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Direct Outpatient Health Care Costs Among Commercially Insured Persons for Common Foodborne Pathogens and Acute Gastroenteritis, 2012–2015

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Abstract

Foodborne illness is common in the United States with most, but not all, foodborne pathogens causing symptoms of acute gastroenteritis (AGI). Outpatient care is the most frequent type of medical care sought; however, more accurate estimates of outpatient costs are needed to inform food safety policy decision. Using the U.S. MarketScan Commercial Claims and Encounters database, we quantified the per-visit cost of outpatient visits with any AGI-related diagnosis (including pathogen-specific and nonspecific or symptom-based diagnoses) and for those with a pathogen-specific diagnosis for 1 of 29 pathogens commonly transmitted through food (including pathogens that cause AGI and some that do not). Our estimates included the per-case cost of office visits and associated laboratory tests and procedures as well as the conservative estimates of prescription cost. Most AGI outpatient visits were coded using nonspecific codes (e.g., infectious gastroenteritis), rather than pathogen-specific codes (e.g., *Salmonella)*. From 2012 to 2015, we identified more than 3.4 million initial outpatient visits with any AGI diagnosis and 45,077 with a foodborne pathogen-specific diagnosis. As is typical of treatment cost data, severe cases of illness drove mean costs above median. The mean cost of an outpatient visit with any AGI was $696 compared with the median of $162. The mean costs of visits with pathogen-specific diagnoses ranged from $254 (median $131; interquartile range [IQR]: $98–184) for *Streptococcus* spp.

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All authors have taken part in writing the article, reviewing it, and revising its intellectual and technical content. All authors assume responsibility and accountability for the results.

Disclaimer
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Group A (*n* = 22,059) to $1761 (median $161; IQR: $104-$1101) for *Clostridium perfringens* (*n* = 30). Visits with two of the most common causes of foodborne illness, nontyphoidal *Salmonella* and norovirus, listed as a diagnosis, had mean costs of $841 and $509, respectively. Overall, the median per-case costs of outpatient visits increased with age, with some variation by pathogen. More empirically based estimates of outpatient costs for AGI and specific pathogens can enhance estimates of the economic cost of foodborne illness used to guide food policy and focus prevention efforts.

Keywords

enteric; foodborne; outpatient; health care; cost; MarketScan

Introduction

The United States experiences an estimated 48 million foodborne illnesses each year (Scallan et al, 2011a; Scallan et al, 2011b). Many pathogens commonly transmitted through food (hereafter, foodborne pathogens) cause acute gastroenteritis (AGI; i.e., diarrhea and vomiting), including the two leading causes of foodborne illness in the United States—*Salmonella* and norovirus (CDC, 2019; Scallan et al, 2011b). Some foodborne pathogens do not usually manifest as AGI, including *Listeria monocytogenes* and *Toxoplasma gondii*. Roughly 20% of people with a foodborne illness have an outpatient visit (e.g., primary care physician or emergency room visit); <1% are hospitalized (Scallan et al, 2011b). While the cost of outpatient care is low compared with hospitalization, the high incidence of foodborne illnesses coupled with the relatively frequent use of outpatient care makes it important to build a stronger empirical basis for estimating the cost of foodborne illness outpatient care.

The U.S. cost of foodborne illness estimates contribute to policy analysis and public education about the impact of these illnesses. However, more detailed, information is needed to determine how best to estimate the cost of U.S. foodborne outpatient cases. Prior estimates of the cost of foodborne illnesses have assumed that all outpatient cases cost the same and based estimates on administrative payment schedules or studies of a single pathogen (Gastanaduy et al, 2013; Hoffmann et al, 2015; Ralston et al, 2011; Scharff, 2015; Scharff, 2012; Scharff et al, 2009; Weycker et al, 2009). In contrast, both medical and epidemiology analyses highlight substantial variation in the type and severity of illness by pathogen and serotype (Jones et al, 2008; Kennedy et al, 2004; Scallan et al, 2011b).

In this study, we quantified the per-visit cost of outpatient visits with any AGI diagnoses (including pathogen-specific and nonspecific or symptom-based diagnoses) and those with specific foodborne pathogens listed as a diagnosis using a large sample of commercial insurance claims from 2012 to 2015. We also explore variation in per-visit costs by age.

Materials and Methods

Data source

We used a commercial insurance claims database, MarketScan Commercial Claims and Encounters (Truven Health Analytics, Ann Arbor, MI). This database contains insurance billing data for outpatient visits (including office and emergency department visits), hospital stays, diagnostic tests and procedures, and prescription medications for >90 million persons in the United States covered by employer-sponsored health insurance (about half of the U.S. population is covered by employer-sponsored health insurance) (Hansen, 2018; Kaiser Family Foundation, 2019). This includes employees, retirees younger than 65, former employees, and spouses/partners and dependents of these individuals. These data are widely used in U.S. cost of medical treatment studies (Appendix A1). Due to changes in diagnostic codes, we limited this analysis to 2012–2015 to improve consistency. MarketScan contains deidentified, preexisting insurance billing records only. As a result, the analysis did not meet the definition of human subjects research (Appendix A1).

