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Seasonality of ER Admissions in Northwestern Pennsylvania: A Cross-Sectional Study

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Abstract

Seasonality, in the context of emergency room (ER) admissions, can be described as the periodic incidence of disease, corresponding to seasons, or other pre-established calendar periods. Respiratory diseases, in general, show a seasonal pattern with incidence peak at the winter season, however research still presents a considerable amount of inconsistency. Incidence of cardiovascular diseases (CVD) is also very well linked to the cold season. Gastrointestinal, genitourinary and neurological diseases are poorly studied in regards their seasonal patterns. This study aimed to assess seasonality of the five categories of diseases—respiratory, cardiovascular, gastrointestinal, genitourinary, and neurological—using data from a community hospital in northwestern PA. We analyzed 14 years (2000-2014) of data from the Meadville Medical Center (MMC) ER admissions. For each ER admission case, we had information about ICD-9 code, sex, insurance, race, age and date, time and year of admission. Statistical analyses were performed using SAS 9.4 University version software. We found significantly fewer cases of respiratory diseases in spring (OR = 0.757), summer (OR = 0.579), and fall (OR = 0.741), when comparing to the winter season; however, seasonal differences were not found for cardiovascular, genitourinary, and neurological diseases. The implications of these results will primarily be used to improve Meadville's public health policies for cold seasons, and more specifically, implement programs that prepare the ER to receive and treat respiratory cases more efficiently in the cold season.

Keywords

Seasonality, Emergency Room, Meadville, Respiratory Diseases, Winter

1. Introduction

Seasonality is a cyclic change in disease occurrence over the course of a year [1] [2]. When focusing on emer-

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gency room (ER) admissions, seasonality can be described as the periodic incidence of disease, corresponding to season, or another pre-established calendar period [3] [4]. For the purpose of this study, the seasonality of ER admissions for five major categories of diseases—cardiovascular, gastrointestinal, genitourinary, neurological and respiratory—was assessed.

Respiratory diseases, especially in Western societies, have been shown to have a winter peak of mortality and ER admissions [5]-[7]. Generally, this can be explained by a combination of environmental factors seen during the winter season. More specifically, when talking about infectious respiratory diseases, the causes can be related to prolonged survival of the pathogen in the environment [3], changes in the mucociliary function due to environmental factors, such as dry air and low temperatures [8] [9], and even changes in air pollution [10]-[12]. Although there is evidence of winter prevalence of respiratory diseases, the role of environmental factors and risk for these diseases still controversial [9] [13]-[15]. Some research shows that different respiratory diseases can have a distinct and particular seasonal pattern [4].

There is a considerable amount of evidence in the literature supporting that cardiovascular diseases (CVD) show higher rates of incidence during winter [16]-[23]. The higher incidence is seen not only in cardiac death [24] [25], but also in overall ER admissions [26]. The reason this is so well documented may be the fact that winter environmental conditions have already been closely related to CVD. In cold temperature people show more sympathetic activation (compensatory vasoconstriction mechanism) and higher sodium intake, both lead to an increase in blood pressure and heart rate [21] [27] [28]. Other behavioral factors related to the cold season, such as social withdrawal, high-fat diet consumption, and decreased physical activity, can also contribute to the seasonality of CVD [29].

Research of gastrointestinal (GI) diseases is restricted to infectious/viral diseases [7] and inflammatory bowel diseases (IBD) [30]. The seasonal pattern of GI diseases is being debated in the research, with some studies showing peaks on spring and fall [31], summer and fall [32] [33], winter and spring [34] and even others showing no association with seasons [35]. Variation in water quality and pollution, which can differ with seasons, seems to be the external factor most related with GI diseases incidence [36] [37]. Jung *et al.* instigated, in his article, the fact that the season of birth may play a bigger role in GI diseases incidence than the actual season of disease appearance. Especially when focusing on IBD, he shows that birth during winter is associated with increased risk for IBD later in life [30].

Seasonal patterns of genitourinary and neurological disease incidence are generally neglected and poorly researched. Urinary tract infections (UTI) often have summer peaks of incidence when looking for drug-related sales and Google searches [38], but information about ER admissions, clinic visits or even seasonality of other genitourinary diseases were not found. The scenario is the same for neurological diseases. Most of the research focus on sports seasons [39], work accidents [40], and some specific diseases, such as multiple sclerosis, frequently appearing on spring and summer [41], or Lyme neuroborreliosis, that doesn't show seasons as a reliable predictor [42].

More research is needed to investigate the seasonality of neural and genitourinary diseases. Knowing more about which diseases are related to each season, or even what underlies this relationship can help to improve the predictability and specificity of the public health surveillance systems, and therefore minimize the impact of disease occurrence [3] [4] [43]. Additionally, with seasonal patterns changing as a result of climate change is important to keep track of the newly emerging seasonal patterns of diseases that are being influenced by environmental factors [44] [45]. Considering this, and thinking about the public health relevance of studying seasonal influence, this study aims to assess seasonal patterns of ER admissions for respiratory, cardiovascular, genitourinary, neurological and gastrointestinal diseases community hospital in rural northwestern Pennsylvania.

