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# Acute Colonic Diverticulitis: Diagnostic Evidence, Demographic and Clinical Features in Three Practice Settings

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## ABSTRACT

**Background & Aims**: Diverticulitis is often diagnosed in outpatients, yet little evidence exists on diagnostic evidence and demographic/clinical features in various practice settings. We assessed variation in clinical characteristics and diagnostic evidence in inpatients, outpatients, and emergency department cases and effects of demographic and clinical variables on presentation features.

**Methods**: In a retrospective cohort study of 1749 patients in an integrated health care system, we compared presenting features and computed tomography findings by practice setting and assessed independent effects of demographic and clinical factors on presenting features.

**Results**: Inpatients were older and more often underweight/normal weight and lacked a diverticulitis past history and had more comorbidities than other patients. Outpatients were most often Hispanic/Latino. The classical triad (abdominal pain, fever, leukocytosis) occurred in 78 (38.6%) inpatients, 29 (5.2%) outpatients and 34 (10.7%) emergency department cases. Computed tomography was performed on 196 (94.4%) inpatients, 110 (9.2%) outpatients and 296 (87.6%) emergency department cases and was diagnostic in 153 (78.6%) inpatients, 62 (56.4%) outpatients and 243 (82.1%) emergency department cases. Multiple variables affected presenting features. Notably, female sex had lower odds for the presence of the triad features (odds ratio [95% CI], 0.65 [0.45-0.94], P<0.05) and increased odds of vomiting (1.78 [1.26-2.53], P<0.01). Patients in age group 56 to 65 and 66 or older had decreased odds of fever (0.67 [0.46-0.98], P<0.05) and 0.46 [0.26-0.81], P<0.01), respectively, while ≥1 co-morbidity increased the odds of observing the triad (1.88 [1.26-2.81], P<0.01).

**Conclusion**: There was little objective evidence for physician-diagnosed diverticulitis in most outpatients. Demographic and clinical characteristics vary among settings and independently affect presenting features.

**Key words:** diverticulitis – abdominal pain – irritable bowel syndrome – fever – leukocytosis – practice setting.

**Abbreviations**: AD: acute colonic diverticulitis; BMI: body mass index; CT: computed tomography; ED: emergency department; IBS: irritable bowel syndrome; ICD-9-CM: International Classification of Diseases, 9th Revision, Clinical Modification; IP: inpatient; KPSC: Kaiser Permanente Southern California; OP: outpatient.

## INTRODUCTION

By the age of 80, about 66% of Western adults will have diverticulosis [1]. Acute colonic diverticulitis (AD) ranks third among gastrointestinal and hepatology principal hospital discharge diagnoses [2]. Recent research has revealed much new information on risk factors for diverticular disease, the prevention and rate of AD over time, conventional and non-absorbable antibiotic therapy, pathological correlates of symptoms, and the relation of diverticular disease to irritable bowel syndrome (IBS) [3, 4]. A majority of hospitalized patients recover without surgery, and complications of perforation, abscess, obstruction and fistula underlie most deaths [5-7]. However, a majority of all patients with AD are diagnosed and treated as outpatients [7-9].

Acute diverticulitis is diagnosed from the history and physical examination and computed tomography (CT) is recommended to confirm the diagnosis and identify complications [5-7, 10, 11]. However, urgent CT is often not readily accessible in the management of outpatients. A modified Hinchey classification system depends on the classical clinical/laboratory triad of abdominal pain, fever, and leukocytosis to diagnose "mild clinical diverticulitis" without confirmation by imaging or surgery [6]. However, we recently

reported that this complete triad occurs in only one-fourth of patients with AD confirmed by CT, including less than 50% of patients with severe AD [12]. Due to the poor sensitivity and specificity of these features, some investigators advise the use of additional clinical and laboratory data to improve diagnostic accuracy [13-15].

Accurate diagnosis of AD in outpatients is especially challenging, and some authors have questioned the validity of the diagnosis in many such cases [8, 16]. It may be particularly difficult to distinguish AD from IBS [17], and a concept of diverticular disease as a chronic illness has been proposed [18]. The issue is further complicated by the recent report of IBS developing after AD [19]. Therefore, it would be important to know more about the evidence by which physicians diagnose AD in outpatients.

In a large integrated health care plan, we compared the demographic and clinical features of patients diagnosed with AD and treated with antibiotics in hospital inpatient (IP), emergency department (ED) and outpatient (OP) settings. We compared the objective evidence for the diagnosis among these settings and assessed the effects of demographic and clinical variables on the presenting features.

