>
<td>29.08</td>
<td>1.00</td>
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<td>25–29</td>
<td>262</td>
<td>580,561</td>
<td>45.13</td>
<td>1.48</td>
<td>1.24, 1.77</td>
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<td>30–39</td>
<td>451</td>
<td>860,004</td>
<td>52.44</td>
<td>1.68</td>
<td>1.42, 1.99</td>
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<td>40–65</td>
<td>159</td>
<td>258,379</td>
<td>61.54</td>
<td>2.16</td>
<td>1.74, 2.69</td>
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<td><strong>Race/ethnicity</strong></td>
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<td>Black</td>
<td>287</td>
<td>551,645</td>
<td>52.03</td>
<td>1.28</td>
<td>1.11, 1.48</td>
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<td>Hispanic</td>
<td>116</td>
<td>195,358</td>
<td>59.38</td>
<td>1.62</td>
<td>1.33, 1.98</td>
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<td>White/other</td>
<td>778</td>
<td>2,013,799</td>
<td>38.63</td>
<td>1.00</td>
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<tr>
<td><strong>Marital status</strong></td>
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<tr>
<td>Married</td>
<td>806</td>
<td>1,572,782</td>
<td>51.25</td>
<td>1.31</td>
<td>1.13, 1.51</td>
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<tr>
<td>Not married</td>
<td>371</td>
<td>1,185,449</td>
<td>31.30</td>
<td>1.00</td>
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<tr>
<td><strong>Grade</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enlisted</td>
<td>1,025</td>
<td>2,315,662</td>
<td>44.26</td>
<td>1.58</td>
<td>1.32, 1.89</td>
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<td>Officer</td>
<td>156</td>
<td>443,788</td>
<td>35.15</td>
<td>1.00</td>
<td></td>
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<tr>
<td><strong>Branch of service</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Army</td>
<td>382</td>
<td>948,352</td>
<td>40.28</td>
<td>0.81</td>
<td>0.70, 0.95</td>
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<td>Air Force</td>
<td>335</td>
<td>725,110</td>
<td>46.20</td>
<td>0.93</td>
<td>0.79, 1.09</td>
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<tr>
<td>Marines</td>
<td>125</td>
<td>342,352</td>
<td>36.51</td>
<td>0.84</td>
<td>0.68, 1.04</td>
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<tr>
<td>Navy</td>
<td>339</td>
<td>745,682</td>
<td>45.46</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>Region†</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>100</td>
<td>298,192</td>
<td>33.54</td>
<td>0.64</td>
<td>0.51, 0.80</td>
</tr>
<tr>
<td>Outside CONUS‡</td>
<td>302</td>
<td>785,817</td>
<td>38.43</td>
<td>0.73</td>
<td>0.62, 0.85</td>
</tr>
<tr>
<td>Southeast</td>
<td>383</td>
<td>867,121</td>
<td>44.17</td>
<td>0.87</td>
<td>0.75, 1.00</td>
</tr>
<tr>
<td>Southwest/south central</td>
<td>380</td>
<td>753,881</td>
<td>50.41</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

* Adjusted for gender, age, race, marital status, grade, service, and region.
† Based on 1,165 cases.
‡ CONUS, Continental United States.
HSV–1 infections cause Bell’s palsy; furthermore, they support the idea that exposures that most commonly trigger HSV–1 reactivations are uniformly distributed in general populations.

Laboratory and clinical studies have identified several factors that may trigger reactivation of latent HSV–1 infections. These factors fall into three general categories: physical stressors (e.g., ultraviolet radiation, local trauma, coinfections, cold) (30–35), psychological stressors (e.g., social stress, mood disorders) (36–41), and immunosuppressed states (e.g., secondary to cancers, burns, HIV–1 infection, transplantation, chemotherapy) (42–48). The findings of this study can be assessed in relation to these categories.

TABLE 2. Incident cases of Bell’s palsy in US Armed Forces assigned to the continental United States, October 1997 to September 1999

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>Person-years</th>
<th>Crude rate per 100,000 person-years</th>
<th>Adjusted* rate ratio</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>863</td>
<td>1,849,055</td>
<td>46.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arid climate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Yes</td>
<td>212</td>
<td>364,460</td>
<td>58.17</td>
<td>1.34</td>
<td>1.14, 1.57</td>
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<tr>
<td>No</td>
<td>651</td>
<td>1,484,595</td>
<td>43.85</td>
<td>1.00</td>
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</tr>
<tr>
<td>Latitude</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25–32</td>
<td>308</td>
<td>602,758</td>
<td>51.10</td>
<td>1.13</td>
<td>0.96, 1.33</td>
</tr>
<tr>
<td>33–36</td>
<td>280</td>
<td>623,218</td>
<td>44.93</td>
<td>1.00</td>
<td>0.85, 1.20</td>
</tr>
<tr>
<td>37–48</td>
<td>275</td>
<td>623,080</td>
<td>44.14</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transitional (April and October)</td>
<td>145</td>
<td>311,855</td>
<td>46.50</td>
<td>1.13</td>
<td>0.93, 1.38</td>
</tr>
<tr>
<td>Cold (November to March)</td>
<td>406</td>
<td>766,396</td>
<td>52.98</td>
<td>1.31</td>
<td>1.13, 1.51</td>
</tr>
<tr>
<td>Warm (May to September)</td>
<td>312</td>
<td>770,804</td>
<td>40.48</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