Inclusion criteria

We constructed a sample that comprised persons with at least one outpatient office visit diagnosed as any AGI or as caused by a specific foodborne pathogen, with the initial visit between January 2012 and December 2015 (Table 1). Any AGI was previously defined by the CDC (Scallan et al, 2011b) as International Classification of Disease (ICD) codes 001–008 (intestinal infections with pathogen-specific diagnoses), 009 (ill-defined intestinal infections), 558.9 (other and unspecified noninfectious diarrhea), or 787.91 (diarrhea, not otherwise specified). The CDC includes “other and unspecified diarrhea” (noninfectious cases) in its definition of AGI because in practice this code is often erroneously used to code infectious illness, including foodborne illnesses (Scallan et al, 2018; Scallan Walter et al, 2020). We refer to the International Classification of Diseases, Ninth Revision (ICD-9) codes 001–008 as pathogen-specific AGI and 009, 558.9, and 787.91 as nonspecific (symptom-based) AGI.

Following CDC’s AGI definition, we exclude cases diagnosed as *Clostridium difficile* colitis (008.45) or botulism food poisoning from any AGI. We also identified cases diagnosed with infections from 29 specific foodborne pathogens including *Clostridium botulinum,* an important foodborne pathogen (Table 1). Our goal was to include cases with diagnoses for all 31 foodborne pathogens for which the CDC has incidence estimates, but sapovirus and “Vibrio, other species” do not have specific ICD-9 diagnostic codes.

We include care in any outpatient setting (office, clinic, or emergency department). We exclude emergency department visits resulting in hospitalization. We only include claims for the first clinic visit with an AGI diagnosis code as most AGI patients have one visit per illness episode. We include only prescriptions filled on the day of this visit to limit costs to those most likely incurred for AGI care. We analyzed a subsample of cases and found a marked increase in the percentage of prescriptions used to treat non-AGI illnesses, particularly chronic health conditions, among those filled after the day of the outpatient visit. Persons covered by capitated insurance plans or plans without prescription drug coverage were also excluded (Appendix A1).

Analytical approach

For each outpatient visit, insurer and out-of-pocket payments for office visits, laboratory testing, and prescription drugs were totaled. We report claim frequencies, and mean, median, and interquartile ranges (IQRs) of per-case cost by diagnosis category and by age (0–4, 5–17, 18–64 years). Laboratory costs are included in office visit costs because it is not possible to separate laboratory from office visit costs for a large proportion of records (hereafter visit costs). A single visit may have several diagnoses. Thus, the sum of claim frequencies for AGI subgroups exceeds that of any AGI. Costs were standardized to July 2015 U.S. dollars. Data management and analyses were conducted using SAS software version 9.4 (SAS Institute, Cary, NC).

Results

Per-case total outpatient costs

From 2012 to 2015, we found more than 3.4 million initial outpatient visits with any AGI diagnosis code listed (Table 2) (visit codes henceforth referred to as diagnosis). Per-case total costs (visit plus prescription costs) were right-skewed, with means often exceeding the 75th percentile. The median cost of an outpatient visit with any AGI diagnosis code listed was $156 (mean: $678; IQR: $95-$520). The median cost of an outpatient visit diagnosed with nonspecific AGI ranged from $120 (IQR: $83–$196; mean: $322) for "ill-defined infections" (*n* = 264,363) to $201 (IQR: $110–$779; mean: $776) for "diarrhea, other gastrointestinal illness symptoms" (*n* = 1,741,599). Cases diagnosed as having "other and unspecified diarrhea from noninfectious causes" (*n* = 1,197,986) had a median cost of $150 (IQR: $91–$821; mean: $807). Only 1.2% of visits with any AGI diagnosis (*n* = 400,189) received a pathogen-specific diagnosis. The median cost of any pathogen-specific AGI outpatient visit was $117 (IQR: $82–$208; mean: $409).

There were 45,077 outpatient visits diagnosed with one of the 29 foodborne pathogens included in this study. Their median per-case costs ranged from $113 (IQR: $80–$235; mean: $525) for cases diagnosed *"Escherichia coli* diarrheagenic, other" (*n* = 305) to $320 (IQR: $123–$1407; mean: $1323) for *Cryptosporidium* spp. (*n* = 334). Mean costs ranged from $254 (median $131; IQR: $98–184) for cases diagnosed with *Streptococcus* spp. Group A (*n* = 22,059) to $1761 (median $161; IQR: $104-$1101) for *Clostridium perfringens* (*n* = 30). Outpatient visits with nontyphoidal *Salmonella* (*n* = 2511) and norovirus (*n* = 1011) listed as diagnoses had median costs of $167 (IQR: $97–$455; mean: $841) and $132 (IQR: $90–$256; mean: $509), respectively.

We assessed the impact of including more than one outpatient visit on per-case cost by looking at six common diagnoses. Most (85%) people with any AGI diagnosis had only one visit in 30 days. Including all of a patient's outpatient visits with a foodborne-illness-related diagnosis within 30 days of their initial diagnosis increased the per-person cost for cases diagnosed as any AGI by ~ 19%. Cost increases ranged from 10% for cases diagnosed as ill-defined intestinal infections to 35% for those with toxoplasmosis diagnoses (Appendix A1).

Per-case prescription costs

One-third (35%) of outpatient visits with any AGI diagnosis filled a prescription on their visit day; their prescription costs were 16% of mean total per-case visit costs (Table

2). For those diagnosed with nonspecific AGI, the percentage filling a prescription was 33% for “diarrhea, other AGI symptoms,” 36% for “other and unspecified diarrhea from noninfectious causes,” and 42% for “ill-defined infectious gastroenteritis” (representing 16%, 15%, and 16% of their mean total per-case costs, respectively).