## MATERIAL AND METHODS

### Practice setting and data sources

The study was conducted within Kaiser Permanente Southern California (KPSC), an integrated health care system that provides comprehensive health services for 3.5 million members throughout 14 hospitals and 198 medical offices in Southern California. The member population is demographically similar to the general population of Southern California [20]. This retrospective cross-sectional study was conducted utilizing the KPSC electronic medical records system and databases in its Research Data Warehouse, which contains information on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes, medical and pharmacy utilization, KPSC membership eligibility, and member-reported demographic features. This study was approved by the KPSC Institutional Review Board. KPSC electronic data have been used extensively in research studies, and validation of the codes has revealed high diagnostic accuracy [21, 22].

### Patient studies and data acquisition

We identified all patients aged 18 to 100 years who had received ICD-9-CM code 562.11 or 562.13 for AD at a KPSC facility between January 1, 2008 and August 31, 2009. Patients with a diagnosis of colorectal cancer (ICD-9-CM codes 153.xx and 154.xx) or who had undergone colon resection during the six months prior to their episode of AD were excluded. The treatment settings were organized into a hierarchy with IP at the top, followed by ED, and finally OP. Patients initially seen in a lower setting who moved to a higher setting for treatment were assigned to the higher setting for analysis; therefore, each patient was placed in only one group. We obtained stratified random samples from the entire KPSC population by stratifying by OP, ED, and IP encounters in a 1:1:1 ratio. Inpatients and ED patients were oversampled to ensure enough cases in those groups, as OPs, represented the majority of all cases. Outpatients who had undergone CT and same-day transfer patients from ED to IP were also oversampled, yielding 2400 patients (OP=868, IP=867, ED=665) for database and record abstraction.

A research associate obtained data as previously detailed [12]. In brief, data was obtained on race/ethnicity, Charlson co-morbidities [23], insurance type, and geo-coded median household income from the KPSC Research Data Warehouse. The research associate recorded other demographic and clinical data from electronic records according to detailed rules, conferred with the gastroenterologist co-author to resolve ambiguities, and entered the data into a Microsoft Excel 2003 (Microsoft, Redmond WA) chart abstraction tool. Data missing from the encounter were imputed only under certain circumstances. Missing height values were imputed from measurement at any other encounter, and missing weight values were imputed from a weight at any OP encounter up to one year before or after the AD event, giving preference to weights recorded before. Body temperature and leukocyte count were imputed only if measured since the onset of abdominal pain. Symptoms and signs were inferred as negative if complete history data were present (i.e., physician history and physical examination) and the presence or absence of a feature was not explicitly stated. We recorded these variables as missing when no information was available for imputing or inferring them, usually when records were missing or incomplete.

Upon review of the initially selected patients' records, 651 (27% of the initial 2400 patients) encounters did not have physician-diagnosed AD and were excluded from further analysis, leaving 1749 patients. The 651 patients were excluded due to lack of physician notes describing antibiotic treatment of AD (185) or whose ICD-9-CM code referred to encounters for elective surgery (130), a past episode of AD (115), an initial but not final diagnosis of AD (115) or was erroneous (106). Patients were pooled and then weighted to reflect the actual proportion of patients from IP, ED, and OP settings within the KPSC population of patients with AD during the study period to adjust for the oversampling before analysis. After applying weights to the data, there were 212 (12.1%) IPs, 340 (19.5%) ED cases and 1197 (68.4%) OPs.

Body mass index (BMI) in $kg/m^2$ was classified as underweight (<18.5), normal weight (18.5 to 24.9), overweight (25.0 to 29.9) and obese (≥30.0) [24]. The highest body temperature was categorized as fever if >37.5°C [25]. Thresholds for leukocyte count were leukocytosis (>11,000 leukocytes/$mm^3$), neutrophilia (>7,700 neutrophils/$mm^3$), and "bandemia" (>700 immature neutrophils/$mm^3$) [26]. The clinical/laboratory triad comprised abdominal pain, fever and leukocytosis. Radiologists' CT reports were used to indicate the performance of a CT as well as the result. Severity of CT findings diagnostic of AD were classified as moderate (inflammation of peri-colonic fat) and severe (abscess and/or extra-luminal gas and/or extra-luminal contrast). Lesser findings such as colonic wall thickening or equivocal findings were considered non diagnostic.

The institutional review board (Ethics Committee) approved the study.

**Data analysis**

Categorical variables were analyzed by chi-square tests, with Fischer's exact test when appropriate. Continuous data were summarized as mean ± standard deviation.