2. Methods

2.1. Data and Population Characteristics

The data used for this cross-sectional study came from ER admissions records from the Meadville Medical Center (MMC), between June 2000 and September 2014. This project was approved by the Institutional Review Boards at Allegheny College and the Meadville Medical Center. We analyzed a total of 75,568 ER admissions. For each ER admission we specifically assessed more detailed information, such as the ICD-9 code, sex, insurance, race, age and date, time and year of admission. The MMC is a non-profit community hospital located in

northwestern Pennsylvania and serves a population composed in its majority of residents from the Crawford County, PA. Crawford County is a rural community located 90 miles north of Pittsburgh, PA and 40 miles south of Erie, PA [46].

2.2. Variables and Grouping

The main variables of this study were the diseases categories and seasons. To categorize the groups of diseases we used the ICD-9 code, as following: neurological (Codes 320 - 389.9), cardiovascular (Codes 390 - 459.9), respiratory (Codes 460 - 519.9), gastrointestinal (Codes 520 - 579.9), and genitourinary diseases (Codes 580 - 629.9) [47]. To determine the seasons we used the following configuration: Spring (March 21st to June 20th), Summer (June 21st to September 20th), Fall (September 21st to December 20th) and Winter (December 21st to March 20th).

The data was stratified by sex, insurance type, race and age. Insurance type was divided in three groups: private, governmental or no insurance. Race was also categorized in three groups: Caucasians, African American and Others. Age was not categorized and was only included as a potential confounder in the multivariable analysis.

2.3. Data Analysis

The raw data was organized in Excel 2013, and all statistical analysis and tests were performed using SAS 9.4 University version software. If an admission was missing any data, we excluded it from the analyses. We calculated of frequencies of each disease and then completed a bivariate analysis of the data using the Student t-test and chi-square tests. The Cochran-Mantel-Haenszel test was used to determine if sex, insurance, race, or age confounded the relationship between disease and season. The Breslow-Day test was used to check for effect modification. Adjusted odds ratios were calculated using multi-variable logistic regression models. During all the analysis winter was the reference group for seasons, and cardiovascular diseases the reference group for the diseases.

3. Results

This study looked at data from a total of 75,568 ER admissions. From those we identified 17,504 (23.16%) cases of respiratory diseases; 21,320 (28.12%) cases of gastrointestinal diseases; 8,021 (10.61%) cases of genitourinary diseases; 17,535 (23.20%) cases of neurological diseases; and 11,187 (14.80%) cases of cardiovascular diseases. Our dataset was comprised of a majority of females (9,617; 56%); Caucasians (16,526; 94%); individuals with private insurance (10,530; 54%) (**Table 1**). The ER admissions were even distributed among the four seasons (**Table 1**).

Through a bivariate analysis of the data, we found no statistically significant relationship between season and gastrointestinal, genitourinary, and neurological disease (**Table 2**). However, the unadjusted odds ratios (ORs) for respiratory diseases reveal a significant decrease in ER admissions during the spring (OR = 0.699), summer (OR = 0.553), and fall (OR = 0.833) when compared to winter (**Table 2**).

After adjusting for sex, insurance, rate and age, we found that ER admissions for respiratory diseases were statistically significantly reduced during the spring (OR = 0.757), summer (OR = 0.579), and fall (OR = 0.741), when comparing to the winter season (**Table 3**). Additionally, we found that there were several differences in ER diagnoses based on insurance type. Individuals with governmental insurance (Medicaid or Medicare) were more likely to be diagnosed with a respiratory disease, but less likely a GI or genitourinary disease than those with no insurance when controlling for season, sex, and race. Similarly, individuals with private insurance were less likely to be diagnosed with a GI or genitourinary disease than those without insurance (**Table 3**).

4. Discussion

4.1. Overview, Implications and Future Research

Our analysis of 14 years of ER admissions from the MMC indicates the presence of a seasonal pattern for respiratory diseases, but not for the other four categories of diseases. Our results suggests that respiratory diseases incidence is higher at winter than in all the other seasons, which is consistent with previous research [5]-[7] [48].

Table 1. Socio-demographic and admissions information for individuals admitted to the Meadville Medical Center ER for the five pre-established diseases categories (2000-2014).

