RGA Global Research and Development

Research Bulletin

The Seasonality of Mortality

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Executive Summary

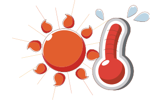
Human mortality rates often follow seasonal trends. The magnitude of seasonal influences varies significantly by cause of death and by a variety of geographic and demographic drivers. Some of the results may be intuitive, but many defy commonly held beliefs:

- Mortality is generally worse in the winter than the summer, although the magnitude varies by cause of death, age and many other demographic, geographic and socio-economic factors.
  - Older ages experience worse winter mortality while younger ages (especially younger men) have worse summer mortality.
  - Individuals with more years of education experience less seasonal mortality variations.
  - Medical causes of death are generally worse during the winter while accidental death rates spike in the summer.
  - Geographical areas with colder winters have less winter mortality seasonality than warmer climates.
- Although it is somewhat muted by volatility and a younger age mix, RGA's U.S. mortality block experiences similar seasonal effects as the broader U.S. population.
- Analysis of a broad cross-section of U.S. life insurance companies indicates consistent seasonal trends with adverse Q1 claims experience.
- Many theories have been advanced to explain why mortality is seasonal, including biomedical, external, and behavioral factors.
- Mortality varies not only by month of death, but also by month of birth.

Contents

Seasonality Myths

Before delving any further, it is worth debunking some of the more common misconceptions associated with mortality seasonality.



Myth #1: There are more heat-related deaths than cold-related deaths

Reality:

There are many tragic cases of heat-related death that are covered extensively in the media during prolonged heat waves. Some researchers have even theorized that global warming will lead to elevated mortality due to increased cases of heatstroke. The reality, however, is that cold-related deaths are far more numerous. In general, mortality rates are 10-20% higher in the winter months than in the summer months.

Grain of truth

Younger ages and accidental causes of death often show reverse seasonal trends with higher mortality rates during the summer. In addition, ancient historical periods often experienced worse mortality in the summer.

Myth #2: Excess deaths in the winter are exclusively attributable to influenza

Reality

The total number of influenza cases in any given year is a relatively small portion of total mortality. In a typical season, flu deaths contribute about 2-3% of the totals. Excess winter deaths are primarily a result of circulatory (cardiovascular and cerebrovascular) and other respiratory causes of death.

Grain of truth

Influenza is one of the most seasonal causes of death. Flu seasons that exceed the epidemic threshold will cause the magnitude of winter seasonality to be more severe than average. Influenza also leads to compromised immune systems and often contributes to more serious conditions resulting in death.

Myth #3: Colder climates must experience worse winter mortality than warmer climates

Reality

Countries (or states) that have colder average winters actually experience less seasonality than their warmer counterparts. Residents of colder climates must be better acclimated to the weather or more prepared for its risk factors.

Grain of truth

There is not much to support this myth. Despite intuition to the contrary, warmer climates have relatively worse winter mortality than cold climates.

Myth #4: Increased depression leads to higher suicides around the holidays

Reality

Suicides only make up 1-2% of total deaths and actually peak during the spring and fall months. Research from the Mayo clinic showed no elevated risk of suicide over a 35 -year period immediately before, during, or after Thanksgiving, Christmas, or New Year’s Day. Research from the Annenberg Public Policy Center shows that the media perpetuates this myth.

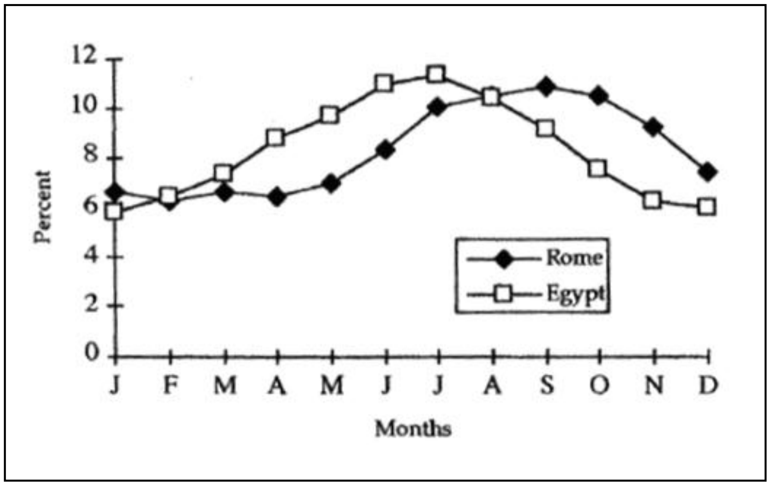
Grain of truth

One specific form of depression, SAD (Seasonal Affective Disorder), is strongly correlated with winter.

Background

Mortality seasonality is by no means a recent phenomenon. Researchers have studied inscriptions on ancient Egyptian and Roman burial tombs and determined that mortality rates were influenced by the seasons. Interestingly, the seasonal mortality variations in ancient times were often the reversed of the present day: summer mortality was worse than winter. The primary drivers of seasonality are often cause-specific. In ancient times, one of the predominant seasonal causes of death was malaria, which peaks in the summer. It was also noted that younger ages were more susceptible to the adverse summer seasonality.

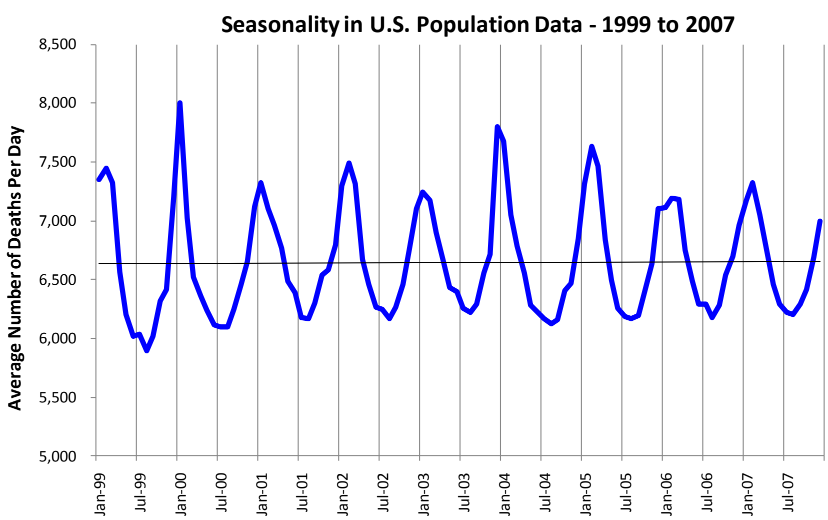
Figure 1: Seasonal Distribution of Deaths: Ancient Egypt and Rome



Source: Scheidel, Walter. Measuring Sex, Age and Death in the Roman Empire. Journal of Roman Archaeology, Supplementary Series Number 21:1-184, 1996

In the modern day, mortality is generally worse during the winter. Figure 2a shows the number of deaths per day from 1999-2007 for the U.S. population. The wave-like pattern demonstrates the elevated mortality associated with the winter months and the correspondingly favorable mortality during the summer. This pattern is fairly consistent from year to year, although some winters were worse than others.

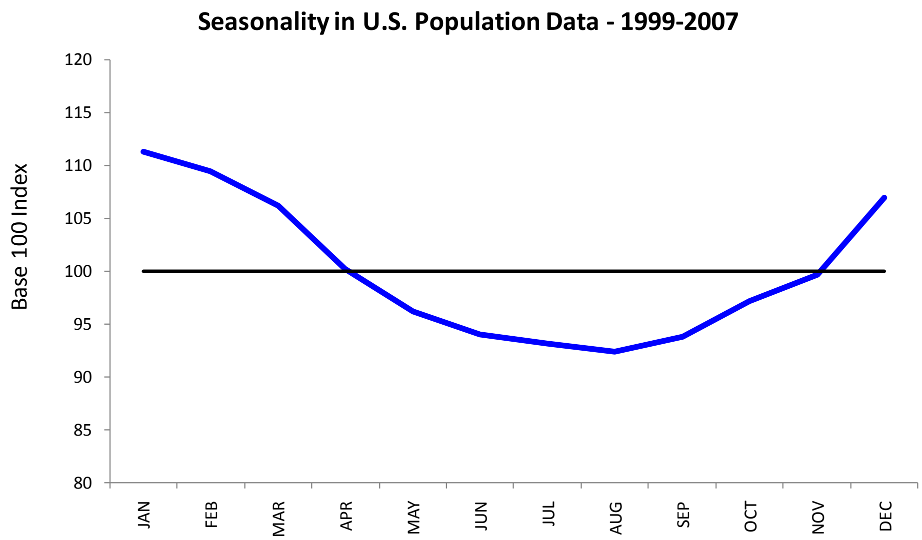
Figure 2a: Seasonal Trend in U.S. Population: Deaths per Day



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Figure 2b crunches these eight years of data into one 12-month calendar period and normalizes the results to a base 100 index. Periods at an index level of 110 would have approximately 10% elevated mortality while periods at an index level of 90% would have mortality approximately 10% lower than average.