Similarly, 34% of outpatient visits with a pathogen-specific AGI diagnosis filled prescriptions on the visit day (17% of the total costs). For visits with individual foodborne pathogens diagnoses, the percent filling same-day prescriptions ranged from 16% for toxoplasmosis (26% of total per-case visit cost) to 72% for *Streptococcus* spp. Group A claims (18% of cost). Almost one-third (32%) of outpatient visits with a non-typhoidal *Salmonella* diagnosis and 41% with a norovirus diagnosis filled a prescription on the same day as their visit, representing 16% and 17% of total visit costs, respectively.

Per-case total outpatient costs by age

Costs of visits with any-AGI diagnosis increased with age. Specifically, they were highest among those age 18–64 (n = 2,338,147; mean: $828; median: $193; IQR: $109–$874) compared with those age 5–17 years (n = 557,577; mean: $437; median: $119; IQR: $82–$238) and <5 (n = 523,035; mean: $262; median: $105; IQR: $78–$172) (Table 3). This held for cases with pathogen-specific or nonspecific AGI diagnoses. However, trends varied among cases with individual foodborne pathogen diagnoses. For example, the median per-case cost of an outpatient visit increased with age for those diagnosed with nontyphoidal *Salmonella* ($127, $157, and $182 for those <5, 5–17, and 18–64, respectively), but decreased with age for those diagnosed with rotavirus ($388, $227, and $137) or *Campylobacter* ($466, $380, and $304).

Discussion

The goal of this study was to improve the basis for estimating the cost of outpatient treatment of foodborne disease in the United States. Limited prior research affected the way all three recent U.S. cost of foodborne illness estimated outpatient costs. Scharff (2012) assumed uniform per-case costs based on “usual, customary, and reasonable rates” from fee schedules for physician office visits, emergency room visits, and laboratory charges (Practice Management Information Corporation, 2009; Scharff, 2012). Noting a lack of research on pharmaceutical costs for foodborne illnesses, he based per-case cost on prior studies of a salmonellosis outbreak and of Shiga toxin–producing *E. coli* (STEC) costs (Cohen et al, 1978; Frenzen, 2007; Frenzen et al, 2005). Frenzen et al (2005) also noted a lack of data on prescription usage and based their prescription cost estimate on assumptions about usage and the average cost of drugs typically used to treat STEC.

Hoffmann et al (2012) assumed illnesses other than STEC had the same per-case outpatient visit cost as *Salmonella* (based on Frenzen et al, 1999 using 1994–1996 MarketScan data ($496 2015$)). Neither Hoffmann et al (2012) nor Minor et al (2015) included pharmaceutical costs due to a lack of research and a finding in Frenzen (2005) that drug costs were <2% of STEC total cost of illness. Ours is the first study to use a large national administrative data set to examine how outpatient treatment and pharmaceutical costs vary by AGI and specific foodborne pathogen diagnoses and by age.

Most outpatient visits in our study had nonspecific, that is, symptom-based, AGI diagnoses. Only 12% of all AGI visits had any pathogen-specific AGI diagnosis; there were even fewer visits with one of the 29 foodborne pathogen-specific diagnoses. Pathogen-specific diagnoses were used infrequently in comparison with their annual incidence. Norovirus, *Salmonella, C. perfringens, Campylobacter,* and *Staphylococcus aureus* collectively cause roughly 18% of all the estimated U.S. foodborne illnesses (known or unspecified etiology), but the number of visits with these diagnoses was <1% of visits with any-AGI diagnoses in our sample (Scallan et al, 2011b).

Differing severity of illness could explain the low utilization of pathogen-specific diagnoses presumably reflecting low rates of stool tests. Research examining laboratory data and medical records found that fewer than half of hospitalized patients with culture-confirmed *Salmonella, Campylobacter,* or *E. coli* 0157 infection received a corresponding pathogen-specific diagnosis in their billing records (Scallan et al, 2018; Scallan Walter et al, 2020). Physicians may be even less likely to order stool tests in an outpatient setting since most of the outpatient treatments do not require a pathogen-specific diagnosis (Mullaney et al, 2019). Having bloody diarrhea or any diarrhea for more than 3 d has been associated with a higher rate of stool sample orders for outpatients than less severe illness with nonbloody diarrhea or diarrhea for 3 d or less (Mullaney et al, 2019; Scallan et al, 2011a).

Previous research found that physicians submitted a stool sample for only 19% of people who sought health care for nonbloody diarrhea (Scallan et al, 2011b). In a survey of U.S. Armed Forces members who visited a physician for AGI, 13% were asked to submit a stool sample, of these 89% did (Mullaney et al, 2019).

AGI is treated with several types of drugs: rehydration therapies, antimotility, antinausea, antiemetic drugs, antacids, probiotics, and antibiotics (Shane et al, 2017). A German study found that 31% of AGI patients reported taking a prescription drug for their AGI and 10% of patients reported taking an antibiotic (Wilking et al, 2013). A recent U.S. study found that 13% of AGI visits were prescribed antibiotics (Collins et al, in press). We found that 35% of patients with “any-AGI” diagnosis filled prescriptions the day of their visit (mean cost $108). Based on assumptions regarding medicine usage and average drug costs, Frenzen et al (2005) estimated prescriptions for treating STEC cost $73 (2015$) compared with our estimate of $126 for cases diagnosed as STEC 0157.

