

## Case Report

# Long-Term Monitoring of *Giardia* as an Etiological Agent for Food-Borne Outbreaks in USA: A Brief Report

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## Abstract

Giardiasis is one of the common outbreaks that are caused by genus *Giardia* which belongs to subfamily Giardiinae. National Outbreak Reporting System (NORS) is a web-based platform database provides detailed outbreaks information by Centers for Disease Control and Prevention (CDC) that helps in the analysis of epidemiological diseases. Nevertheless, statistical process control software provides an indispensable tool for the processing of these records to derive useful information, future preventive actions and learning lessons. The study showed that *Giardia duodenalis* is the most common cause of Giardiasis with almost 80% of outbreaks occurred between June and November during 20 years of monitoring from 1998 to 2017. More than 80% of outbreaks have occurred in the years 2006, 2009 to 2015 and 2017. The non-normally distributed illness cases of the outbreaks followed Weibull (3) spreading with few cases of the spiking for the number of ill individuals in some recorded outbreaks. More than 65% of overall Giardiasis outbreaks are centered in New York, California and Pennsylvania. However, food-borne Giardiasis showed different order with 60% of outbreak cases involving New York, Pennsylvania, Wisconsin, California, Illinois, and Utah. This protozoan disease is disseminated primarily by water (>65% recreational, environmental and drinking) then food with these modes of transfer accounts by more than 70% of the total potential sources. Most of the recorded settings of occurrence were restaurants, camps, religious places, parks, child day care and private residences or homes. From trending charts, the outbreaks magnitudes tend to decrease but increase in frequency.

**Keywords:** *Giardia duodenalis*; G-chart; Laney-attribute chart; NORS; Pareto diagram; Weibull (3)

## Introduction

Epidemics are affecting human life adversely by affecting health and economy due to outbreaks encountered [1]. Giardiasis is one of the commonly reported outbreaks belonging to the phylum Metamonada that infect vertebrates by colonizing the small intestine [2]. *Giardia* is a tiny flagellated anaerobic protozoan of microscopic size that infects tenths of millions of people every year causing diarrhea, a disease named as Giardiasis and belonging to subfamily Giardiinae [3,4]. *Giardia* (Beaver disease which is also commonly assigned to *Giardia intestinalis*, *Giardia lamblia*, or *Giardia duodenalis*) is found on the ground or in the soil, food, or water that has been tainted with fecal matter from infected humans or animals [5]. It is one of the neglected tropical diseases (NTDs) classified by WHO [6].

*Giardia* is covered by an external shield that provides durable protection outside the host for an extended time and withstands Chlorine-compound sanitization process that allows for good survivability in water. While the parasite has many ways to spread and disseminate, aquatic environments (potable water and recreational water) are the major mean of transfer [7]. Despite the absence of

some observations from outbreak dataset, most of the observed food materials contaminated with *Giardia* were recorded as being from multiple or unclassified sources according to Interagency Food Safety Analytics Collaboration (IFSAC) categorization during long term observation [8].

The present case is showing a multidimensional study of overall *Giardia* outbreak in the USA for 20 years from 1998 to 2017 with a special focus on food-related illnesses. National Outbreak Reporting System (NORS) database provides comprehensive useful information (Table 1), from which preventive actions and learning lessons could be derived and concluded from the appropriate thorough analysis. The use of statistical software will be considered herein to visualize the pattern and behavior of the outbreak in the long term study from the database record of NORS. These programs include XLSTAT version 2014.5.03 built-in Microsoft Excel for normality, distribution fitting and statistical analysis and MINITAB version 17.1.0 for Shewhart charts construction and Pareto charts.

## Case Presentation

Dataset was obtained from the National Outbreak Reporting System (NORS) which is a web-based platform database that provides detailed outbreaks information by the Centers for Disease Control and Prevention (CDC) in the 2000's [9]. The record was processed and classified in an Excel sheet to isolate *Giardia* spp. as an etiological agent for the recorded outbreaks. After that, these data were processed using statistical software packages and processed by statistical process control (SPC) tools [10-12]. The analysis was done for both food-borne illnesses alone and the overall outbreaks in the USA from this parasite.