Figure 2b: Seasonal Trend in U.S. Population: Base 100 Index

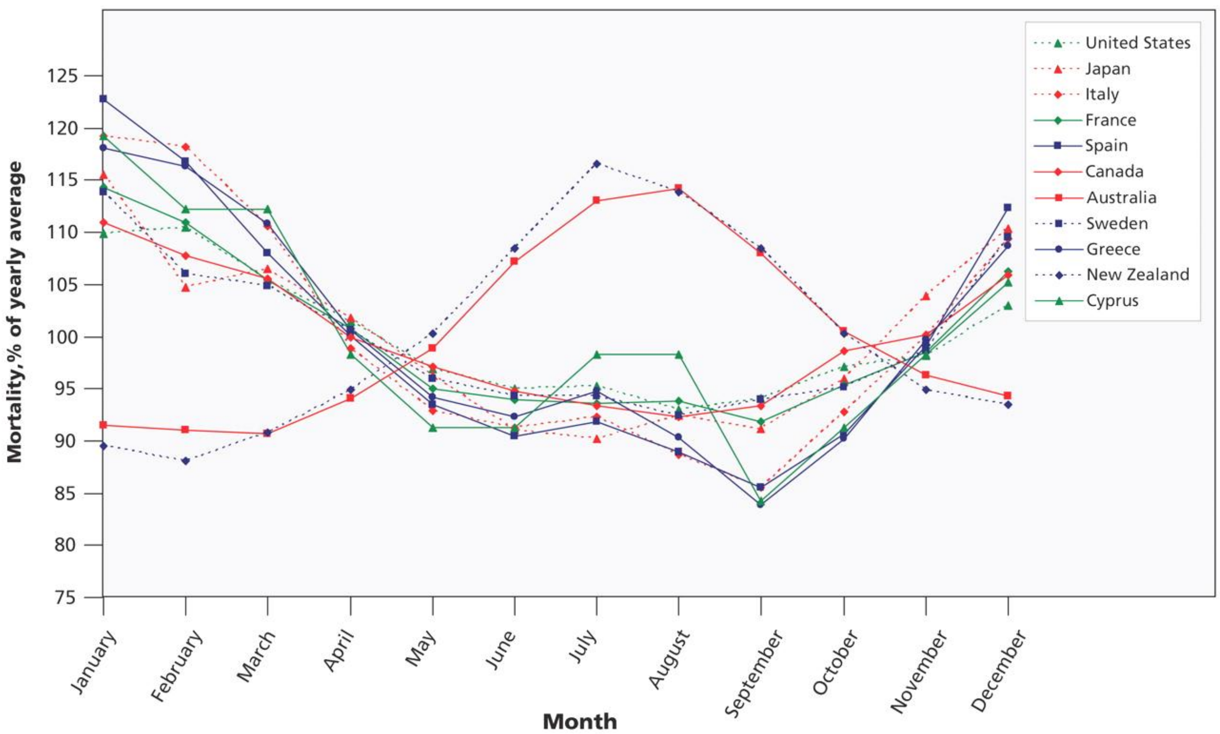


Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Similar seasonal trends are evident in most every country studied. Figure 3 comes from the Canadian Medical Association. This research covered different periods of study for each country ranging from 2-57 years.

The graph demonstrates similar seasonal trends for a variety of different countries using a metric similar to our "Base 100" index. The two countries that initially appear to be outliers (Australia and New Zealand) actually follow the same Winter/Summer trend, they just happen to be in the Southern Hemisphere. Also evident is slightly elevated summary mortality in the Mediterranean countries of France, Spain, Greece and Cyprus probably due to increased exposure to the heat and accidental or other non-medical causes of death.

Figure 3: Seasonal Trend in U.S. Population: Base 100 Index



Source: Falagas M.E. et al, CMAJ 2009 (http://www.ecmaj.ca/content/181/8/484/F1.large.jpg)

In order to drill down into the drivers of seasonality, it is useful to define a single metric that quantifies the magnitude of seasonal differences in mortality across the entire year. One commonly used statistic is the Winter/Summer Ratio. This ratio is very simply calculated as

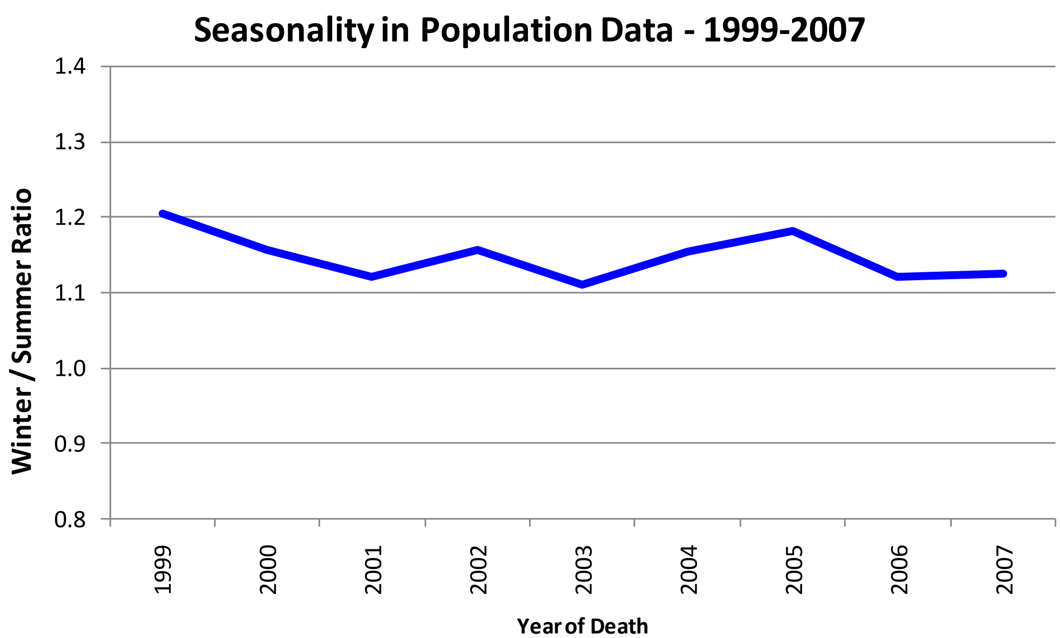
Winter/Summer Ratio = (Total # of deaths in January, February and March) / (Total # of deaths in July, August and September)

This is a very straightforward way to demonstrate seasonality with one number to describe the entire year. A W/S ratio of 1.2 would mean that winter mortality is approximately 20% higher than summer mortality while a ratio of 0.80 would mean the opposite.

Note: One problem with this metric is that there are generally 90 days in Q1 and 92 days in Q3. As a result, the true Winter/Summer ratio should probably be bumped up about 2.5% to adjust for this, but we will leave it as defined for consistency with other published research on the topic.

Figure 2c shows the W/S ratio for the same U.S. population dataset used in Figures 2a and 2b. For each calendar year, the entire seasonal relationship is boiled down to one number. For 1999-2007, the metric was fairly stable with a range between 1.1 and 1.2, indicating winter deaths were 10-20% higher than summer deaths over this period.

Figure 2c: Seasonal Trend in U.S. Population: (Winter/Summer Ratio)



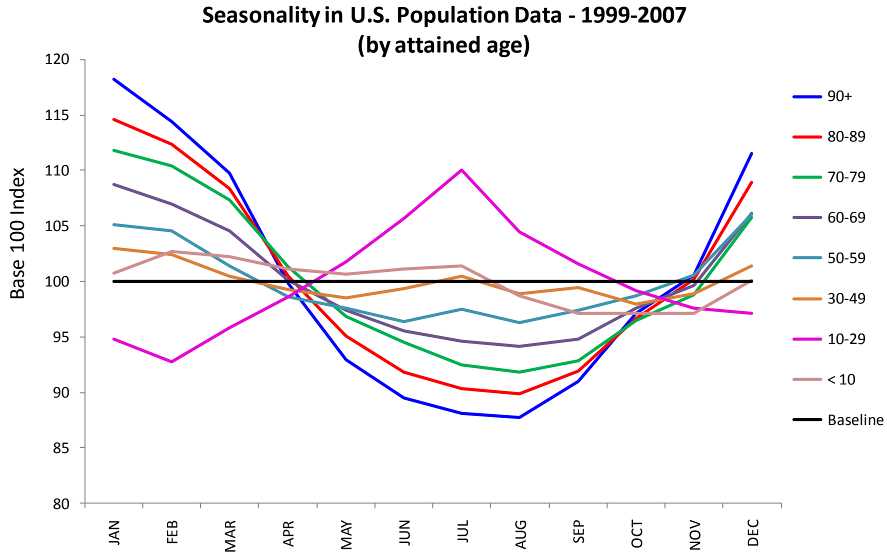
Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Demographic and Socio-Economic Drivers of Seasonality

Age

Figure 4a shows the dramatic correlation between age and the direction and magnitude of seasonality for the US population dataset. The oldest ages experience the biggest relative difference between the adverse mortality of the winter months versus the favorable mortality of the summer months. On the other end of the spectrum, ages 10-29 have the best mortality in the winter months but have mortality rates that spike during the summer. The ages between follow a continuum: The older the age, generally, the worse the relative mortality in the winter. Ages in the middle, between 30-49 (and, interestingly, <10), show very little seasonal variation in their mortality rates.