We performed a series of multivariate logistic regressions to identify how patient demographic and clinical factors contributed to the odds of having various presenting features of AD, adjusting for the patients' type of insurance, and Charlson's co-morbidity conditions. We assessed abdominal pain with two complementary approaches, either as pain limited to the left lower quadrant or abdominal pain at any site. All tests of significance used 2-tailed p-values with an alpha of 0.05. For the logistic regression, odds ratios with 95% confidence intervals were also reported. All analyses were conducted in SAS statistical software (version 9.2 SAS Institute, Cary NC).

## RESULTS

As shown in Table I, the majority of patients were women and sex did not vary among practice settings. Age varied with

**Table I.** Characteristics of patients with acute diverticulitis cared for in three settings.

| | | Overall (n=1749)[a] | Outpatients (n=1197)[a] | Inpatients (n=212)[a] | Emergency Department (n=340)[a] | P-value |
|---|---|---|---|---|---|---|
| Sex | Male | 779 (44.6%) | 528 (44.2%) | 92 (43.6%) | 159 (46.7%) | 0.681 |
| Age | | | | | | <0.001 |
| | 18 to 45 | 396 (22.6%) | 259 (21.6%) | 43 (20.1%) | 94 (27.8%) | |
| | 46 to 55 | 423 (24.2%) | 310 (25.9%) | 40 (19.1%) | 73 (21.5%) | |
| | 56 to 65 | 401 (22.9%) | 283 (23.7%) | 37 (17.4%) | 81 (23.7%) | |
| | 66 or older | 529 (30.2%) | 345 (28.8%) | 92 (43.4%) | 92 (27.0%) | |
| Race/Ethnicity | | | | | | <0.001 |
| | Caucasian | 1093 (62.4%) | 737 (61.5%) | 144 (67.8%) | 212 (62.2%) | |
| | API[b] | 64 (3.6%) | 33 (2.8%) | 12 (5.5%) | 18 (5.4%) | |
| | AA[c] | 128 (7.3%) | 78 (6.5%) | 22 (10.2%) | 28 (8.3%) | |
| | Hisp/Lat[d] | 302 (17.3%) | 244 (20.4%) | 20 (9.5%) | 38 (11.1%) | |
| | Other | 151 (8.7%) | 94 (7.9%) | 14 (6.7%) | 43 (12.6%) | |
| | Unknown | 11 (0.7%) | 10 (0.9%) | 0 (0.2%) | 1 (0.4%) | |
| Body Mass Index | | | | | | 0.014 |
| | Under/Normal weight | 309 (17.7%) | 199 (16.6%) | 56 (26.5%) | 54 (15.9%) | |
| | Overweight | 612 (34.9%) | 424 (35.4%) | 70 (32.9%) | 118 (34.6%) | |
| | Obese | 802 (45.9%) | 557 (46.6%) | 85 (40.3%) | 160 (47.2%) | |
| | Not Available | 26 (1.5%) | 17 (1.5%) | 1 (0.4%) | 8 (2.2%) | |
| Insurance | | | | | | <0.001 |
| | Commercial/ Private | 1169 (66.9%) | 834 (69.7%) | 112 (52.7%) | 223 (65.7%) | |
| | Government | 580 (33.1%) | 363 (30.3%) | 100 (47.3%) | 117 (34.3%) | |
| Income[e] | | | | | | 0.538 |
| | $45,000 or less | 411 (23.5%) | 278 (23.2%) | 59 (27.9%) | 74 (21.7%) | |
| | $45,001 to $80,000 | 844 (48.3%) | 578 (48.3%) | 98 (46.2%) | 168 (49.4%) | |
| | More than $80,000 | 487 (27.8%) | 339 (28.3%) | 54 (25.3%) | 94 (27.8%) | |
| | Unavailable | 7 (0.5%) | 2 (0.2%) | 1 (0.6%) | 4 (1.1%) | |
| Charlson's co-morbidities | | | | | | <0.001 |
| | 0 | 952 (54.4%) | 691 (57.7%) | 70 (33.0%) | 191 (56.3%) | |
| | 1 | 417 (23.9%) | 285 (23.9%) | 49 (23.0%) | 83 (24.4%) | |
| | 2 | 170 (9.7%) | 113 (9.4%) | 29 (13.6%) | 28 (8.2%) | |
| | 3+ | 210 (12.0%) | 108 (9.0%) | 64 (30.5%) | 38 (11.1%) | |
| | Average (SD) | 1.2 (1.9) | 1.0 (2.1) | 2.3 (1.7) | 1.1 (1.6) | |
| Diverticulitis history | Prior episode | 435 (24.9%) | 347 (29.0%) | 26 (12.2%) | 62 (18.3%) | <0.001 |

a: Group numbers and variable percentages represent weighted values; b: Asian/Pacific Islander; c: African American d: Hispanic/Latino; e: Based on geo-coded median household information.