What do these results say about best estimates of the cost of outpatient treatment for foodborne infections? First, right-skewed distributions are typical of medical treatment cost data. Cost-of-illness studies use mean estimates because severe/costly cases, not just typical cases, need to be reflected in society’s cost of treating illness. ERS currently assumes uniform cost for outpatient visits, $496, for all pathogens except STEC 0157 (2015$) (Hoffmann et al, 2012; USDA ERS, 2021). We find a mean per-case visit cost for cases with “any AGI” diagnoses of $678 (2015$), $409 for pathogen-specific AGI, and $322 for ill-defined intestinal infections. The mean cost of outpatient visits diagnosed with a specific foodborne pathogen ranges from $254 for *Streptococcus* spp. to $1761 for *C. perfringens*. Given the low rate of stool samples ordered in outpatient cases, most cases will be diagnosed as nonspecific AGI.

More severe cases, for example, those with bloody diarrhea, are more likely to have a stool sample ordered and therefore should be more costly. Some nonspecific AGI cases were more costly, likely because this category included noninfectious cases such as chronic gut disorders, but cannot be separated based on ICD codes. Ideally, one might calculate a weighted mean of the foodborne-pathogen-specific and nonspecific AGI per-case costs, but we are aware of no source of data to construct such a weighting for inpatient cases.

The mean per-case costs of cases with a foodborne pathogen-specific diagnosis, including pathogens not causing AGI symptoms, fall within one standard deviation of the mean cost of any AGI. The differences between mean any-AGI per-case outpatient cost and that of each foodborne pathogen diagnosis averages to $23. Together, this suggests that the practice of using a uniform per-case cost for outpatient cases is defensible even based on more detailed data than prior studies examined. In general, disease severity among cases treated in only an outpatient setting does not vary enough to create substantial differences in per-case medical treatment and prescription costs. The one exception is *Streptococcus,* which does not cause AGI. Cases with a *Streptococcus* diagnosis have a mean per-case cost, $254, that is less than half that of cases diagnosed as any AGI.

It is unclear to us why outpatient cases among adults younger than 65 would be more costly in general than those in children, particularly children younger than 5 years. It is possible that physicians are more likely to admit children <5 to the hospital than an adult with the same symptoms. There are foodborne pathogen-specific diagnoses for which those younger than 5 have higher mean per-case costs than adults, but with the exception of rotavirus, the number of observations is quite small.

These are several limitations to this analysis. First, although MarketScan provides a large sample of insured patients, it is not nationally representative (differences in patient characteristics, as well as plan and benefit type between these data and that of all privately insured individuals, may affect the results). Medical care seeking behavior may differ by insurance plan, which could impact the aggregate results. Most importantly, it does not include those 65 years and older. Analyses specific to Medicare would be needed to explore age effects more comprehensively. Second, as with all medical claims data, physicians use diagnostic codes inconsistently, affecting estimates. For instance, specific clinical features may influence a physician's decision to order laboratory diagnostics, such that those cases with a pathogen-specific diagnosis may differ from those with more generic, symptom-based coding.

Third, we examined costs resulting from the first outpatient visit for each person during the study time period. As most episodes of foodborne illness are self-limiting, most people have only one outpatient visit. All prior costs of foodborne illness estimates assume one outpatient visit. Our sensitivity analysis shows these results in conservative outpatient visit cost estimates. Similarly, our prescription costs include only prescriptions filled the day of the office visit resulting in conservative estimates of prescription costs, but less likely to pick up non-foodborne illness-related prescriptions, and in line with prior estimates. Fourth, some foodborne pathogens do not present with classic AGI symptoms (e.g., *C. botulinum, Brucella, Listeria,* and *T. gondii)*. With the exception of *Streptococcus,* mean estimates of per-case costs of cases with these non-AGI diagnoses do not differ substantially from mean per-case cost of cases with "any-AGI" diagnosis.

Conclusion

Cost-of-illness estimates, along with incidence and burden estimates, help guide decisions about where to best focus scarce prevention resources. Although outpatient costs for many pathogens were comparable, some variation was observed. When conducting pathogen-specific economic analyses, researchers may consider these results to determine if general AGI or pathogen-specific costs are needed to most accurately reflect economic burden. Age effects were present both among aggregate AGI diagnosis groups and among cases with pathogen-specific diagnoses. These effects should be considered in cost or decision analytic studies specific to age subgroups and to inform weighting of cost estimates across diverse samples or populations.

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Appendix

Appendix A1. Data and Methods

To estimate costs for this analysis, we used payment data from a commercial insurance claims database, MarketScan Commercial Claims and Encounters (CCAE; Truven Health Analytics) (Hansen, 2018). This database contains insurance payment data for patient visits (including outpatient office and emergency department [ED] visits), hospital stays, diagnostic tests and procedures, and prescription medications for more than 25 million persons in the United States covered by employer-sponsored health insurance annually (Hansen, 2018). About half of the U.S. population is covered by employer-sponsored health insurance (Kaiser Family Foundation, 2021). People covered by employer-sponsored health insurance include employees, retirees younger than 65, former employees, and spouses, partners and dependents of these individuals. The MarketScan CCAE database is a large convenience sample of this group (roughly ten to twenty percent of the Americans covered by employer-sponsored health insurance were included in MarketScan during the years of this analysis).