Attribute control charts were selected for data trending and C-type (or more generally U chart) was selected for recording the multiple

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illnesses per a single outbreak on the vertical axis and the outbreak number ordered chronologically on the horizontal axis [13]. However, data should be subjected to a diagnostic test to determine the validity of the ordinary chart type, otherwise, Laney-corrected chart should be used to avoid false alarms "red dots out-of-control" of outbreaks. Based on the outcome of this test, Laney-modified charts were selected with Sigma Z values indicating the magnitude of Overdispersion or Underdispersion as could be seen in Figure 1. Process-behavior charts are showing the mean number of outbreak cases with upper and lower control limits (UCLs and LCLs) as windows for the monitored outbreaks trend. Alarming dots (numbered outbreaks) are indicative of two major types of the out-of-control number of ill individuals per single outbreak *viz.* excursion spiking beyond the upper threshold and assignable-cause pattern of aberrant points within the Control Limits (CLs). Otherwise, the remaining points in the Figures are within the expected count of cases in the outbreaks.

G-type of control chart is a rare event trending chart which has similar parameters of the previously mentioned control chart but y-axis is an interval time between events of outbreak incidences with initial alarming points are an indication of higher-than-normally expected interval trend which is desirable. However, the following outbreaks tended to occur in a higher rate with a probability of occurrence approximately 0.4 and 0.1 for overall and food-borne *Giardiasis*, respectively. Figure 2 illustrates this phenomenon graphically. On the other hand, this protozoan disease is abundant in few states in the country when analyzed using Pareto diagram as could be found in Figure 3 with *Giardia duodenalis* showed prevalence as could be seen in Pareto analysis in Figure 4. More than 65% of overall *Giardiasis* outbreaks are centered in New York, California and Pennsylvania. However, food-borne *Giardiasis* showed different order with 60% of outbreak cases involving New York, Pennsylvania, Wisconsin, California, Illinois, and Utah.

In Pareto charts of Figure 5, almost 80% of outbreaks occurred between June and November during 20 years of monitoring from 1998 to 2017. More than 80% of outbreaks have occurred in the years 2006, 2009 to 2015 and 2017. Common food vehicles included vegetables, whole and pasteurized milk in addition to multiple consumable food products.

This protozoan disease is disseminated primarily by water (>65% recreational, environmental and drinking) then food with these modes

of transfer accounts by more than 70% of the total potential sources as could be illustrated in Figure 6. Most of the recorded settings of occurrence of *Giardiasis* outbreaks were restaurants, camps, religious places, parks, child day care and private residences or homes.

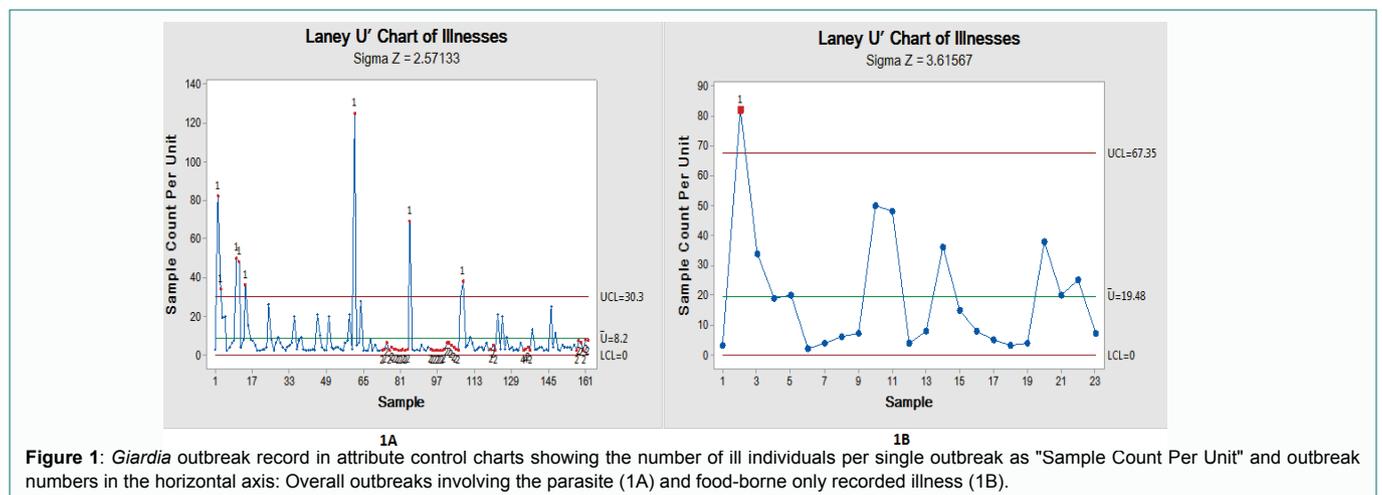
Many of the reported cases of *Giardia* outbreaks have been hospitalized but no deaths were recorded during the current study period. Statistically, the spreading of illness data for outbreaks did not follow Gaussian distribution but it followed the Weibull (3) pattern according to the distribution fitting test at confidence level 5% as could be seen in Figure 7.