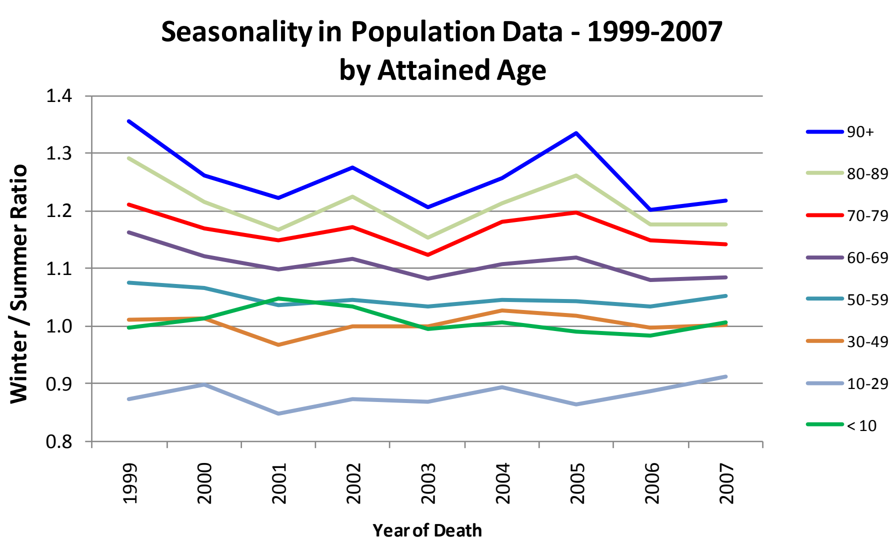
Figure 4a: Seasonality in U.S. Population: by Age (Base 100 Index)



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

The Winter/Summer ratio demonstrates the seasonal variability of mortality by age even more clearly. For all of the years in the study, the Winter/Summer ratio was monotonically increasing by age for ages above 10, as seen in Figure 4b.

Figure 4b: Seasonal Trend in U.S. Population: by Age (Winter/Summer Ratio)

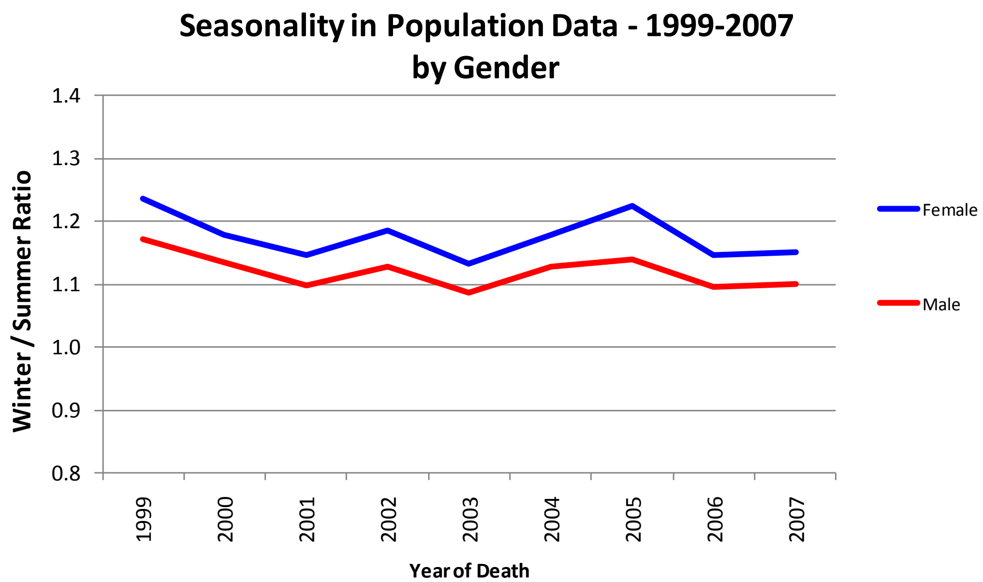


Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Gender

At first glance, Figure 5a seems to suggest that female mortality experiences significantly higher seasonally variability. The female W/S ratio is approximately 10% higher than males for every year in the study period.

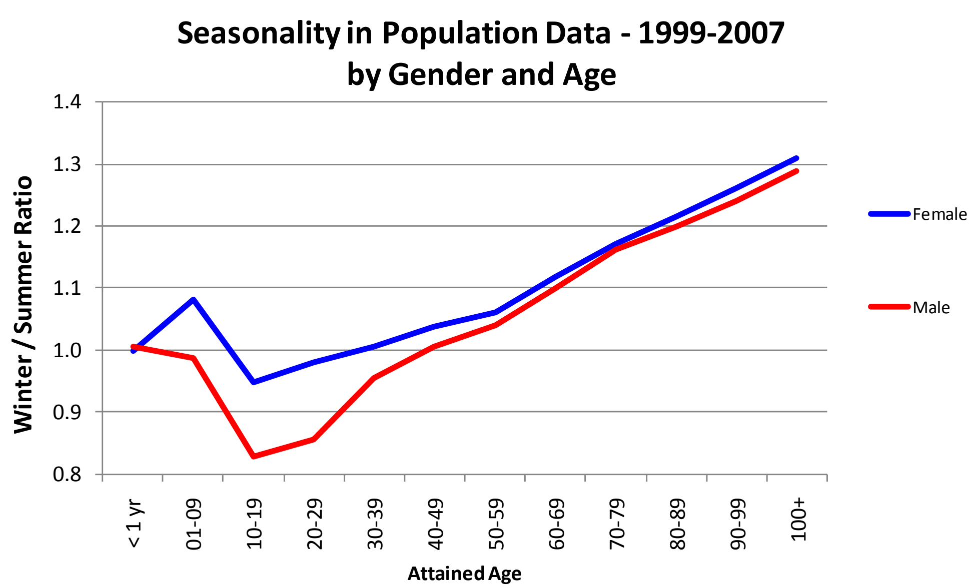
Figure 5a: Seasonal Trend in U.S. Population: by Gender (Winter/Summer Ratio)



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

One must be careful, however, when analyzing aggregate results by gender because of the differences in average age between the male population and the female population. Due to longer life expectancies a larger portion of the elderly population is female. Figure 5b shows that when the data is combined over the entire period and stratified by age band, the magnitude of the seasonal variations between men and women is dramatically reduced above age 40. The larger differences between the male and female ratios at the younger ages is primarily attributable to adverse male summer mortality due to violent and accidental causes of death.

Figure 5b: Seasonality in U.S. Population: by Gender and Age (Winter/Summer Ratio)

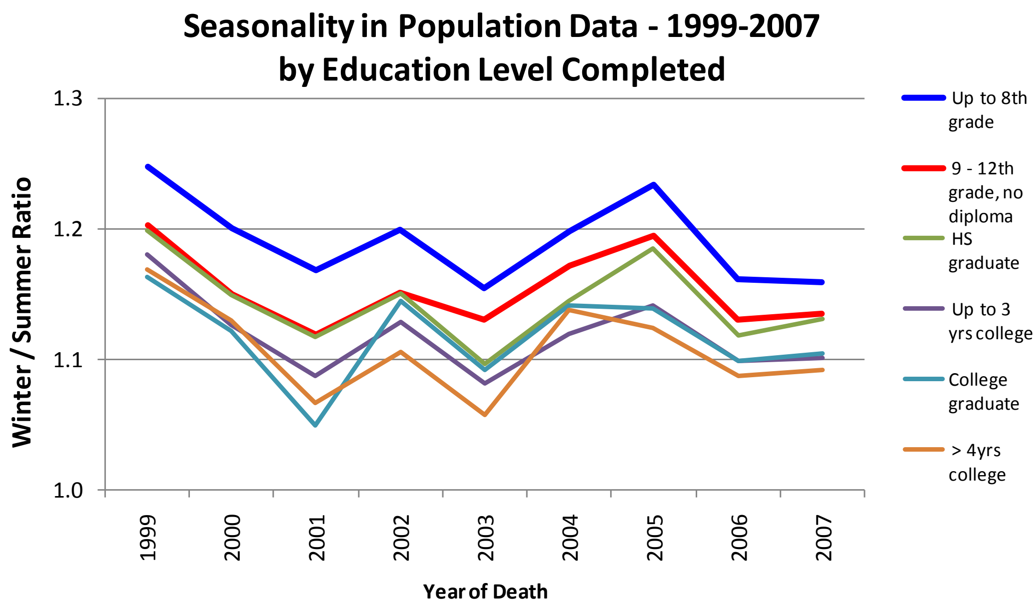


Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Educational Level

Educational level, which may be viewed as a proxy for general socio-economic status, is also a predictor of the magnitude of seasonal trends. Individuals with advanced educational backgrounds have less seasonal variability than those with fewer years of education. This could be attributable to quality of life, type of work, access to medical care or other socio-economic factors.