MarketScan is frequently used to estimate the cost of medical treatment in the United States (Clabaugh and Ward, 2008; Hodgkins et al, 2011; Huse et al, 2005; Song et al, 2011). Due to changes in the International Classification of Disease (ICD) coding implemented in 2016, we limited this analysis to 2012–2015 to improve consistency. Diagnosis codes of interest are outlined in the main article (Table 1).

MarketScan contains deidentified, preexisting insurance billing records. No interaction or intervention with human subjects occurred and no personally identifiable information was used, collected, or transmitted. This analysis did not meet the definition of human subjects research (as defined in the U.S. Code of Federal Regulations, Title 45 Part 46), and was not subject to review by the Centers for Disease Control and Prevention (CDC) Institutional Review Board.

Medical treatment costs are often estimated using administrative data sources containing either hospital and provider billing data or insurance payment data (Muennig and Bounthavong, 2016). When hospital or provider billing data (charges) are used, conversion of charges (the amount i.e., billed) to costs (as measured by the amount i.e., paid) is needed, using cost-to-charge ratios for the hospital or provider. If a particular disease or procedure of interest has a specific cost-to-charge ratio that is different than the general cost-to-charge ratio that is commonly available, charge data can produce inaccurate cost estimates. When insurance payment data are used, as it is in MarketScan, cost-to-charge ratios are not needed and costs can be estimated more directly.

To calculate outpatient costs, we summed insurer payments and payments from the insured person (known as out-of-pocket payments) to calculate the sum of total payments for each visit. Cost estimates included payments for outpatient office visits and ED visits that did not result in hospital admission, diagnostic testing, procedures (e.g., colonoscopies), and prescription medication. We followed the methods recommended in the MarketScan database documentation for calculating costs. This method has been used previously to estimate direct health care costs for a number of foodborne and waterborne diseases (Adam et al, 2017; Collier et al, 2021; Collier et al, 2012).

We began by identifying the earliest payment associated with a diagnostic code of interest for each person in the outpatient table of the MarketScan CCAE database. The outpatient table contains payments for office and ED visits, diagnostic testing, and procedures (but does not contain payments for prescriptions). Each payment in the outpatient table has a diagnosis code associated with it. Because outpatient visits can involve one or multiple payments (e.g., an ED visit can result in payments to the facility and to multiple providers), we then included all outpatient payments that occurred on the same day for the same person (a person-visit-day). This process is recommended in the MarketScan documentation to ensure that all payments associated with a given visit are captured.

We limited analysis to claims dated the same day of each patient’s first acute gastroenteritis (AGI) diagnosis (i.e., the first outpatient visit with an AGI diagnosis code) to best reflect the typical experience of outpatient care as the majority of patients with acute AGI have one visit per episode of illness, and because we faced practical computing limitations given the hundreds of millions of records contained in the MarketScan database. We conducted a sensitivity analysis using a slightly more recent set of MarketScan data (2013–2020), because that set is available in an online tool that enables more rapid analysis. Thus, the costs per visit differ very slightly, but all our samples, except 2012, are included in the online tool.

We chose six diagnoses (any AGI, salmonellosis, *C. perfringens* infection, toxoplasmosis, diarrhea, not otherwise specified, and ill-defined intestinal infections) that we felt spanned a wide range of disease severity. For each diagnosis, we assessed how many people had an additional visit for one of these diagnoses in the 30 d after the initial visit. For people with any AGI diagnosis, 85% had only one visit in 30 d, while 15% had more than one visit. The proportion of people with multiple visits ranged from 10% of people for ill-defined intestinal infections to 37% of people with a toxoplasmosis diagnosis. We then calculated the mean total costs for additional visits to examine how much additional cost was incurred in the 30-d time frame. If we reported outpatient costs that incurred within 30 d of the initial visit, the per-person cost would increase by ~ 19%.

For cases with more specific diagnoses, the % increase varied: 10% for those diagnosed with ill-defined intestinal infections, 21% for diarrhea, not otherwise specified diagnoses, 23% for *C. perfringens* infection, 24% for salmonellosis, and 35% for toxoplasmosis diagnoses. We have no way of knowing whether these additional visits are in fact related to the initial visit or to a new infection or to a noninfectious illness. We therefore decided to adhere to a conservative estimate and provide information that would allow users to conduct sensitivity analysis if they think that is appropriate. Prior cost-of-illness estimates also limited costs to one outpatient visit (Hoffmann et al, 2012; Minor et al, 2015; Scharff, 2012).

Next, to incorporate prescription costs, we used the prescription table of the MarketScan CCAE database. Unlike the outpatient table, the prescription table only includes the date the prescription was filled, the name of the drug, and information about the specific formulation of the drug. It does not include a diagnostic code to indicate why the drug was prescribed. Thus, prescription costs must be associated with the outpatient visit that generated the prescription using a date or range of dates. The MarketScan documentation does not include a recommended range of dates for joining outpatient and prescription costs, because the most appropriate window can vary depending on the nature of the illness of interest. We joined prescription costs with outpatient visit costs that occurred on the same day.