the largest proportion of older patients in IP settings. Race/ethnicity also varied with Hispanics/Latinos predominating in OP settings and other/unknown status was most common in ED settings. Body mass index varied with IP settings having the largest proportion of underweight/normal weight patients. The number of co-morbidities and past history of AD also varied with IPs having the most co-morbidities and least history of prior AD.

The most common component of the clinical/laboratory triad was abdominal pain, predominantly limited to the left lower quadrant (Table II). Inpatients were most likely to have fever and leukocytosis, but over 50% of OPs lacked a leukocyte count. Neutrophilia occurred in 124 (77.1%) IPs, 108 (30.8%) OPs and 152 (51.4%) ED cases (P<0.001) and "bandemia" occurred in 21 (13.0%) IPs, 1 (0.2%) OPs and 9 (3.2%) ED cases (P<0.001). Complete data on all three components of the triad were present in most IPs and ED cases, but were absent in over 50% of OPs, mainly due to lack of a leukocyte count. The complete triad was present in less than 40% of IPs, fewer ED patients, and in only 1 of 20 OPs.

CT was performed on 603 (34.7%) of patients overall (196 [94.4%] IPs, 110 [9.2%] OPs, and 296 [87.6%] ED cases, P<0.001). All IPs and ED patients who underwent CT had it during the encounter, but only 68 (62%) OPs had it on the day of the encounter; it was performed 4.8 ± 9.3 days after the encounter in this group. Diagnostic findings were reported in 153 (78.6%) IPs, 62 (56.4%) OPs, and 243 (82.1%) ED cases (P<0.0001). Figure 1 displays the performance of CT and the results overall in relation to the recording of all three components of the clinical/laboratory triad and whether the triad was fulfilled. From the less than two-thirds of patients who had the complete triad data recorded, patients who fulfilled the triad were nearly twice as likely to undergo CT as patients who did not fulfill it. Few patients, who did not have the complete triad data recorded, underwent CT. Most patients who fulfilled the triad and underwent CT had diagnostic findings, and the proportion with diagnostic findings declined in patients who did not fulfill the triad and decreased further in patients who did not have the complete triad data recorded.

Assessment of clinical features exclusive of the clinical/laboratory triad showed statistically significant variations among practice settings for all symptoms and signs assessed (Table III). Nausea was most common in IPs and ED cases, vomiting was mainly present in IPs, constipation was most common in OPs, diarrhea and rectal bleeding were most common in IPs, fever was most common in IPs, and abdominal tenderness was usually present in all settings, but least often in IPs.

Multiple logistic regression analyses (Table IV) revealed that female sex was associated with reduced odds for having the

**Table II**. Data on the clinical/laboratory triad in patients with acute diverticulitis cared for in three settings.

| | | Overall (n=1749)[a] | Outpatient (n=1197)[a] | Inpatient (n=212)[a] | Emergency Department (n=340)[a] | P-value |
|---|---|---|---|---|---|---|
| Abdominal pain[b] | Yes | 95.7% | 95.3% | 93.8% | 98.0% | 0.057 |
| | No | 3.5% | 3.6% | 5.7% | 1.9% | |
| | Missing | 0.8% | 1.0% | 0.5% | 0.2% | |
| Abdominal pain site | | | | | | <0.001 |
| | Lower left quadrant exclusively | 42.5% | 45.9% | 24.4% | 41.9% | |
| | Lower[c] | 25.2% | 20.7% | 34.5% | 35.4% | |
| | Upper/Mid[d] | 3.8% | 3.2% | 8.1% | 3.2% | |
| | General[e] | 13.8% | 14.7% | 10.4% | 12.6% | |
| | Unspecified[f] | 9.9% | 10.9% | 11.8% | 5.0% | |
| | None | 4.0% | 3.6% | 9.8% | 1.9% | |
| | Missing | 0.9% | 1.0% | 1.0% | 0.2% | |
| Pyrexia | Yes | 14.0% | 7.9% | 47.5% | 14.6% | <0.001 |
| | No | 83.8% | 90.4% | 48.6% | 82.8% | |
| | Temperature not taken | 2.1% | 1.7% | 3.9% | 2.6% | |
| Leukocytosis | Yes | 26.8% | 13.5% | 71.4% | 45.7% | <0.001 |
| | No | 36.4% | 34.1% | 27.4% | 50.2% | |
| | Test not performed | 36.8% | 52.5% | 1.2% | 4.1% | |
| Triad collected[b] | Yes | 62.0% | 47.1% | 95.3% | 93.7% | <0.001 |
| | | Overall (n=1085)[b] | Outpatient (n=564)[b] | Inpatient (n=202)[b] | Emergency Department (n=319)[b] | |
| Triad present[b] | Yes | 13.0% | 5.2% | 38.6% | 10.7% | <0.001 |