		Demographics: Frequency (row %)					
Variables		Respiratory	Gastrointestinal	Genitourinary	Neurological	Cardiovascular	p-value (chi-square)
Sex	Male	7887 (23.57)	10047 (30.02)	2715 (8.11)	7170 (21.42)	5647 (16.87)	<0.0001
	Female	9617 (22.84)	11273 (26.78)	5306 (12.50)	10365 (24.62)	5540 (13.16)	
Insurance	Private insurance	10530 (25.71)	11048 (26.98)	4567 (11.15)	12081 (29.50)	2730 (6.67)	<0.0001
	Government Insurance	5699 (20.33)	7535 (26.87)	2670 (9.52)	4067 (14.51)	8067 (28.77)	
	No insurance	1275 (19.40)	2737 (41.64)	784 (11.93)	1387 (21.10)	390 (5.93)	
Race	African American	780 (22.29)	965 (27.57)	377 (10.77)	841 (24.03)	537 (15.34)	0.268
	Others	171 (21.67)	230 (29.15)	67 (8.49)	191 (24.21)	130 (16.48)	
	Caucasian	16526 (23.22)	20093 (28.23)	7566 (10.63)	16478 (23.15)	10504 (14.76)	
Seasons	Spring	4244 (21.68)	5652 (28.88)	2106 (10.76)	4608 (23.54)	2964 (15.14)	<0.0001
	Summer	3221 (17.99)	5324 (29.74)	2116 (11.82)	4393 (24.54)	2846 (15.90)	
	Fall	4795 (24.68)	5403 (27.81)	2030 (10.45)	4388 (22.58)	2814 (14.48)	
	Winter	5244 (28.10)	4941 (26.47)	1769 (9.48)	4146 (22.22)	2563 (13.73)	

The results our study should be used to improve Meadville’s public health policies for cold seasons, and more specifically, implement some programs that prepare the ER to receive and treat respiratory cases more efficiently in the cold season. “Winter bed crisis”—a lack of staff and/or material to attend all the population during the cold season—is a common problem in hospitals and ERs [43]. Knowing that respiratory diseases will be more incident during winter, the MMC can prepare the staff and material necessary in advance with the goal of reducing the “winter bed crisis”. Additionally, this information can be used to warn the population served by the MMC about the respiratory health risks that are greater during the winter season. Examples are campaigns to encourage proper nutrition, preparation of appropriate clothing, and arrangement of heating systems, among others.

As mentioned in the Introduction, the combination of climate changes and air pollution is tightly related with the increasing incidence of respiratory diseases [4], and that makes the study of seasonality of these diseases relevant and necessary. What would make research in this area even more relevant to Meadville’s public health system would be the possibility of assessing the environmental factors related with the cold season and the incidence of respiratory diseases, at the same time. Some of them end up being intuitive, such as dry air and low temperatures, however others aren’t, like air pollution and how climate change is affecting the seasons, and therefore they requires further investigation. Knowing more environmental causes of these diseases would take health policies to another level, improving the city’s public health.

In respect to the overall study of seasonal patterns, the field is lacking some global assessment. Studies always highlight the fact that seasonality of diseases change between countries [47], and even hemispheres [3] [20], but more detailed information within this subject is not often researched. As an example, comparison between temperate and tropical places could give us information about which environmental factors are influencing diseases cycles. Also, comparing different countries, that have the same climate configuration, can elucidate some behavioral and cultural practices that could be related to seasonality of diseases.

Table 2. Unadjusted odds ratio for each of the variables, regards Respiratory Gastrointestinal, Genitourinary and Neurological diseases. Cardiovascular diseases were used as the reference group in the analysis.

		Unadjusted ORs (95%CI)				
	Variables	Respiratory	Gastrointestinal	Genitourinary	Neurological	Cardiovascular
Sex	Male	0.805 (0.7672 - 0.8437)	0.874 (0.8352 - 0.9153)	0.502 (0.4731 - 0.5326)	0.679 (0.6470 - 0.7118)	1.0 (Ref)
	Female	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Insurance	Private insurance	1.180 (1.0454 - 1.3388)	0.577 (0.5145 - 0.6463)	0.832 (0.7305 - 0.9481)	1.244 (1.1039 - 1.4026)	1.0 (Ref)
	Government Insurance	0.216 (0.1920 - 0.2432)	0.133 (0.1192 - 0.1487)	0.165 (0.1447 - 0.1873)	0.142 (0.1259 - 0.1596)	1.0 (Ref)
	No insurance	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Race	African American	0.923 (0.8249 - 1.0332)	0.939 (0.8431 - 1.0467)	0.975 (0.8516 - 1.1155)	0.998 (0.8934 - 1.1155)	1.0 (Ref)
	Others	0.836 (0.6647 - 1.0516)	0.925 (0.7450 - 1.1483)	0.716 (0.5321 - 0.9622)	0.937 (0.7485 - 1.1719)	1.0 (Ref)
	Caucasian	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Seasons	Spring	0.699 (0.6547 - 0.7480)	0.989 (0.9267 - 1.0558)	1.029 (0.9480 - 1.1179)	0.961 (0.8983 - 1.0282)	1.0 (Ref)
	Summer	0.553 (0.5162 - 0.5927)	0.970 (0.9085 - 1.0365)	1.077 (0.9917 - 1.1701)	0.954 (0.8913 - 1.0215)	1.0 (Ref)
	Fall	0.833 (0.7794 - 0.8899)	0.996 (0.9324 - 1.0639)	1.045 (0.9617 - 1.1359)	0.964 (0.9003 - 1.0321)	1.0 (Ref)
	Winter	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Age*	Mean (sd)	46.0 (28.6)	49.6 (23.9)	55.9 (23.0)	43.1 (27.5)	(Ref)