We chose to only include same-day prescription costs for at least three reasons. First, we reasoned that patients were likely to fill prescriptions relatively quickly for the acute infectious illnesses of interest in this analysis. Second, if a range of dates are used and multiple visits occur in the date range, an algorithm to assign costs to a single visit must be devised to avoid double-counting costs. We felt that we had insufficient data to inform such an algorithm. Finally, we conducted a sensitivity analysis comparing same-day prescriptions with prescriptions up to 3 d after the visit. We observed a notable loss of specificity when additional days of prescriptions were included.

For the prescription sensitivity analysis, we also used the more recent set of MarketScan data (2013–2020) available in the online analysis tool. Thus, the percentage of visits associated with a prescription is slightly different, but all our samples, except 2012, are included in the online tool. In the sensitivity analysis, 31% of people with an outpatient visit for AGI filled a prescription on the day of the visit. When the date range was expanded to include prescriptions filled up to 3 d later, 43% of people with an outpatient visit for AGI filled a prescription.

Among people who filled a prescription on the same day, the most common categories of drugs prescribed included the following: antiemetics, several categories of antimicrobials, antidiarrheal drugs, and analgesics, all of which would be appropriate for people with AGI. Among people who filled a prescription up to 3 d later, the most common categories of drugs included antidepressants, cholesterol-lowering drugs, beta-blockers, and hormonal birth control. When the time between the outpatient visit and filling a prescription was expanded, a fairly small number of additional prescriptions were added (12% of people did not fill a prescription on the same day of the visit, but did fill a prescription 1,2, or 3 d later.) Within the 12% of people filling a prescription at least 1 d after the visit, many of the prescriptions were for chronic diseases or other health care needs.

After identifying all payments associated with the outpatient visit, we summed the payments for a given person-visit-day to create the total outpatient visit cost. All payments were adjusted to 2015 U.S. dollars using the Medical Care Consumer Price Index (Bureau of Labor Statistics, U.S. Department of Labor).

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Table 1.

Defined Pathogens or Illness Groupings with Associated International Classification of Diseases, Ninth Revision, Clinical Modification Codes

Pathogen or illness grouping	ICD-9 code
Any AGI	001–008, 009, 558.9, 787.9[a]
Pathogen-specific AGI	
Intestinal infectious diseases, excluding ill defined	001–008[a]
Unspecified AGI	
Ill-defined intestinal infections	009
Other and unspecified diarrhea, noninfectious causes	558.9
Diarrhea, not otherwise specified	787.91
Potentially foodborne pathogen-specific diagnoses	
Bacteria	
Bacillus cereus	00589
Brucella spp.	0230–0233, 0238–0239
Campylobacter	00843
Clostridium botulinum	0051
Clostridium perfringens	0052
Escherichia coli: STEC O157	00804, 04141
E. coli: STEC non-O157	00804
E. coli enterotoxigenic	00802
E. coli diarrheagenic, other	00801, 00803, 00809
Listeria monocytogenes	0270
Mycobacterium bovis	0310–0312, 0318–0319
Salmonella (nontyphoidal)	0021–0022, 0023, 0029–0032, 00321–00324, 00329, 0038–0039
Salmonella enterica Typhi	0020
Shigella spp.	0040, 0041, 0042, 0043, 0048, 0049
Staphylococcus aureus	0050, 00841
Streptococcus spp. Group A	04101
Vibrio cholerae	0010, 0011
Vibrio parahaemolyticus	0054
Vibrio vulnificus	00581

Pathogen or illness grouping	ICD-9 code
Yersinia enterocolitica	00844
Parasites	
Cryptosporidium spp.	0074
Cyclospora cayetanensis	0075
Giardia intestinalis	0071
Toxoplasma gondii	1300–1305, 1307–1309
Trichinella spp.	124
Viruses	
Astrovirus	00866
Hepatitis A virus	0700, 0701
Norovirus	00863
Rotavirus	00861

The heading “Potentially foodborne pathogen-specific diagnoses” is used to refer to cases that have been diagnosed as having an infection with a pathogen that is frequently foodborne.

[a] Excluding 008.45 (*Clostridium difficile* colitis) and 005.1 (botulism).

AGI, acute gastroenteritis; ICD-9, International Classification of Diseases, Ninth Revision; STEC, Shiga toxin–producing *E. coli*.

Table 2.

Outpatient Costs per-Case, Acute Gastrointestinal Illness-Related Commercial Insurance Claims Aggregated by Diagnostic Code, 2012–2015, 2015 Dollars