a: Group numbers and data represent weighted values; b: Abdominal pain at any site; c: Refers to pain occurring within the lower abdomen but not exclusive to the lower left quadrant; d: Refers to pain occurring in the upper abdomen, epigastric, or mid abdominal area; e: Refers to pain occurring in both the upper and lower abdomen; f: Refers to pain where the location was not provided

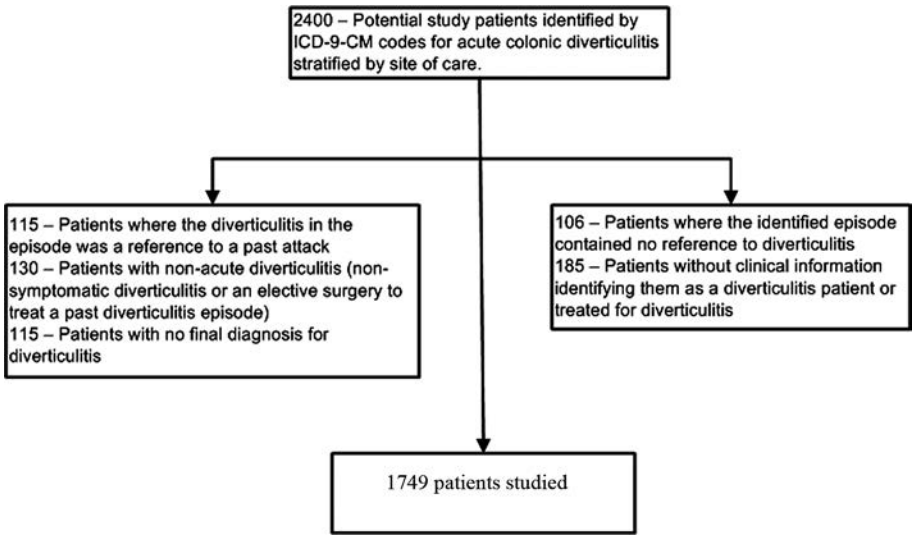


**Fig. 1.** Study patients distributed according to data on the clinical/laboratory triad and computed tomography.

complete triad whether triad fulfillment required abdominal pain limited to the left lower quadrant or not. There were multiple age and race effects on clinical presentation, including some older patients having increased odds for the complete triad, leukocytosis, nausea, and vomiting, but reduced odds for constipation compared with younger patients. Lack of a past history of AD was associated with greater odds for pain limited to the left lower quadrant and lower odds for fever, leukocytosis, nausea, and vomiting. Co-morbidity increased odds for the complete triad, leukocytosis, nausea, and vomiting and decreased odds for abdominal tenderness.

## DISCUSSION

We studied patients with AD diagnosed and treated with antibiotics in IP, OP, and ED settings in a large managed care system. Most previous reports on the clinical features of AD have mainly studied IPs [5-7, 10]. We included OPs because they comprise approximately 7 of every 10 cases with physician-diagnosed AD in our health care system. Our most important finding is that complete data on the classical clinical/laboratory triad of abdominal pain, fever, and leukocytosis were absent in over 50% of OPs, mainly due to lack of a blood leukocyte count. Few underwent urgent CT. Thus, there was little objective evidence for the diagnosis and treatment of AD in the practice setting where most patients were managed.