4.2. Strengths and Limitations

One strength of our study is that we assessed approximately 14 years of ER admission data, summing a total of 75,568 cases. Also, from each of these admissions we had access to a broad range of information such as ICD-9 code, cause of admission, date, time and year of admission, sex, race, and insurance. Our data allowed us to look at both potential confounders to the disease-season relationship as well as trends over time. We feel the reliability of our data will allow our results to be used to help improve the public health system of Meadville, and it can even be generalized to inspire future research of seasonality in other small cities around the United States.

The cross-sectional collection and analysis of data does not allow us to assume causality from our results. We therefore, can only discuss our results in terms of associations between season and disease. Additionally, for our study, seasons were not assessed using any environmental factors, such as temperature, humidity, rain fall or pollen counts. Even though the categorization of seasons followed precisely the standard annual cycle, this division alone does not account for possible interference of seasonal variations or climate change. Basically, without using environmental factors, we cannot certainly assess if the winter in one year was more or less rigorous than in others, and how this could potentially influence the seasonality of respiratory diseases.

5. Conclusion

Research in the field of seasonality of diseases is still considerable inconsistent. While some diseases categories have a seasonal pattern while established, like cardiovascular diseases and winter, others still show a lot of variation (gastrointestinal, genitourinary, neurological). In our study we looked at seasonality of ER admissions

Table 3. Adjusted odds ratio for each of the variables, regards Respiratory Gastrointestinal, Genitourinary and Neurological diseases. ORs were obtained after performing a multivariable analysis using regression model.

		Adjusted ORs (95%CI)				
Variables		Respiratory	Gastrointestinal	Genitourinary	Neurological	Cardiovascular
Sex	Male	0.643 (0.606 - 0.683)	0.705 (0.667 - 0.744)	0.608 (0.567 - 0.653)	0.456 (0.425 - 0.488)	1.0 (Ref)
	Female	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Insurance	Private insurance	0.936 (0.812 - 1.078)	0.590 (0.521 - 0.668)	0.851 (0.734 - 0.988)	0.999 (0.863 - 1.157)	1.0 (Ref)
	Government Insurance	1.375 (1.186 - 1.594)	0.666 (0.585 - 0.758)	0.828 (0.706 - 0.970)	1.042 (0.893 - 1.215)	1.0 (Ref)
	No insurance	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Race	African American	0.914 (0.794 - 1.052)	0.968 (0.852 - 1.101)	0.936 (0.794 - 1.104)	1.048 (0.894 - 1.229)	1.0 (Ref)
	Others	0.637 (0.474 - 0.855)	0.851 (0.660 - 1.098)	0.675 (0.475 - 0.961)	0.869 (0.633 - 1.194)	1.0 (Ref)
	Caucasian	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Seasons	Spring	0.757 (0.697 - 0.822)	1.001 (0.927 - 1.082)	1.004 (0.908 - 1.110)	1.073 (0.972 - 1.184)	1.0 (Ref)
	Summer	0.579 (0.531 - 0.632)	0.929 (0.858 - 1.005)	0.972 (0.878 - 1.075)	1.015 (0.919 - 1.120)	1.0 (Ref)
	Fall	0.741 (0.681 - 0.806)	0.938 (0.867 - 1.015)	0.943 (0.851 - 1.044)	0.962 (0.870 - 1.063)	1.0 (Ref)
	Winter	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)

using 14 years of data from the MMC in northwestern PA. We did not find any significant difference in seasonality of ER admissions for gastrointestinal, genitourinary and neurological diseases, when comparing at CVD. However, we found significantly fewer ER admissions for respiratory diseases in the spring, summer, and fall, when comparing to the winter across 14 years of data.

The application of our results would mainly be related to improve Meadville's public health policies for cold seasons, and more specifically, implement some programs that prepare the ER to receive and treat respiratory cases more efficiently during the cold season. However, the methodology we developed and used to assess the seasonality of diseases can be used by other small community hospitals to identify patterns of ER admissions by season. In future research, we propose an investigation of environmental factors related to respiratory diseases in Meadville during the winter. Information from this study could be used to further improve local health policies.

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