Diagnosis group	**N**	***Percent of patients filling a prescription the day of the office visit, %***	***Mean total costs per-visit (SD), $ [a]***	***Median total costs per-visit (IQR), $ [a]***	***Mean RX costs as a percent of total costs, %[b]***
Any AGI	3,418,759	34.7	678 (1516)	156 (95–520)	16.0
Pathogen-specific AGI					
Intestinal infectious diseases, excluding ill defined	400,189	34.3	409 (1116)	117 (82–208)	16.8
Unspecified AGI					
Ill-defined intestinal infections	264,363	42.1	322 (924)	120 (83–196)	16.2
Other and unspecified diarrhea, noninfectious causes	1,197,986	36.2	807 (1684)	150 (91–821)	15.1
Diarrhea, not otherwise specified	1,741,599	33.0	776 (1594)	201 (110–779)	15.6
Potentially foodborne	45,077	34.9			20.6
pathogen-specific diagnoses					
Bacteria					
Bacillus cereus	606	40.4	631 (1255)	156 (101–420)	13.1
Brucella spp.	305	31.1	726 (4235)	185 (106–368)	28.9
Campylobacter	853	33.3	1647 (2747)	309 (123–1935)	11.9
Clostridium botulinum	216	25.0	883 (4052)	147 (75–420)	37.1
Clostridium perfringens	30	20.0	1761 (5213)	161 (104–1101)	39.1
Escherichia coli: STEC O157	539	29.5	782 (1840)	181 (108–465)	16.1
E. coli: STEC non-O157	231	30.3	1018 (2016)	198 (106–677)	17.2
E. coli enterotoxigenic	57	35.1	540 (1462)	123 (80–346)	13.8
E. coli diarrheagenic, other	305	44.6	525 (1464)	113 (80–235)	20.5
Listeria monocytogenes	199	28.1	543 (1026)	165 (87–494)	19.9
Mycobacterium bovis	4271	30.6	817 (1766)	258 (130–640)	31.3
Salmonella (nontyphoidal)	2511	32.4	841 (2343)	167 (97–455)	15.9
Salmonella enterica Typhi	1267	18.2	481 (1357)	192 (89–407)	22.3
Shigella spp.	1142	44.3	548 (2032)	148 (92–284)	26.7
Staphylococcus aureus	522	42.9	586 (1603)	151 (91–385)	21.2
Streptococcus spp. Group A	22,059	72.3	254 (838)	131 (98–184)	17.5

Diagnosis group	N	Percent of patients filling a prescription the day of the office visit, %	Mean total costs per-visit (SD), $ [a]	Median total costs per-visit (IQR), $ [a]	Mean RX costs as a percent of total costs, % [b]
Vibrio cholerae	1350	27.0	796 (4310)	184 (91–494)	25.0
Vibrio parahaemolyticus	40	30.0	591 (926)	172 (105–522)	17.2
Vibrio vulnificus	27	48.1	548 (1184)	164 (82–297)	12.3
Yersinia enterocolitica	26	50.0	947 (1694)	223 (119–935)	21.2
Parasites					
Cryptosporidium spp.	334	32.6	1323 (2585)	320 (123–1407)	28.0
Cyclospora cayetanensis	93	36.6	645 (1695)	202 (112–575)	13.0
Giardia intestinalis	1879	51.0	511 (1325)	151 (100–292)	19.0
Toxoplasma gondii	1805	16.5	638 (1857)	180 (111–385)	25.6
Trichinella spp.	407	36.9	576 (1505)	183 (96–339)	15.7
Viruses					
Astrovirus	12	41.7	481 (542)	176 (89–1071)	6.9
Hepatitis A virus	1372	18.0	501 (2553)	180 (93–371)	26.3
Norovirus	1011	40.7	509 (1401)	132 (90–256)	17.5
Rotavirus	1608	24.8	1079 (4714)	216 (96–1029)	16.6

Total cost includes the cost of in-patient visits, associated laboratory tests and procedures, and cost of prescriptions filled the day of the office visit. Visits due to an infection with a particular pathogen may be diagnosed with pathogen-specific and nonpathogen-specific diagnoses. For example, cases of salmonellosis may be diagnosed as *Salmonella* or as AGI.

The heading "Potentially foodborne pathogen-specific diagnoses" is used to refer to cases that have been diagnosed as having an infection with a pathogen that is frequently foodborne.

[a] Outpatient and prescription drug costs aggregated on patient identification number and visit date, means and medians assessed for all ICD-9-CM codes with the diagnosis code examined.

[b] Percent of total cost attributed to prescription drug costs calculated for each record, then averaged for all ICD-9-CM codes with diagnosis code examined.

ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; IQR, interquartile range; RX, prescriptions; SD, standard deviation; STEC, Shiga toxin–producing *E. coli*.

Table 3.

Total Outpatient Costs per-Case by Age Group, Acute Gastrointestinal Illness-Related Commercial Insurance Claims Aggregated by Diagnostic Code, 2012–2015, 2015 Dollars