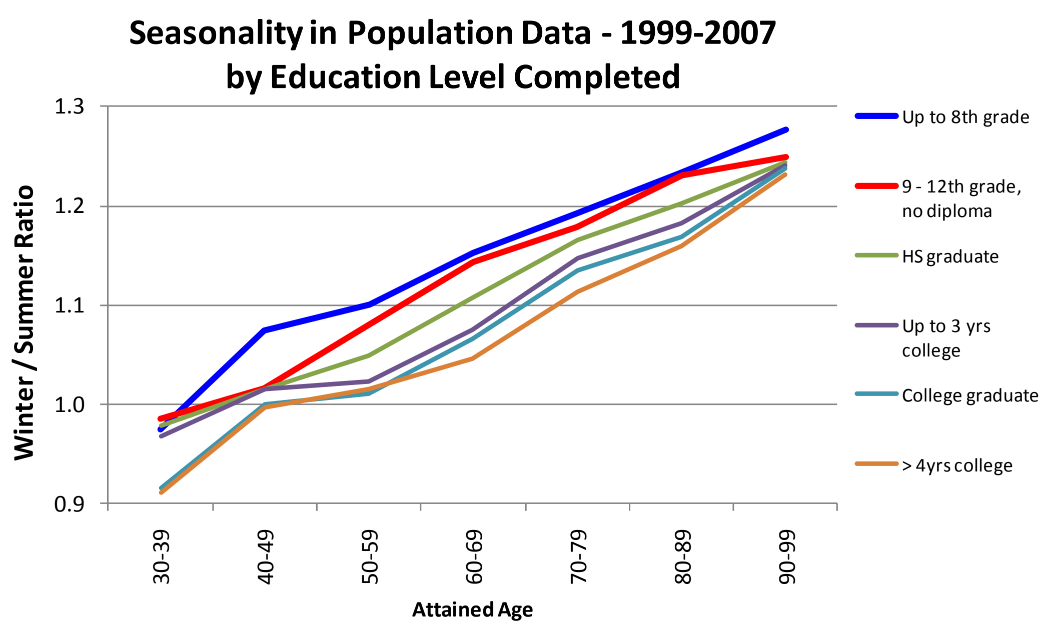
Figure 6a: Seasonal Trend in U.S. Population: by Educational Level (Winter/Summer Ratio)



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

The Winter/Summer ratio demonstrates that the differential in seasonal trend by years of education persists throughout life. Those with less education have worse relative winter mortality, even at advanced ages. The relationship follows a continuum: the more years of education, the lower the Winter/Summer ratio, regardless of age.

Figure 6b: Seasonality in U.S. Population: by Educational Level and Age (Winter/Summer Ratio)



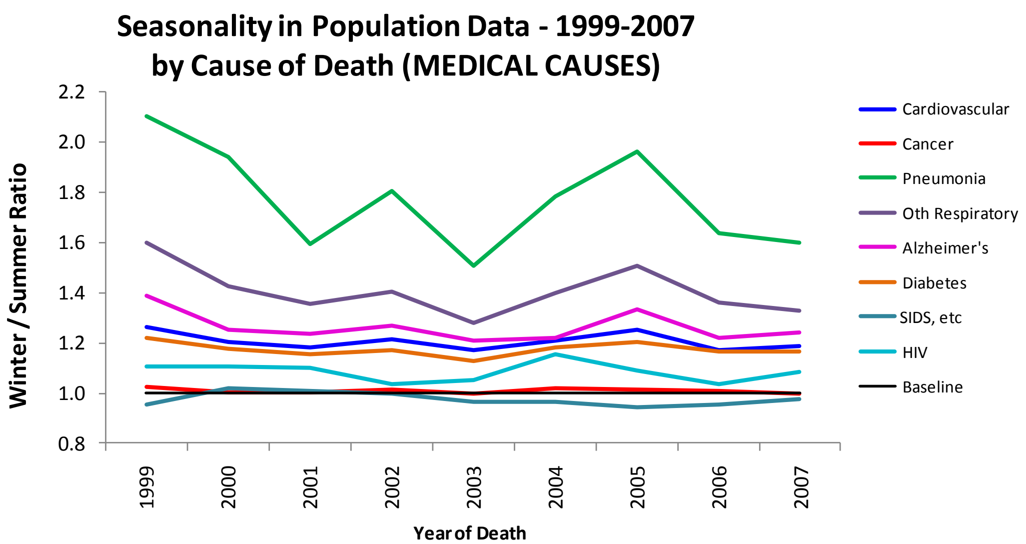
Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Variations by Cause of Death
Medical Cause of Death

Some medical causes of death are more susceptible to seasonal variations than others. Figures 7a and 7b show the Winter/Summer ratio by cause for 1999-2007 in the U.S. Population. The following can be observed:

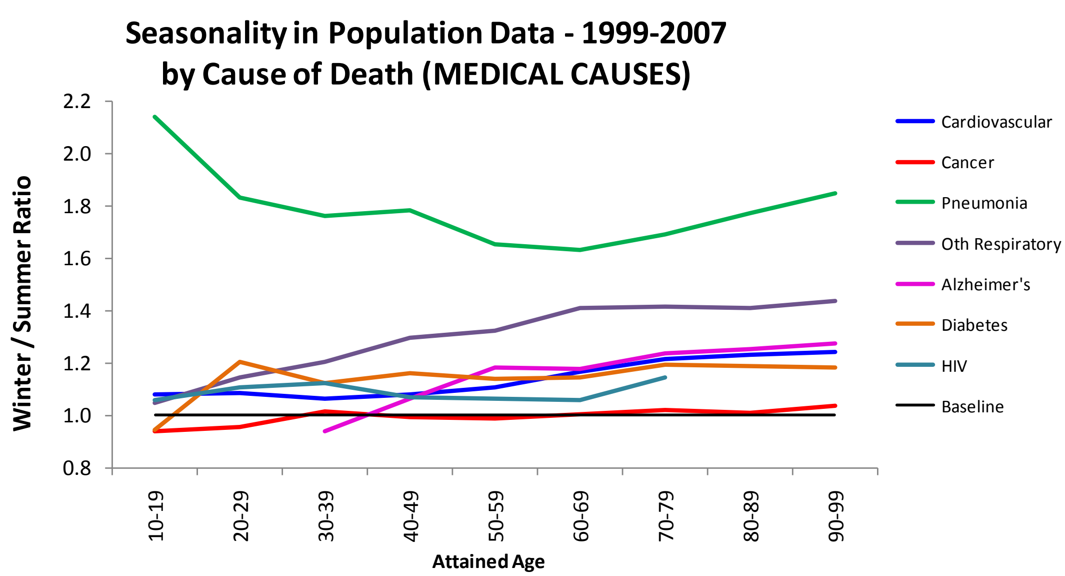
- The least seasonal cause of death on the graph is cancer, which shows no seasonal variation at all throughout the period.
- The respiratory causes of death including pneumonia, pneumonitis, influenza and other respiratory diseases show the largest seasonal effects. (Influenza is not included in the chart. The influenza W/S ratio is 100 times higher than other causes, as almost all influenza deaths occur in the winter).
- Almost all other medical causes of death demonstrate some level of adverse winter month seasonality. This includes possibly surprising causes such as Alzheimer's, diabetes, Parkinson's, septicemia, and nephritis. *(Note: not all causes are displayed in graph).*

Figure 7a: Seasonal Trend in U.S. Population: Medical Causes of Death (Winter/Summer Ratio)



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Figure 7b: Seasonality in U.S. Population: Medical Causes of Death by Age (Winter/Summer Ratio)