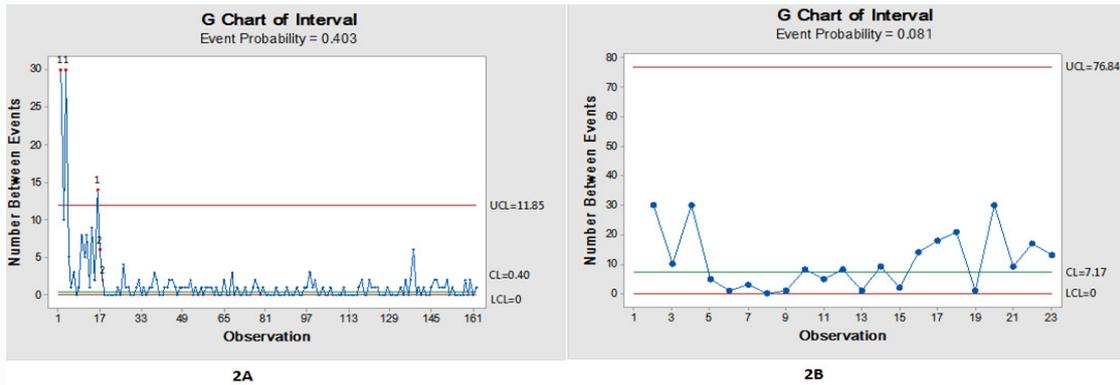
## Discussion

*Giardiasis* is a self-limiting disease that is caused by a parasite of Diplomonadida (twin nuclei, each associated with four flagella) order although it is characterized by symptoms such as abdominal cramps and bloating, yet asymptomatic carrier cases are very common with much greater rate in developing nations more than the developed countries [5,14]. This pathogen colonizes the intestine of human and other animals as trophozoites which excyst in the duodenum from the ingested contaminated material and undergoes repeated mitotic division. When excreted in the feces, it forms environmentally resistant cysts that can survive in water, soil and food for weeks or even months [5].