* Adjusted for sex, age group, race, marital status, grade, season, latitude, and climate

FIGURE 2. Bell’s palsy incidence rates and 95% confidence intervals by month in US Armed Forces assigned to the continental United States, October 1997 to September 1999.
Our results indicate that two physical stressors, residence in an arid climate and exposure to cold, are independent predictors of Bell’s palsy. Results from other studies that examined relations between facial paralysis and climate (6, 49) were inconclusive. Although a study in southern Israel, which has a desert climate, reported an incidence rate that was substantially higher than rates found in most other studies (2, 50), to our knowledge, ours is the first study to show that residence in an arid region is associated with increased risk of Bell’s palsy.

Low humidity has not been directly associated with herpes virus reactivation. However, breathing cold, dry air has measurable physiologic effects on the respiratory tract (51–54). A study of participants in a military training exercise found that those who trained during hot, humid weather had significantly less lip damage (including reactivated herpes infections) than did those who trained in hot, dry weather (55). The authors suggested that a critical risk factor may be low humidity. In a similar study during cold weather, soldiers who trained when outdoor temperatures were lowest had higher lip injury rates (including reactivated herpes infections) than did those who trained in less cold temperatures. The group with the higher injury rate spent more time indoors—and thus had less overall exposure to outdoor air and ultraviolet radiation—than did the lower-injury group (56). The authors hypothesized that prolonged exposure to dry indoor air may be a critical determinant of lip injury risk. The findings of our study suggest that cold, dry air (especially when heated but not humidified for indoor use), such as that in arid areas during winter months, may traumatize mucus membranes of the nasopharynx, which may, in turn, induce reactivations of herpes infections.

In our study, Bell’s palsy rates were relatively high during cold seasons of the year. Furthermore, the increased risk associated with cold months was independent of demographic, climate, and latitude effects. While results of other studies have been inconsistent in this regard (2, 5, 49, 57), when seasonal variations in Bell’s palsy rates were observed, they were generally lower in summer.

Exposure to cold may trigger reactivation of HSV–1; however, there is little empirical support for this association. Large variations in day-night temperatures (common in desert environments) and frequent, sudden, and/or prolonged exposures to cold outdoor air (common for military personnel during winter months) may induce vasomotor changes in facial areas, initiate the development of edematous neuritis by reflex ischemia (58), and/or provoke the reactivation of HSV–1 in ganglion cells (59). On the other hand, while temperatures are generally colder in winter months, they are generally warmer in southern latitudes (where Bell’s palsy rates were relatively high). Thus, it is not clear that cold outdoor air has a significant independent effect on risk of Bell’s palsy.

In controlled settings, ultraviolet radiation reliably triggers reactivations of latent herpes infections (31, 32, 35). Ultraviolet radiation is generally stronger at higher elevations and in areas with low average cloud covers (60). In the United States, areas at high elevations and/or with low cloud covers tend to be arid (61). Thus, ultraviolet radiation tends to be high in arid areas (where Bell’s palsy rates were high). On the other hand, there is more ultraviolet radiation in summer (when Bell’s palsy rates were low) than in winter (when rates were high). We conclude that some of the climate-related (but not season-related) variability in Bell’s palsy risk may be related to ultraviolet radiation.

Certain psychological stressors also may trigger reactivation of latent HSV–1 infections. Seasonal affects on mood (e.g., seasonal affective disorder) (62, 63) are well documented; furthermore, depression has been associated with increased susceptibility to infectious illnesses such as the common cold (64). However, to our knowledge, mood changes and immunosuppression have not been associated with arid climates. It is possible that immunosuppression secondary to mood changes may explain some of the seasonal variation in risk of Bell’s palsy.

Finally, studies and clinical observations have documented that coinfections (e.g., upper respiratory viral infections) often trigger reactivations of latent herpes infections (e.g., cold sores) (30, 33). It is not clear, however, whether other infections often precede the onset of Bell’s palsy. In general, acute respiratory illnesses are most common from late fall through early spring (when Bell’s palsy rates in our study were highest). In addition, very low humidity (common in arid regions during winter months) may lead to dehydration of nasopharyngeal mucosal surfaces and, in turn, to increased susceptibility to upper respiratory infections. To the extent that upper respiratory infections can trigger reactivations of herpes infections of facial nerve ganglia, they may account for some of the season- and climate-related effects found in this study. More detailed studies are necessary to clarify relations between temperature, humidity, respiratory tract infections, and risk of Bell’s palsy.

In conclusion, during a 2-year surveillance period, members of the US Armed Forces experienced a relatively high incidence of Bell’s palsy. Arid climates and cold seasons were significant independent correlates of Bell’s palsy risk. Southern latitude was a weak, but not statistically significant, correlate of risk. The findings are consistent with the hypothesis that reactivations of herpes virus type 1 infections cause most cases of Bell’s palsy. Low humidity, cold temperatures, ultraviolet radiation, coinfections of the upper respiratory tract, and dry indoor air should be assessed as possible triggers of this disease.

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REFERENCES