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Foodborne Outbreak Calendar: Application of Time Series Analysis

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Abstract : The Centers for Disease Control and Prevention (CDC) estimate that 31 known foodborne pathogens cause 9.4 million cases of these illnesses annually in US. Over 90% of these illnesses are associated with exposure to Campylobacter, Cryptosporidium, Cyclospora, Listeria, Salmonella, Shigella, Shiga-Toxin Producing E.Coli (STEC), Vibrio, and Yersinia. Contaminated products contain parasites typically causing an intestinal illness manifested by diarrhea, stomach cramping, nausea, weight loss, fatigue and may result in deaths in fragile populations. Since 1998, the National Outbreak Reporting System (NORS) has allowed for routine collection of suspected and laboratory-confirmed cases of food poisoning. While retrospective analyses have revealed common pathogen-specific seasonal patterns, little is known concerning the stability of those patterns over time and whether they can be used for preventative forecasting. The objective of this study is to construct a calendar of foodborne outbreaks of nine infections based on the peak timing of outbreak incidence in the US from 1996 to 2017. Reported cases were abstracted from FoodNet for Salmonella (135115), Campylobacter (121099), Shigella (48520), Cryptosporidium (21701), STEC (18022), Yersinia (3602), Vibrio (3000), Listeria (2543), and Cyclospora (758). Monthly counts were compiled for each agent, seasonal peak timing and peak intensity were estimated, and the stability of seasonal peaks and synchronization of infections was examined. Negative Binomial harmonic regression models with the delta-method were applied to derive confidence intervals for the peak timing for each year and overall study period estimates. Preliminary results indicate that five infections continue to lead as major causes of outbreaks, exhibiting steady upward trends with annual increases in cases ranging from 2.71% (95%CI: [2.38, 3.05]) in Campylobacter, 4.78% (95%CI: [4.14, 5.41]) in Salmonella, 7.09% (95%CI: [6.38, 7.82]) in E.Coli, 7.71% (95%CI: [6.94, 8.49]) in Cryptosporidium, and 8.67% (95%CI: [7.55, 9.80]) in Vibrio. Strong synchronization of summer outbreaks were observed, caused by Campylobacter, Vibrio, E.Coli and Salmonella, peaking at 7.57 ± 0.33, 7.84 ± 0.47, 7.85 ± 0.37, and 7.82 ± 0.14 calendar months, respectively, with the serial cross-correlation ranging 0.81-0.88 ($p < 0.001$). Over 21 years, Listeria and Cryptosporidium peaks (8.43 ± 0.77 and 8.52 ± 0.45 months, respectively) have a tendency to arrive 1-2 weeks earlier, while Vibrio peaks (7.8 ± 0.47) delay by 2-3 weeks. These findings will be incorporated in the forecast models to predict common paths of the spread, long-term trends, and the synchronization of outbreaks across etiological agents. The predictive modeling of foodborne outbreaks should consider long-term changes in seasonal timing, spatiotemporal trends, and sources of contamination.

Keywords : foodborne outbreak, national outbreak reporting system, predictive modeling, seasonality
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