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MAJOR ARTICLE

Improving Early Recognition of Coccidioidomycosis in Urgent Care Clinics: Analysis of an Implemented Education Program

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Background. Only 0.2% of coccidioidomycosis (CM) diagnoses were made in patients (pts) with pneumonia (PNA) in urgent care (UC), because they were not being tested for CM. Our objective in this study was to improve CM testing rates.

Methods. This was a time series of clinician practice before and after an intervention that occurred at UC clinics in Phoenix and Tucson Arizona. All patients in UC were >18 years old. We included information about CM in periodic educational activities for clinicians. Coccidioidal serologic testing (CST), CST results, and their relation to *International Classification of Diseases, Tenth Revision* (ICD-10) codes were extracted from medical records.

Results. Urgent care received 2.1 million visits from 1.5 million patients. The CST orders per 10^4 visits increased from 5.5 to 19.8 ($P < .0001$). Percentage positive CSTs were highest for August, November, and December (17.0%) versus other months (10.6%). Positive CSTs were associated with PNA ICD-10 codes, and, independently, for *Erythema nodosum* (EN) which had the highest positivity rate (61.4%). Testing of PNA pts increased on first visits and on second visits when the first CST was negative. Yearly rates of PNA due to CM ranged from 17.3% to 26.0%. Despite this improvement, CST was still not done for over three quarters of pts with PNA. This was a noncomparative study.

Conclusions. Routine quality improvement activities have significantly but only partially improved rates of testing pts with PNA for CM in UC clinics located in a highly endemic area. Innovative strategies may be needed to improve current practice. Also in our region, EN, independent of PNA, is a strong predictor of CM.

Keywords. coccidioidomycosis; diagnosis; *Erythema nodosum*; pneumonia; urgent care.

Coccidioidomycosis (CM), also known as San Joaquin Valley fever, is a systemic fungal infection endemic to the western United States [1], especially parts of Arizona and California, and elsewhere in the Western Hemisphere [2]. Coccidioidomycosis is nationally reportable in the United States, and since 2010, clinically diagnosed infections range year-to-year from approximately 9400 to 22 600 cases. However, there is significant underreporting because clinicians may fail to order the necessary testing [3, 4], serologic tests are frequently insensitive early in CM [5, 6], and state public health departments, even in states known to be highly endemic such as Texas, do not all report documented infections [7, 8]. Preliminary estimates from the Centers for Disease Control and Prevention (CDC) suggest that the actual burden of clinical illness is 6 to 14 times higher than the reported cases [9]. Even considering only reported infections, the direct medical cost in 2019 was over $385 million [10] and the overall annual economic impact of CM approaches $1.5 billion [11, 12].

Early and precise recognition of CM from other causes of similar illnesses has several significant advantages. Since within endemic regions CM is a common cause of community-acquired pneumonia (CAP) [13, 14], its prompt diagnosis would obviate the subsequent need for continued empiric antibacterial treatment [15]. In addition, identifying CM when it first presents in ambulatory care settings could make subsequent hospitalization and other healthcare services unnecessary [16] because most infections eventually resolve without serious complications, and many of the complications, when they do occur, do not need hospital support [17]. Furthermore, early recognition of complications can allow them to be addressed before extensive tissue destruction occurs, thus limiting residual morbidity.

In 2018, the University of Arizona's Valley Fever Center for Excellence, in collaboration with its clinical partner, Banner

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Health Systems, developed a healthcare system-wide clinical practice for the ambulatory recognition and management of Valley fever [18]. Although intended for adoption in all ambulatory care units within the healthcare system, coordination of its implementation was most readily instituted within the Banner Urgent Care Services (BUCS), located in metropolitan Phoenix and Tucson, Arizona. This was particularly useful because in our previous report, BUCS visits had surprisingly few *International Classification of Diseases, Tenth Revision* (ICD-10) codes for newly diagnosed CM [16]. In this study, we analyze changes in testing practices for CM in BUCS clinics since incorporating training about the CM clinical practice guidelines for its clinicians. Although this seemed to have increased the diagnosis of CM, our findings also provide an estimate of how frequently CM might still be underrecognized in urgent care clinics within an intensely endemic area.