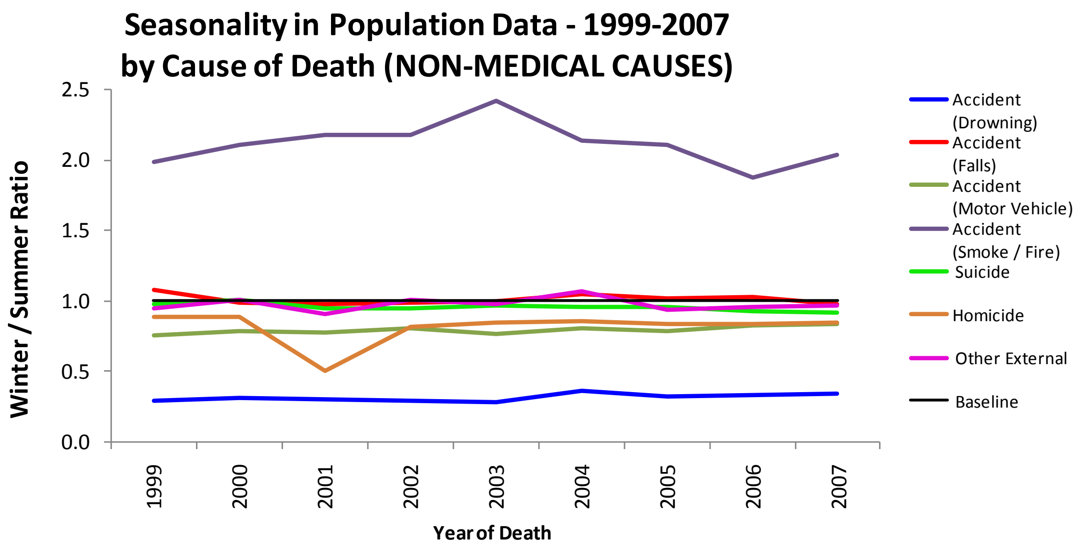
Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Non-Medical Cause of Death

Non-medical causes of death often follow the opposite seasonal trend with unfavorable summer mortality. The following graph shows the Winter/Summer ratio by cause for 1999-2007 in the U.S. Population.

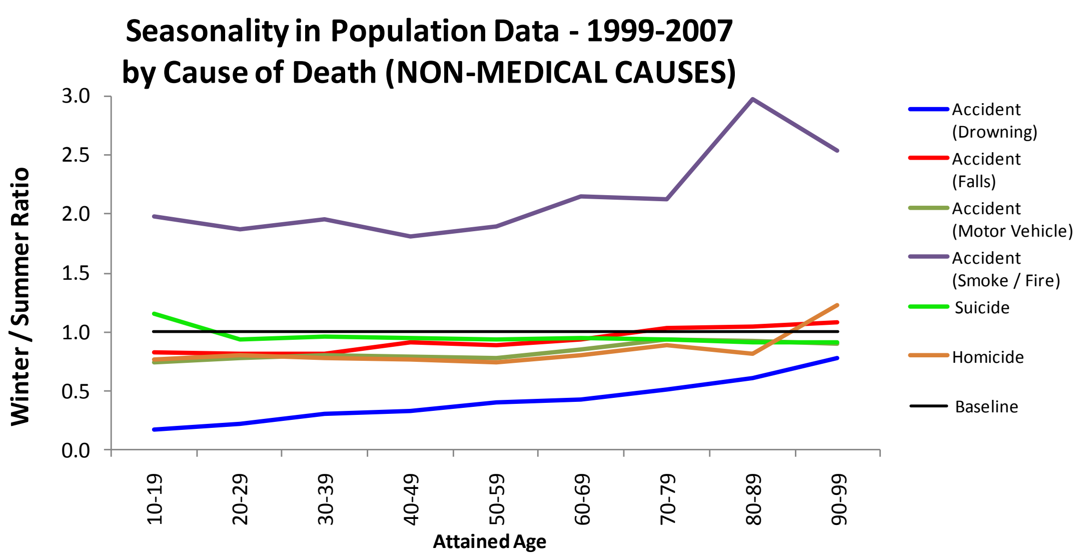
- The most reverse-seasonal cause of death on the graph is accidental death due to drowning. This is primarily a risk factor that peaks during the summer months. Homicide and motor vehicle mortality are also generally higher during the summer.
- Accidental death due to falls has higher summer mortality at the younger ages but higher winter mortality at advanced ages.
- Accidental death due to smoke inhalation or fire is much higher during the winter months.
- Suicide, as described earlier, shows little to no seasonal variability when comparing winter with summer.

Figure 8a: Seasonal Trend in U.S. Population: Non-Medical Causes of Death (Winter/Summer Ratio)



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Figure 8b: Seasonality in U.S. Population: Non-Medical Causes of Death by Age (Winter/Summer Ratio)



Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Geographical Influences

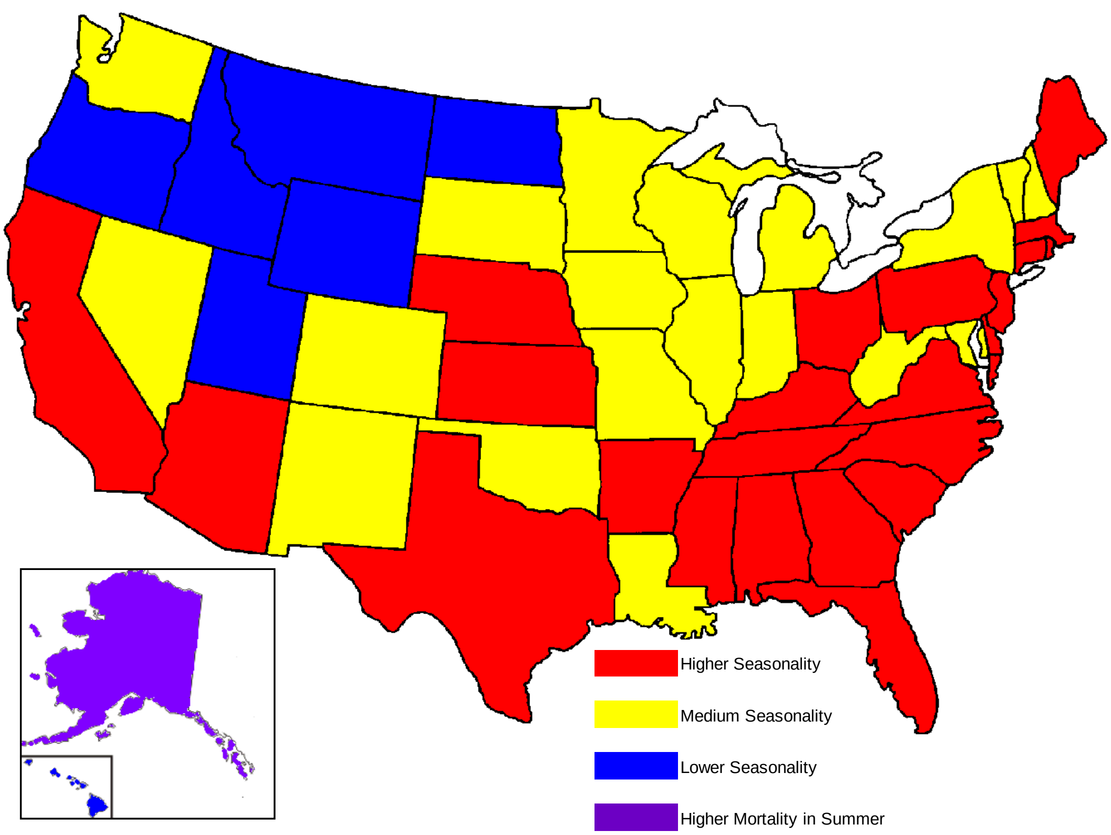
As mentioned in the earlier discussion of Seasonality Myths, clients in warmer climates generally experience more seasonal variation than colder climates. This seems counterintuitive since much of the seasonal variation is explained by exposure to cold weather. The most common explanation is that people in warmer climates do not fully appreciate the risks associated with cold weather. Individuals raised in colder climates are more acclimated to the weather and are aware of the risk factors. In other words, preparedness for the cold is an important mitigant against the dangerous effects of low temperatures.

U.S. States

To explore the impact of geography on seasonality, we calculated the Winter/Summer ratios by state from age-adjusted US CDC mortality rates. The regions with colder climates generally experience the lowest amount of seasonal variability. Figure 9 demonstrates this very clearly.

- The warmer climates in the South-East, Texas and California experience the greatest amount of seasonal variation with mortality in the winter significantly worse than mortality in the summer.
- The colder climates in the mountains and high plains of the North-West have much less seasonal variation. Mortality is still worse in the winter, but not much.
- The other states in the continental U.S. experience seasonal variability in between the colder and warmer climates.
- Alaska, by far the coldest state in the U.S. actually has reverse seasonality with higher mortality rates in the summer than in the winter.