In contrast, most IPs and ED cases had complete triad data although only a minority fulfilled the triad. The majority of ED and IP patients had undergone CT and had diagnostic findings. In addition, there was significant variation of some demographic and clinical features exclusive to the triad among the practice settings. Notably, having co-morbidity increased the odds of fulfilling the triad. Another finding of potential clinical usefulness is the association of advanced age with reduced odds for leukocytosis. Our finding of minor female predominance is consistent with other reports [27, 28], and

**Table III.** Symptoms and signs exclusive of the clinical/laboratory triad in patients with acute diverticulitis cared for in three settings.

| | | Overall (n=1749)[a] | Outpatient (n=1197)[a] | Inpatient (n=212)[a] | Emergency Department (n=340)[a] | P-value |
|---|---|---|---|---|---|---|
| Abdominal tenderness | Yes | 1504 (86.0%) | 1031 (86.1%) | 169 (79.6%) | 304 (89.4%) | 0.001 |
| | Missing | 39 (2.2%) | 29 (2.4%) | 3 (1.3%) | 7 (2.0%) | |
| Nausea | Yes | 386 (22.1%) | 190 (15.9%) | 92 (43.6%) | 104 (30.6%) | <0.001 |
| | Missing | 16 (1.0%) | 7 (0.6%) | 7 (3.3%) | 2 (0.7%) | |
| Vomiting | Yes | 168 (9.6%) | 85 (7.1%) | 54 (25.6%) | 29 (8.5%) | <0.001 |
| | Missing | 18 (0.8%) | 7 (0.6%) | 8 (3.6%) | 3 (0.7%) | |
| Constipation | Yes | 282 (16.2%) | 209 (17.5%) | 33 (15.8%) | 40 (11.7%) | 0.04 |
| | Missing | 14 (0.8%) | 5 (0.4%) | 6 (2.9%) | 3 (0.9%) | |
| Diarrhea | Yes | 406 (23.3%) | 275 (23.0%) | 66 (31.1%) | 65 (19.3%) | 0.003 |
| | Missing | 16 (0.9%) | 8 (0.6%) | 5 (2.6%) | 3 (0.7%) | |
| Rectal bleeding | Yes | 129 (7.3%) | 84 (7.0%) | 24 (11.4%) | 21 (6.1%) | 0.04 |
| | Missing | 15 (0.9%) | 7 (0.6%) | 6 (2.8%) | 2 (0.7%) | |

a: Data represents weighted values

**Table IV**. Odds ratios for occurrence of the clinical/laboratory triad and other clinical features in relation to demographic factors, body mass index and past history of diverticulitis in patients with acute diverticulitis.