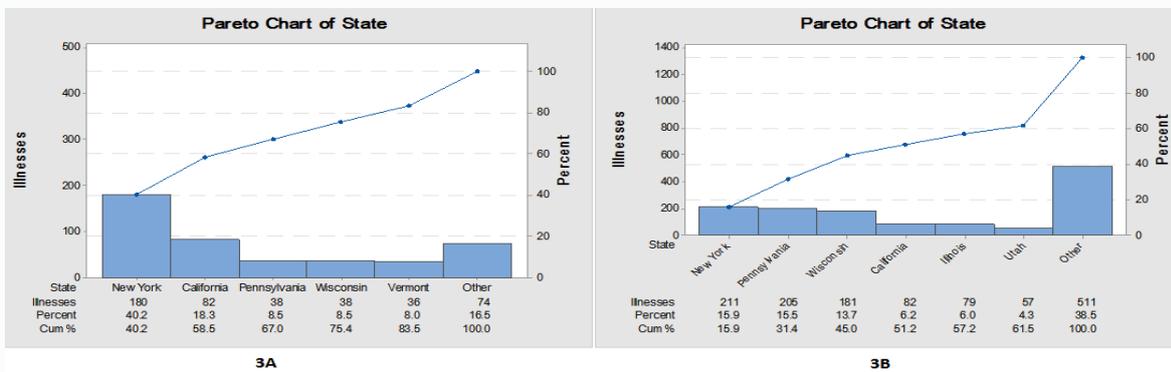
Being a tropical parasite, *Giardia* outbreaks were observed to flourish in hot weather or summer [15]. The phenomenon of global warming may be a contributing factor in the increase in the number of infected populations in the recent trend [16]. Identification of the distribution type and parameters are a useful key step in the outbreak modeling and prediction [17]. The ability of this parasite to survive in the harsh conditions as the cyst is responsible for its wide dissemination from different vehicles and affecting different settings either closed or open in an environment [5,18-20].

The general trend of illness cases per an outbreak is generally descending but the frequency of occurrence has risen during the recent years of monitoring of *Giardiasis* outbreaks. It is expected that the carriers for the parasite asymptotically are actually much higher than could be anticipated with only symptomatic cases could be observed and recorded. A problem that is more intense in the developing countries where poor sanitation and hygiene are common in the absence of an effective and rigorous regulatory supervision and control.

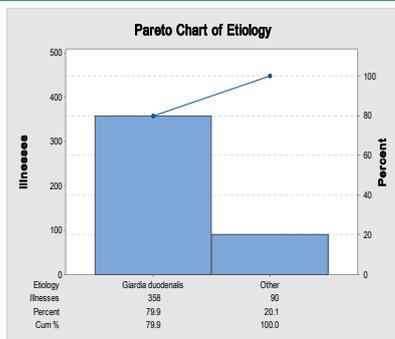




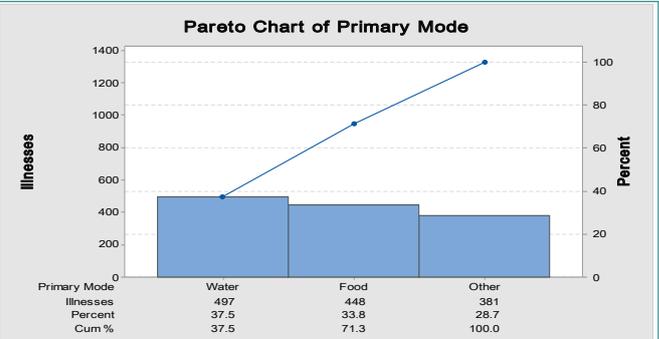
**Figure 2:** *Giardia* outbreak record in rare event trending charts showing the time interval between outbreaks on the vertical axis and the outbreak ordered events on the x-axis with the possibility of occurrence is indicated for each: Overall outbreaks involving the parasite (2A) and food-borne only recorded illness (2B).



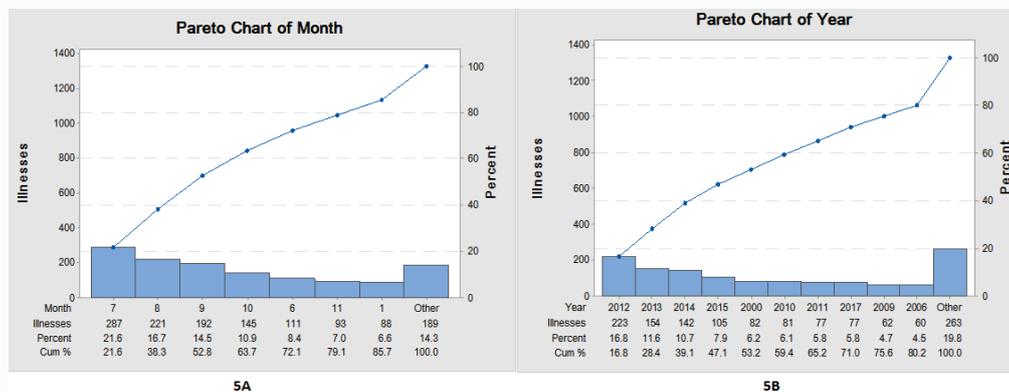
**Figure 3:** Major USA States involving *Giardia* outbreak as showing the time interval between outbreaks on the vertical axis and the outbreak ordered events on the x-axis with the possibility of occurrence is indicated for each: Overall outbreaks involving the parasite (3A) and food-borne only recorded illness (3B).