Figure 9: Seasonality in U.S. Population: Non-Medical Causes of Death by Age (Winter/Summer Ratio)

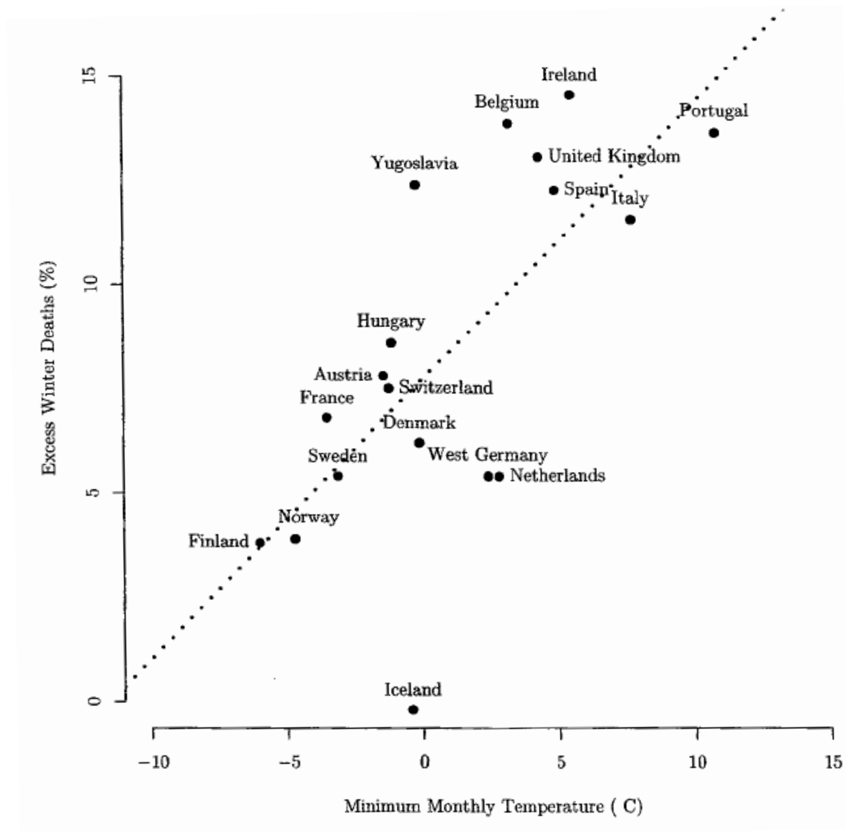


Source: National Center for Health Statistics Multiple Cause-of-Death Files. Analysis by RGA

Other Countries

Figure 10 presents a compilation of many studies covering different time periods and sources of data. It demonstrates the phenomenon we showed earlier for the U.S.: Warmer climates generally experience worse winter month seasonality than colder climates. The graph plots the percentage of excess deaths on the Y-axis (a measure of seasonality) against the minimum monthly temperature on the X-axis (a measure of climate). As with the US states, the colder climates such as Finland, Norway and Sweden have far fewer excess winter deaths compared to the warmer climates such as Portugal, Italy and Ireland.

Figure 10: Seasonality of European Nations: by Minimum Monthly Temperature



Source: Rao, Roland. Seasonality in Human Mortality: A Demographic Approach

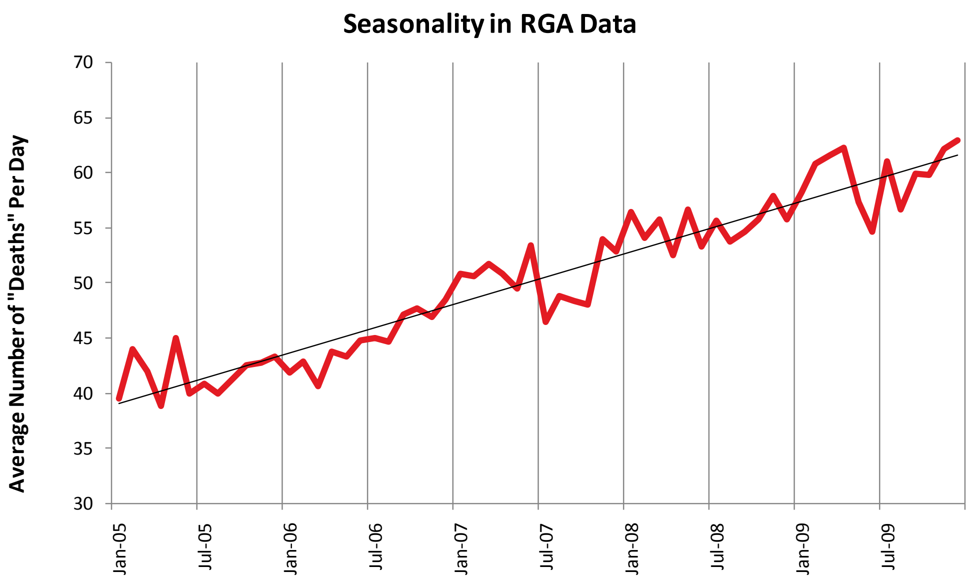
Seasonality in RGA's U.S. Mortality Markets Block of Business

The evidence presented up to this point clearly demonstrates that human mortality is subject to significant seasonal variation. Isolating seasonal trends in RGA's block of business, however, has proven over the years to be a challenge. Although intuition and evidence from general population suggest that there should be some seasonal variability, a number of factors potentially reduce or obfuscate the impact:

- RGA's block generally has much younger average ages than the general population. As has been demonstrated previously, younger ages experience less seasonal variability than older ages.
- RGA's block likely has a higher socio-economic mix than the general population. As has been demonstrated previously, cohorts with more years of education experience less seasonal variability.
- RGA's death benefits are subject to variability by policy size in addition to claim frequency. Previous internal research suggests that claim frequency (i.e., number of deaths) accounts for less than 10% of aggregate death benefits paid in a given reporting period, while severity (i.e., claim size) accounts for over 90%. Seasonal trends will primarily only impact the frequency component and could be obscured by the normal volatility of large face amount claims.
- RGA's growing block is subject to lapses and new entrants, which continuously changes the block size and demographic mix of the in-force risks from one period to another period.
- Claims on a reported basis will be subject to reporting lags that could obscure seasonal trends. IBNR estimates will further serve to mask underlying seasonality.

To illustrate the challenge, Figure 11a shows the average number of policy deaths per day for RGA's Core USMM Automatic business. Although one might detect some dips in the summer and spikes in the winter, it is difficult to make any definitive statements due to the random volatility around the trend line.

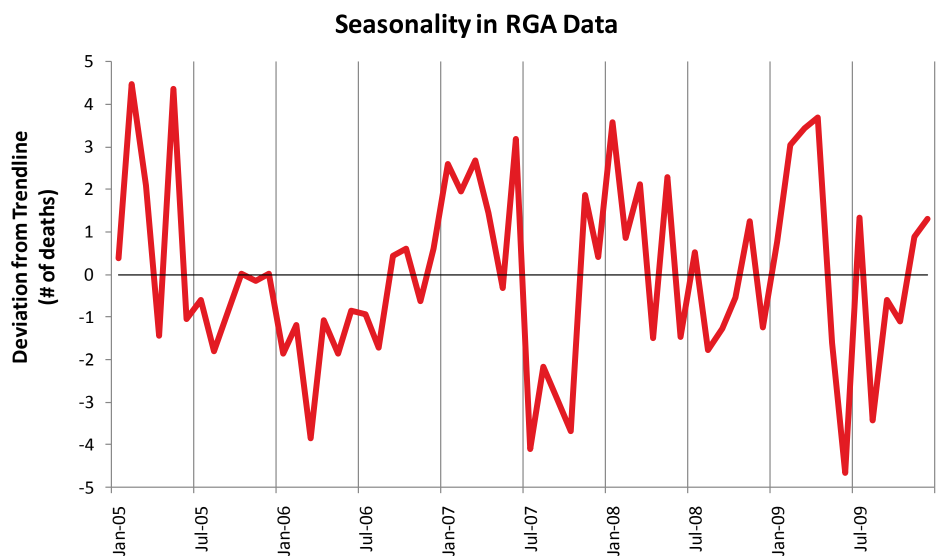
Figure 11a: Seasonal Trend in RGA USMM Claims (by Count and Date of Death)



Source: RGA

To take the analysis one step further, we have flattened the trend-line to standardize the results. The metric graphed in Figure 11b is the deviation from the trend line. A lot of volatility is still present, but some of the seasonal trends are starting to appear.