| | Triad (any pain) | Abdominal pain in left lower quadrant | Pyrexia | Leukocytosis | Abdominal tenderness | Nausea | Vomiting | Constipation | Diarrhea | Rectal bleeding |
|---|---|---|---|---|---|---|---|---|---|---|
| | adjusted odds ratio (95% confidence interval) | | | | | | | | | |
| Sex and age | | | | | | | | | | |
| Male | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Female | 0.65 (0.45, 0.94)[a] | 0.85 (0.69, 1.04) | 1.12 (0.85, 1.49) | 0.89 (0.69, 1.15) | 1.42 (1.04, 1.92)[a] | 1.63 (1.28, 2.08)[b] | 1.78 (1.26, 2.53)[b] | 0.95 (0.72, 1.24) | 1.41 (1.11, 1.78)[b] | 1.00 (0.69, 1.46) |
| Age group (years) | | | | | | | | | | |
| 18 to 45 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 46 to 55 | 0.60 (0.35, 1.01) | 1.01 (0.76, 1.35) | 0.80 (0.53, 1.21) | 0.73 (0.51, 1.04) | 1.42 (0.83, 2.45) | 0.70 (0.50, 0.98)[a] | 0.74 (0.47, 1.16) | 1.56 (1.03, 2.37)[a] | 0.75 (0.53, 1.05) | 0.95 (0.56, 1.61) |
| 56 to 65 | 0.54 (0.31, 0.95)[a] | 1.30 (0.97, 1.76) | 0.80 (0.52, 1.22) | 0.67 (0.46, 0.98)[a] | 0.67 (0.41, 1.09) | 0.60 (0.42, 0.85)[b] | 0.51 (0.31, 0.85)[b] | 1.32 (0.85, 2.06) | 0.83 (0.59, 1.17) | 0.65 (0.36, 1.18) |
| 66 or older | 0.60 (0.27, 1.33) | 0.84 (0.53, 1.32) | 0.76 (0.41, 1.39) | 0.46 (0.26, 0.81)[b] | 0.63 (0.32, 1.20) | 0.43 (0.26, 0.73)[b] | 0.42 (0.21, 0.85)[a] | 1.92 (1.04, 3.55)[a] | 0.93 (0.56, 1.55) | 0.80 (0.36, 1.80) |
| Race | | | | | | | | | | |
| Caucasian | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Asian/Pacific Islander | 1.33 (0.58, 3.06) | 0.77 (0.44, 1.35) | 1.04 (0.52, 2.10) | 1.01 (0.53, 1.93) | 0.88 (0.42, 1.84) | 1.17 (0.65, 2.12) | 0.86 (0.34, 2.15) | 0.74 (0.33, 1.64) | 0.99 (0.55, 1.79) | 0.55 (0.15, 2.05) |
| African American | 0.99 (0.50, 1.94) | 1.62 (1.11, 2.36)[a] | 1.00 (0.58, 1.70) | 0.80 (0.50, 1.27) | 0.98 (0.55, 1.73) | 0.84 (0.53, 1.32) | 1.65 (0.96, 2.82) | 1.97 (1.23, 3.14)[b] | 0.79 (0.50, 1.24) | 1.04 (0.50, 2.13) |
| Hispanic | 0.82 (0.48, 1.42) | 1.40 (1.02, 1.77)[a] | 1.16 (0.79, 1.70) | 0.70 (0.49, 1.01) | 1.59 (0.95, 2.66) | 0.83 (0.59, 1.16) | 1.34 (0.86, 2.10) | 2.17 (1.54, 3.06)[b] | 0.93 (0.67, 1.28) | 1.34 (0.82, 2.18) |
| Others/ Unknown | 0.66 (0.31, 1.38) | 1.21 (0.86, 1.70) | 1.02 (0.62, 1.67) | 1.10 (0.70, 1.74) | 0.91(0.53, 1.55) | 0.98 (0.65, 1.47) | 1.03 (0.57, 1.84) | 1.20 (0.70, 1.30) | 0.58 (0.37, 0.91)[a] | 1.33 (0.73, 2.42) |
| Weight | | | | | | | | | | |
| Under/Normal weight | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Overweight | 0.82 (0.49, 1.38) | 0.96 (0.71, 1.29) | 0.71 (0.48, 1.04) | 1.18 (0.82, 1.70) | 1.42 (0.94, 2.16) | 0.94 (0.66, 1.33) | 0.96 (0.58, 1.57) | 1.02 (0.71, 1.47) | 0.82 (0.59, 1.13) | 1.03 (0.59, 1.84) |
| Obese | 0.71 (0.43, 1.17) | 1.09 (0.81, 1.47) | 0.74 (0.51, 1.07) | 1.19 (0.83, 1.69) | 1.25 (0.83, 1.89) | 1.08 (0.77, 1.51) | 1.11 (0.69, 1.79) | 0.71 (0.48, 1.03) | 0.87 (0.63, 1.20) | 1.20 (0.70, 2.06) |
| Diverticulitis history | | | | | | | | | | |
| No prior history | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Prior history | 0.68 (0.42, 1.12) | 1.37 (1.09, 1.72)[b] | 0.59 (0.41, 0.84)[b] | 0.57 (0.41, 0.78)[b] | 0.76 (0.55, 1.06) | 0.54 (0.40, 0.72)[b] | 0.34 (0.20, 0.57)[b] | 0.95 (0.70, 1.30) | 1.01 (0.78, 1.32) | 1.00 (0.66, 1.53) |
| Insurance status | | | | | | | | | | |
| Commercial/ Private | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Government | 1.03 (0.51, 2.06) | 1.09 (0.74, 1.62) | 1.37 (0.81, 2.31) | 1.29 (0.79, 2.10) | 0.92 (0.54, 1.57) | 1.39 (0.89, 2.17) | 1.49 (0.81, 2.72) | 1.29 (0.77, 2.16) | 0.79 (0.50, 1.24) | 1.58 (0.78, 3.20) |
| Charlson co-morbidities | | | | | | | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| At least one | 1.88 (1.26, 2.81)[b] | 0.83 (0.67, 1.03) | 1.12 (0.83, 1.51) | 1.59 (1.21, 2.08)[b] | 0.53 (0.38, 0.73)[a] | 1.33 (1.04, 1.72)[a] | 1.66 (1.16, 2.37)[b] | 0.87 (0.65, 1.16) | 1.14 (0.89, 1.46) | 1.01 (0.68, 1.51) |

[a]$p<0.05$; [b]$p<0.01$

our results on the racial/ethnic breakdown of AD patients most resemble those of Masoomi et al [27].

We previously reported the association of severe CT findings with male gender, constipation, less pain limited to the left lower quadrant, fever, and leukocytosis. In that study, only 1 of 20 patients lacking both fever and leukocytosis had severe disease; however, the presence of the complete triad occurred in less than 50% of patients with severe disease [12]. This study complements those findings, as nearly 50% of OPs had left lower quadrant pain exclusively, and fever and leukocytosis were uncommon, although leukocyte counts were often not measured. Few OPs underwent CT, and just over 50% of those who did, had diagnostic findings which were consistent with mild disease in most cases. However, we emphasize that it was impossible to accurately determine retrospectively whether most of the OPs actually had AD even though their physicians diagnosed it and treated them for it.