	Age <5			*Age 5–17*			*Age 18–64*		
Diagnosis group	**N**	***Mean (SD), $***	***Median (IQR), $***	**N**	***Mean (SD), $***	***Median (IQR), $***	**N**	***Mean (SD), $***	***Median (IQR), $***
Any AGI	523,035	262 (721)	105 (78–172)	557,577	437 (1147)	119 (82–238)	2,338,147	828 (1690)	193 (109–874)
Pathogen-specific AGI									
Intestinal infectious diseases, excluding ill defined	93,071	240 (894)	99 (76–145)	104,916	290 (788)	106 (78–165)	202,202	549 (1318)	138 (91–310)
Unspecified AGI									
Ill-defined intestinal infections	51,133	159 (388)	95 (75–131)	56,461	203 (593)	104 (78–152)	156,769	418 (1114)	143 (94–238)
Other and unspecified diarrhea, noninfectious causes	176,184	288 (718)	104 (78–174)	229,147	468 (1241)	115 (81–225)	792,655	1021 (1894)	198 (104–1347)
Diarrhea, not otherwise specified	223,339	319 (784)	117 (81–237)	191,795	628 (1386)	164 (97–538)	1,326,465	874 (1705)	230 (122–1002)
Potentially foodborne pathogen-specific diagnoses	6603			13,880			24,594		
Bacteria									
Bacillus cereus	8	1077 (2589)	110 (81–355)	56	441 (697)	126 (97–321)	542	644 (1272)	164 (104–422)
Brucella spp.	6	159 (102)	130 (72–258)	39	674 (1709)	200 (105–466)	260	747 (4541)	183 (106–360)
Campylobacter	56	1266 (1797)	466 (150–1726)	102	1535 (2579)	380 (116–1926)	695	1694 (2833)	304 (123–1940)
Clostridium botulinum	30	2159 (10,285)	190 (109–315)	16	812 (1182)	146 (64–1376)	170	665 (1508)	141 (70–402)
Clostridium perfringens	1	584 (NA)	584 (NA)	11	2327 (5247)	1101 (143–1286)	18	1481 (5458)	128 (83–185)
Escherichia coli: STEC O157	69	810 (2148)	173 (119–454)	95	809 (1842)	174 (96–425)	375	770 (1782)	183 (109–478)
E. coli: STEC non-O157	30	913 (1508)	184 (115–1085)	49	1387 (2826)	252 (113–742)	152	921 (1777)	198 (101–622)
E. coli enterotoxigenic	2	188 (158)	188 (76–300)	6	146 (168)	84 (74–101)	49	602 (1569)	136 (92–362)
E. coli diarrheagenic, other	42	766 (2271)	90 (79–134)	44	422 (1404)	106 (77–170)	219	499 (1271)	118 (82–255)
Listeria monocytogenes	3	82 (17)	80 (67–101)	3	104 (63)	127 (33–151)	193	557 (1039)	171 (89–501)
Mycobacterium bovis	201	1511 (3362)	252 (153–609)	265	1039 (2002)	311 (143–950)	3805	765 (1612)	256 (128–626)
Salmonella (nontyphoidal)	345	593 (1613)	127 (79–316)	365	639 (1333)	157 (93–534)	1801	930 (2602)	182 (102–467)
Salmonella enterica Typhi	61	236 (422)	120 (59–214)	200	302 (743)	153 (77–274)	1006	532 (1479)	210 (103–460)
Shigella spp.	129	588 (1954)	100 (78–260)	140	588 (1505)	157 (87–308)	873	535 (2117)	154 (94–284)
Staphylococcus aureus	27	496 (1048)	149 (101–356)	71	216 (260)	120 (87–205)	424	654 (1748)	155 (91–434)
Streptococcus spp. Group A	4426	198 (584)	126 (96–167)	11,280	198 (605)	126 (96–173)	6353	392 (1234)	144 (104–227)

	Age <5			Age 5–17			Age 18–64		
Diagnosis group	**N**	***Mean (SD), $***	***Median (IQR), $***	**N**	***Mean (SD), $***	***Median (IQR), $***	**N**	***Mean (SD), $***	***Median (IQR), $***
Vibrio cholerae	49	540 (872)	226 (100–488)	123	369 (747)	145 (92–334)	1178	851 (4602)	193 (91–525)
Vibrio parahaemolyticus	—	—	—	4	481 (550)	270 (166–797)	36	603 (963)	171 (102–522)
Vibrio vulnificus	1	39 (NA)	39 (NA)	—	—	—	26	568 (1203)	166 (87–297)
Yersinia enterocolitica	—	—	—	4	583 (498)	507 (211–955)	22	1013 (1830)	213 (119–935)
Parasite									
Cryptosporidium spp.	28	572 (739)	320 (106–591)	47	1832 (4132)	410 (139–1302)	259	1312 (2327)	309 (123–1557)
Cyclospora cayetanensis	1	288 (NA)	288 (NA)	33	1184 (2727)	416 (125–770)	59	350 (444)	160 (100–388)
Giardia intestinalis	193	521 (869)	224 (116–525)	246	444 (1172)	137 (94–264)	1440	521 (1398)	147 (100–270)
Toxoplasma gondii	19	347 (504)	172 (72–289)	95	846 (2481)	198 (120–448)	1691	629 (1825)	179 (111–383)
Trichinella spp.	3	1156 (1853)	104 (69–3295)	31	465 (684)	115 (73–543)	373	580 (1554)	194 (97–328)
Virus									
Astrovirus	—	—	—	2	112 (81)	112 (54–169)	10	555 (568)	184 (92–1219)
Hepatitis A virus	19	167 (189)	106 (57–166)	56	304 (647)	170 (97–236)	1297	515 (2622)	184 (93–385)
Norovirus	77	528 (893)	139 (90–367)	153	473 (1552)	127 (89–203)	781	514 (1412)	133 (90–269)
Rotavirus	777	1279 (6547)	388 (112–1163)	344	1120 (1732)	227 (95–1579)	487	730 (1656)	137 (87–395)

Total cost includes the cost of in-patient visits, associated laboratory tests, and cost of prescriptions filled the day of the office visit. The heading “Potentially foodborne pathogen-specific diagnoses” is used to refer to cases that have been diagnosed as having an infection with a pathogen that is frequently foodborne.

IQR, interquartile range; SD, standard deviation; STEC, Shiga toxin–producing *E. coli*.