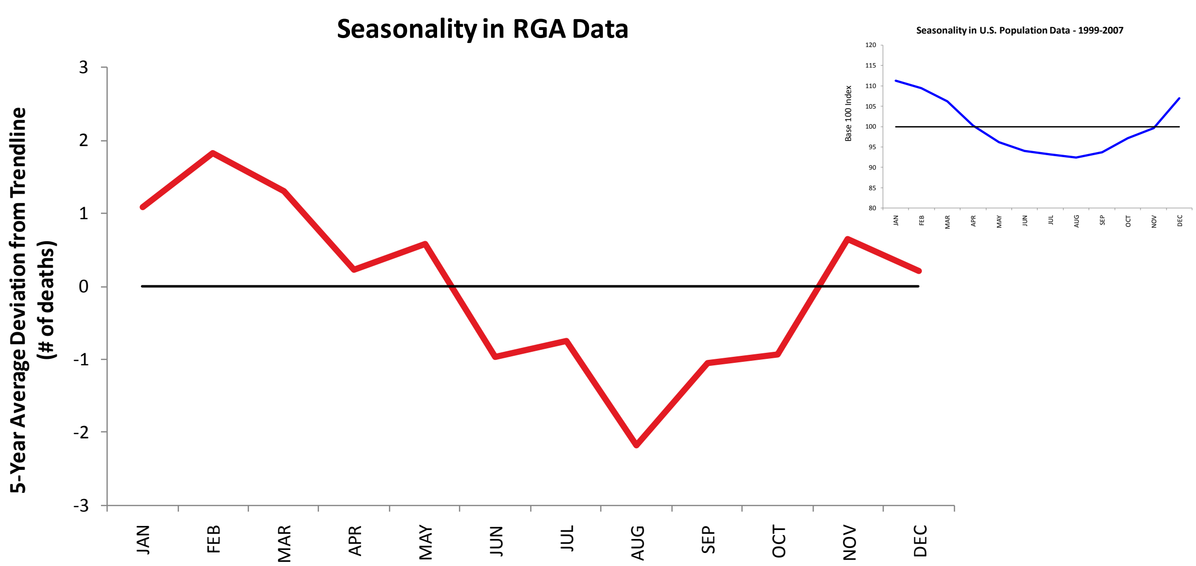
<u>Figure 11b: Deviation from Trend Line in RGA USMM Claims (by Count and Date of Death)</u>



Source: RGA

Finally, we take these results and average them over the entire five-year period by month of death. The RGA data in Figure 11c resembles the shape of the U.S. Population graphs shown earlier (and redrawn to the right). The magnitude of seasonality is lower than the general population, with a Winter/Summer ratio calculated at about 106%-108%. This seems to make sense given the caveats previously mentioned about RGA's mix of risks compared to the general population.

<u>Figure 11c: Deviation from Trend Line in RGA USMM Claims: 5-Year Average (by Count and Date of Death)</u>



Source: RGA

Seasonality Observed in Other U.S. Companies

To expand the analysis of seasonality to other companies, we looked at the "Death Benefits" reported on the "Summary of Operations" report from the Quarterly Statements of U.S. life insurance companies for 2007-2011. After removing several companies with obvious data errors or unusual reporting blips, a total of 56 different company groups were analyzed. A linear trend- line was drawn through each company's quarterly claims and the actual claims were then compared with the trended claims. The deviations from the trend line were then aggregated by quarter, similar to the previous analysis on RGA's internal data.

For the companies studied, death benefits were consistently higher in the first quarter. On average, death benefits were approximately 5% higher than the trend-line in the first quarter. Figure 12a shows the distribution of results for the 56 companies studied and Figure 12b shows the results for each individual company.

It is worth noting that the Q4 results do not increase in the same way as observed in the previous analysis of general population levels and RGA internal data. This is probably due to reporting lags. The death benefits reported by these companies in Q1 are primarily from deaths that occurred in December, January, and February, which are the most seasonally adverse months. The previous analysis of general population and RGA mortality was based on date of death, so December deaths were included in the fourth quarter leading to elevated Q4 mortality levels.

The authors of this bulletin were surprised by how much extra mortality is observed in the first quarter for all of these companies. This is despite the claim size volatility, lower average ages, higher socio-economic status and other reporting noise generally experienced in the death benefits paid in insurance populations. In addition, the first quarter is shorter than the third and fourth quarters, so without seasonality we would actually expect Q1 deaths to be a bit lower than average.

Figure 12a: Variation from Death Benefit Trend Line: 5-Year Average (by Amount and Date Reported)

	Actual Claims/Trended Claims - 1 2007-2011				
	Q1	**Q2**	**Q3**	**Q4**	**Trend**
15th percentile	+ 2%	- 4%	- 5%	- 6%	
Median	+ 6%	- 0%	- 3%	- 3%	
85th percentile	+ 9%	+ 2%	+ 1%	+ 1%	
Companies above trendline	52	28	12	9	

Source: Quarterly Statement data from SNL.com; analysis by RGA

Figure 12b: Variation from Death Benefit Trend Line: 5-Year Average (by Amount and Date Reported)

Company	2011Q4 Death Benefits (000s)	Actual Claims/Trended Claims - 1 2007-2011				Trend
		Q1	Q2	Q3	Q4	
MetLife Inc.	1,676,290	+ 2%	+ 3%	+ 3%	- 8%	
Prudential Financial Inc.	1,114,477	+ 4%	- 3%	+ 4%	- 6%	
New York Life Insurance Group	819,893	+ 6%	- 4%	- 4%	+ 2%	
Northwestern Mutl Life Ins Co.	565,037	+ 11%	- 4%	- 4%	- 3%	
American International Group	553,103	+ 5%	+ 2%	- 9%	+ 2%	
AXA	455,656	+ 4%	- 4%	- 0%	- 0%	
Massachusetts Mutl Life Ins Co	367,033	+ 7%	- 2%	- 2%	- 3%	
Minnesota Mutual Companies Inc	327,337	+ 4%	+ 0%	- 2%	- 3%	
State Farm Mutl Automobile Ins	304,478	+ 3%	+ 3%	- 3%	- 3%	
Cigna Corp.	282,848	+ 3%	+ 2%	+ 0%	- 5%	
Hartford Financial Services	282,005	+ 1%	- 1%	+ 2%	- 3%	
Sun Life Financial Inc.	208,703	+ 5%	+ 0%	- 2%	- 4%	
Guardian Life Ins Co. of Am	207,890	+ 5%	- 4%	- 3%	+ 1%	
Allstate Corp.	195,593	+ 2%	- 0%	- 1%	- 1%	
StanCorp Financial Group Inc.	151,417	+ 4%	+ 1%	- 1%	- 4%	
Unum Group	147,318	+ 7%	- 2%	- 1%	- 3%	
Genworth Financial Inc.	141,529	+ 1%	+ 2%	+ 1%	- 4%	
Protective Life Corp.	130,098	+ 6%	+ 2%	- 1%	- 6%	
Principal Financial Group Inc.	130,021	+ 4%	+ 3%	- 4%	- 2%	
Assurant Inc.	129,513	+ 6%	- 4%	- 6%	+ 3%	
Jackson National Life Group	128,273	+ 6%	+ 1%	- 5%	- 3%	
Torchmark Corp.	126,926	+ 4%	+ 1%	+ 1%	- 6%	
CNO Financial Group Inc.	121,227	+ 6%	+ 0%	- 7%	+ 1%	
Phoenix Companies Inc.	113,152	- 0%	+ 11%	- 9%	- 2%	
Sammons Enterprises Inc.	103,231	+ 12%	- 6%	- 5%	- 0%	
Western & Southern MHC	83,116	+ 6%	- 1%	- 4%	- 1%	
Zurich Insurance Group Ltd.	69,311	- 5%	- 2%	- 2%	+ 9%	
Ameriprise Financial Inc.	67,098	+ 6%	- 2%	+ 5%	- 9%	
National Life Group	60,348	+ 4%	- 4%	- 8%	+ 7%	
WellPoint Inc.	49,510	+ 6%	- 1%	- 1%	- 4%	
Penn Mutual Life Insurance Co.	49,435	+ 10%	- 5%	- 1%	- 4%	
OneAmerica Financial Partners	45,784	+ 6%	- 2%	- 3%	- 0%	
National Guardian Life Ins Co.	42,515	+ 6%	+ 1%	- 5%	- 2%	
Kemper Corp.	40,414	+ 7%	+ 2%	- 6%	- 3%	
COUNTRY Financial	32,687	+ 4%	- 5%	- 3%	+ 4%	
Kansas City Life Insurance Co.	31,113	+ 10%	- 4%	- 5%	- 1%	
Physicians Mutual Insurance Co	27,798	+ 8%	+ 1%	- 6%	- 3%	
HSBC	25,025	- 0%	- 1%	+ 4%	- 3%	
Americo Life	18,123	+ 4%	+ 1%	- 1%	- 5%	
Beneficial Financial Group	17,640	+ 11%	- 4%	- 4%	- 2%	
Citigroup Inc.	15,783	- 2%	+ 2%	+ 1%	- 0%	
SBLI USA Mutual Life Ins Co.	15,513	+ 8%	+ 1%	- 5%	- 5%	
Boston Mutual Life Ins Co.	14,457	+ 4%	+ 0%	+ 2%	- 7%	
Great Western Insurance Group	13,743	+ 5%	- 3%	- 5%	+ 3%	
Humana Inc.	12,064	+ 4%	+ 5%	+ 1%	- 9%	
Trustmark Mutual Holding Co.	10,723	+ 0%	+ 1%	- 0%	- 1%	
Horace Mann Educators Corp.	10,392	+ 13%	- 8%	- 4%	- 1%	
ULLICO Inc.	9,124	+ 1%	+ 7%	- 3%	- 5%	
GPM Life Group	7,278	+ 8%	- 2%	- 4%	- 2%	
Funeral Directors Group	5,676	+ 16%	- 1%	- 9%	- 5%	
Security National Financial	5,568	+ 6%	+ 0%	- 5%	- 1%	
Citizens Inc.	5,465	+ 8%	- 1%	- 3%	- 4%	
Sentry Insurance a Mutual Co.	5,255	+ 11%	- 2%	- 4%	- 5%	
Independence Holding	4,946	+ 10%	+ 3%	- 2%	- 11%	
Atlantic American / Delta Grp	2,505	+ 6%	+ 2%	- 3%	- 6%	
American Equity Investment	1,479	+ 4%	+ 2%	+ 3%	- 9%	
	AVERAGE	**+ 5%**	**- 0%**	**- 2%**	**- 3%**	

Source: Quarterly Statement data from SNL.com; analysis by RGA

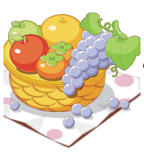
Explanations for Seasonality

The rationales for seasonality are not entirely understood by researchers. A number of theories have been advanced, which can be broadly categorized as biomedical, external and behavioral factors.