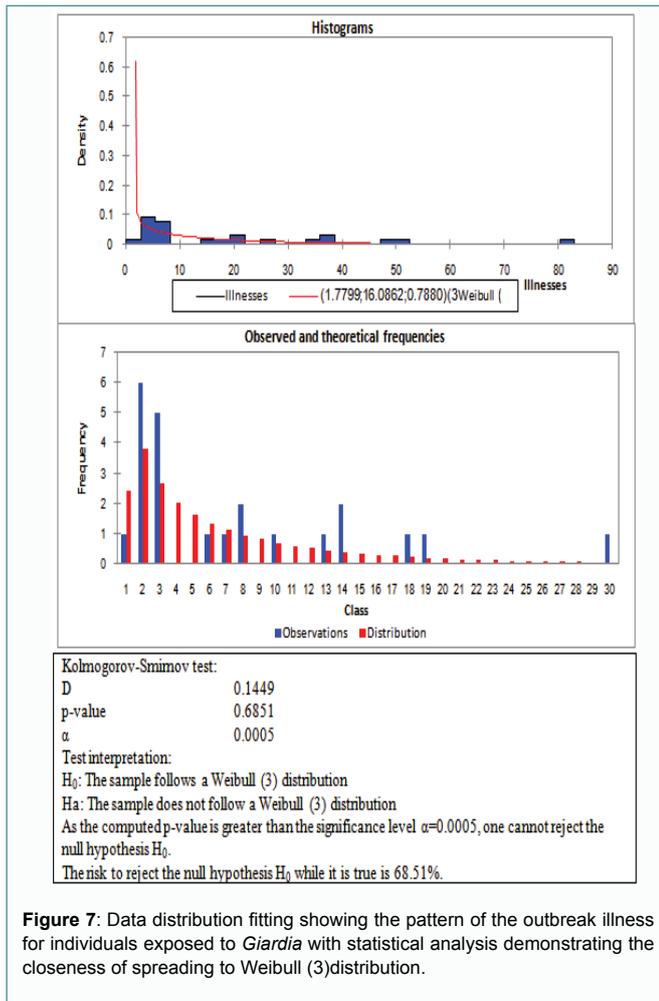
**Figure 4:** Pareto chart showing the main contributor species for Giardiasis outbreaks from 1998 to 2017.



**Figure 6:** Major vehicles for transmission of Giardiasis to human from 20 years trend monitoring.



**Figure 5:** Pareto chart showing the major (>80%) months (5A) and years (5B) from 1998 to 2017 monitoring of outbreaks involving *Giardia* spp.



**Figure 7:** Data distribution fitting showing the pattern of the outbreak illness for individuals exposed to *Giardia* with statistical analysis demonstrating the closeness of spreading to Weibull (3) distribution.

## Conclusion

Giardiasis outbreaks cause a greater number of illnesses during summer/warm climates with the rate affected individuals are ascending especially during the last ten years. Water followed by food sources are the major vehicles for the transfer of this parasite and special control measures are required to limit the hazard from this microorganism. Despite the outbreaks have encountered a relatively lower number of the affected individuals in the latest portion of the monitoring, yet the frequency of the incidents has increased if compared with the initial trend of the survey. Despite the outbreaks are rebound persistent in nature, appropriate control and preventive measures could contain the events and limit the magnitude of causalities.

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