The potential for misdiagnosis of AD in OPs was studied by O'Connor et al who found that body temperature was often unmeasured and also revealed frequent lack of a leukocyte count [8]. Surgeon record reviewers disagreed with the practitioners' diagnoses of AD in 54% of cases. The low proportion of our OPs who underwent prompt CT is the principal reason it was impossible to be sure which patients had AD, as in their study. Spiller has emphasized the difficulty of distinguishing symptoms of IBS from those of diverticular disease in older patients who often have diverticulosis [17]. This conundrum is underlined by increasing evidence that diverticulosis can cause chronic symptoms, including post-diverticulitis IBS [20]. The reduced odds for fever and leukocytosis associated with a past history of AD in our OPs would be expected if both the past and current illnesses in some patients actually consisted of pain from IBS, not AD. The limitation of diagnostic evidence for AD in many OPs to abdominal pain and tenderness as well as the common reports of diarrhea and constipation, all of which characterize IBS [29], raises speculation that IBS was the cause of symptoms in some cases.

Some investigators have attempted to improve the accuracy of diagnosis. For example, Laméris et al found that a clinical decision rule that emphasizes tenderness only in the left lower quadrant, the absence of vomiting, and elevated C-reactive protein identified AD with a high probability in 25% of patients presenting to an emergency facility [14]. Andeweg et al found that these features, as well as age, past history of AD, and aggravation of pain on movement independently predicted AD in hospitalized patients [13]. Wilkins et al advised various tests on blood, urine, and stool, as well as abdominal radiography routinely at the start of an algorithm for the diagnosis and treatment of AD [15]. Although these approaches could help physicians manage patients who seek emergency care, they would not necessarily have similar practicality and value in the typically busy OP arenas where most patients seek care for abdominal pain.

Limitations of this study include its retrospective design that makes it impossible to ascertain the process used by physicians to diagnose AD, including their decision to order leukocyte counts and CT. There was no standardized symptom recording, and we could not rate symptom severity, particularly regarding abdominal pain. We used multiple radiologists' reports of CT results, and such interpretations are subject to inter-observer variability. We could not confirm the accuracy of a past history of AD. Laboratory test results other than the leukocyte count, such as fecal calprotectin and C-reactive protein [14, 15] could have provided more objective evidence for AD in OPs; however, the former test was not available in the KPSC laboratory during the study period, and it is unlikely that a large proportion of patients had the latter test because only a minority had a leukocyte count.

Strengths include the large number of cases assessed from all health care settings and extensive analysis of demographic and clinical features. We identified patients through comprehensive record review instead of relying only on ICD-9-CM codes. The same abstractor reviewed all records using detailed rules and conferred with a single gastroenterologist, thus minimizing variation in interpretation. In the capitated system in which the study was performed, there is unrestricted access to care, minimizing potential bias related to variations in health care financing and lending generalizability to our findings to other practice settings.

The diagnosis of AD without imaging confirmation is challenging, and there is lack of urgent access to CT for the many patients who present to OP offices as well as increasing concern about its carcinogenic effects [30]. Furthermore, our results indicate a myriad of patient demographic and other features which affect the presentation of the illness that physicians diagnose and treat as AD. The potential for unnecessary treatment of AD due to misdiagnosis is great. Furthermore, a recent randomized trial found no benefit of initial intravenous and subsequent oral antibiotic treatment of uncomplicated AD verified by CT [31].

## CONCLUSIONS

Improved sensitivity of diagnosis of AD without CT, especially in outpatients, is needed. If the availability of such testing is absent, the uncertain diagnosis of AD in many outpatients and uncertainty of antibiotic therapy of proven AD suggests that physicians should carefully consider other causes of pain in outpatients, particularly IBS, and also consider treating outpatients without antibiotics, especially those with little objective evidence of AD.

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**Authors' contribution:** R.I. planned the study, collected and analyzed data, and wrote the initial draft of the manuscript. G.L. was involved in study planning, data interpretation, and manuscript organization, editing and review. L-H.C. was involved in data collection and analysis, and manuscript editing and review. W.C. was involved in the research design, data analysis and manuscript editing and review. L.Y. contributed to the research design, analysis and interpretation of the data and helped with critically revising the manuscript. P.H.

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