<u>Biomedical Factors</u>

- Cold temperatures allow bacteria to survive longer, which has adverse effects on immune systems' resistance against respiratory infections.
- Social crowding (more common in winter) facilitates the rapid spread of infectious diseases.
- Cold air leads to coronary vasospasm, a condition where blood vessels spasm causing them to narrow.
- Cold air also affects the composition of blood. Reduced levels of plasma cause the blood to be thicker.

<u>External Factors</u>



- Internal air pollution is more present during the winter due to central heating. Smoke, sulfur dioxide, and carbon monoxide can adversely affect respiratory diseases (small particles getting into the sensitive parts of the lungs) and cardiovascular diseases (aggravating existing heart disease).
- Access to nutrition including vitamins C and D is reduced during the winter. Fresh fruits and vegetables provide good sources for vitamin C while the UV radiation of the sun provides a synthesizable source of vitamin D. Both have positive effects on cardiovascular disease, renal function, autoimmune disorders and infections (including influenza).
- Influenza vaccinations have reduced the effects of seasonality over time. Reduced hospitalizations related to heart disease, cerebrovascular disease, pneumonia or influenza have been noted.

<u>Behavioral Factors</u>

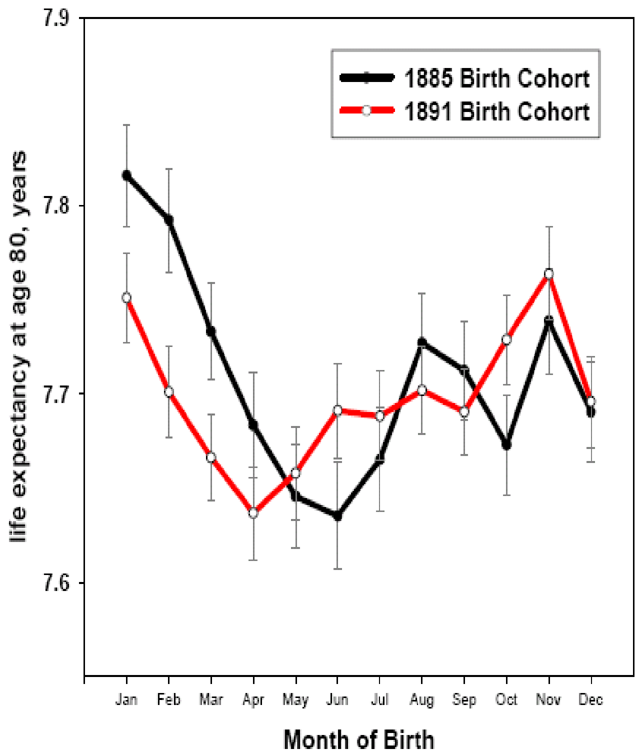
- Individuals with known coronary artery disease could be over-exerting themselves in winter activities such as shoveling snow.
- Normal exercise routines and eating habits may be altered during the winter.
- Some individuals may not properly prepare for the cold weather. Unnecessary or prolonged exposure to cold air due can lead to many of the biomedical risk factors described above. It has been shown previously that individuals living in warmer climates have worse relative winter mortality.
- More research is needed on other social, and behavioral, and socio-economic risk factors including the effects of income, marital status, living alone, education, occupation, etc. Data and intuition suggest that these factors are also strongly correlated with an individual's susceptibility to seasonal mortality risk.

Mortality by Season of Birth

Up to this point, all of the results have focused on the impact that exposure to seasonal conditions has on mortality. Surprisingly, life expectancies also vary based on the season of birth. This may sound absurd, especially for individuals who have already reached advanced ages, but there is solid research to support this.

Figure 13 shows the mean remaining life expectancy at age 80 for an extinct cohort of individuals born in the U.S. in 1885 and 1891. (The research actually includes birth years 1885-1899 with each individual year showing a similar pattern.) The pattern shifts slightly from year to year, but in general those born in the winter have longer remaining life expectancies than those born in the spring. This suggests that the number of additional (fractional) years lived after age 80 is dependent on the month that an individual was born more than 80 years earlier. It is remarkable that early life conditions can have an impact on mortality so many years later.

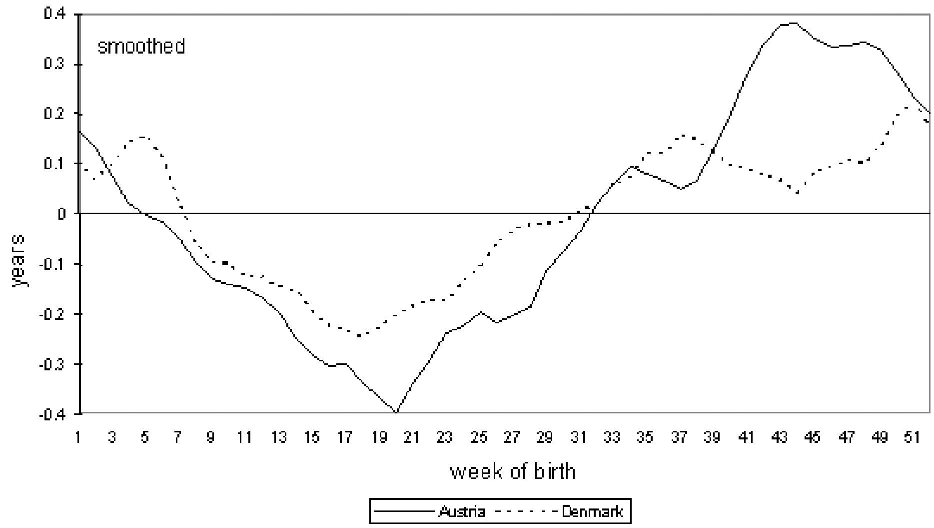
Figure 13: Future Life Expectancy at Age 80 by Month of Birth



Source: Gavrilova and Gavrilov "Search for Predictors of Exceptional Human Longevity"

Another study of individuals in Austria and Denmark shows similar trends. Figure 14 shows the deviation in life expectancy at age 50. Both countries have similar trends with individuals born in spring and summer months having slightly lower life expectancies than those born during fall and winter months.

Figure 14: Future Life Expectancy at Age 50 by Month of Birth



Source: Doblhammer "Longevity and month of birth: Evidence from Austria and Denmark" Demographic Research, Vol 1, Aug 1999

Many additional studies show similar results linking season of birth with long-term life expectancy. The same relationships have been shown to hold even when controlling for the end-of-life seasonality described earlier. Additional studies also have linked the month of birth with higher likelihoods of developing certain conditions later in life.

So what possible explanations exist for this phenomenon? Several theories have been advanced:

- There may be critical periods early in human life sensitive to seasonal variations. Among these variables are vitamin supply and seasonal exposure to infectious diseases.
- There is a higher risk of infant mortality in certain months. This could lead to prolonged influences throughout life for the survivors. This theory of 'selective survival' suggests that those who have to struggle a little harder during the first six months of life are in better shape later in life.
- The impact may be attributable to pre-natal influences. Nutrition of the mother has been linked to many health-related risk factors for the child. In the late 1800s, there was a big difference in the available fresh fruits and vegetables from one part of the year to the next. This might explain why the winter month-of-births have favorable mortality if the real influence is the pregnant mother's exposure to seasonal risk factors.
- The impact may even be pre-conception. Male sperm virility has been shown to vary by season, which could also influence the viability of the embryo and, ultimately, the health of the newborn.
- There are social factors that are closely related to a child's birthday. Research of professional athletes has shown surprisingly strong correlations with month of birth, which is attributed to the cut-off dates for entering school or junior sports clubs. These sorts of social factors can have a lasting influence on the opportunities available later in life.

Conclusion

The influence of the seasons on mortality is profound. A variety of demographic, socio-economic and geographic factors influence the magnitude and direction of seasonal effects. The impact of seasonality can be observed both in general populations and insurance company results. There are many theories to help explain the causes for seasonality and researchers continue to search for solutions that may lead to future improvements in mortality.

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