METHODS

Ambulatory Clinics Analyzed

Banner Urgent Care Services comprises urgent care clinics within metropolitan Phoenix and Tucson, and they use a common Cerner electronic medical record system (EMR) to record their patients' personal health information. During 2018–2021, they were staffed in different years by nurse practitioners (49.2% ± 2%), physician assistants (39% ± 2%), and medical or osteopathic doctors (13% ± 1%). Total numbers of BUCS units were 41, 44, 47, and 48 for the 4 years, respectively. The number of clinic visits grew from 3.73×10^5 to 6.98×10^5, but the average number of annual visits for each patient remained between 1.4 and 1.6.

Implementation Activities for the Ambulatory Diagnosis of Coccidioidomycosis Clinical Practice

Banner Health had implemented a clinical consensus process to utilize EMR to improve patient safety [19], and, over time, this has been expanded to implement a variety of best practices in healthcare, primarily for hospitalized patients. Beginning in 2017, this system-wide structure was used to develop a clinical practice for the early recognition and management of CM in ambulatory patients, and its completion was announced on September 20, 2018 [20].

Within BUCS, the CM clinical practice was first implemented in February 2020 when information on the CM clinical practice was included during clinical orientation lectures to all newly hired clinicians. Since July 2020, BUCS has also presented the CM topic on a single slide as part of quarterly refresher lectures covering pulmonology, head, ear, nose, and throat topics. These lectures are attended by newly hired urgent care clinicians without prior urgent care experience, optionally by established BUCS clinicians, and are also available to clinicians online. In addition, periodic reminders about CM are placed in emails and in monthly provider meeting presentations.

Data Selection

Data for this study were obtained for years 2018 through 2021 by queries of the Banner Enterprise data warehouse on March 16, 2022. Patient ages, gender, and self-identified race/ethnicity (SIRE) for all BUCS patients were collected.

All visits were identified in which coccidioidal serologies were ordered, and these statistics were used to identify testing frequencies. In BUCS, 98% of coccidioidal tests involved initial enzyme immunoassay testing for both specific immunoglobulin IgM and IgG antibodies with subsequent testing by immunodiffusion for both IgM and IgG antibodies [21]. Any positive coccidioidal test was considered diagnostic. A small proportion of ordered tests did not populate the result field in Cerner, because either the test was not done or the results were not provided electronically by the reference laboratory. For analyzing clinician practices, we used all tests that were ordered. However, in calculating percentages of coccidioidal tests that were positive, we used only tests for which there were tests results as the denominator.

The ICD-10 diagnostic codes were retrieved from all visits in which a coccidioidal serology was positive, and all codes found at least 10 times during the study period were compiled in descending order along with their frequency for those where coccidioidal testing was done and for all BUCS visits. For the reasons indicated in the results, subanalyses were also conducted on visits with and without codes for pneumonia (codes J18.1 and J18.9) and on those coded for *Erythema nodosum* (code L52).

In other analyses, diagnoses of CM were assigned per patient, regardless of the number of positive tests. For patients with multiple visits in the same year, the first visit in which a coccidioidal serology was ordered was considered the first visit for this study, and a second visit was included if it occurred in the subsequent 3 months. Patients were excluded who had had a positive coccidioidal serology in the prior year. Patients seen on multiple years were included as multiple occurrences.

Tests used to determine the significance of differences between different groups are indicated in the results. Probability values are shown and $P < .05$ was interpreted as significant.

Patient Consent Statement

Before data collection, the University of Arizona Human Subjects Committee determined that this investigation did not constitute human subject experimentation.

RESULTS

Overall Trends of Banner Urgent Care Services Testing Practices

After the institution of CM training in 2020, the overall number of coccidioidal tests ordered increased significantly. As shown in Table 1, approximately 3-fold increases were apparent both for testing as a proportion of visits and of patients.

Table 1. Overall Changes in Testing Patterns by BUCS Clinicians

	Years			
Results	2018	2019	2020	2021
Total BUCS visits[a]	373 272	413 968	592 678	697 523
Visits with coccidioidal tests (per 10^4)[b]	5.5	6.7	15.7	19.8
Total BUCS pts	264 970	295 121	427 836	488 249
Patients with coccidioidal tests (per 10^4)	7.8	9.4	21.7	28.1

Abbreviations: BUCS, Banner Urgent Care Services; pts, patients.

[a]Differences in visits between success years: $P < .0001$ for all 3 comparisons (χ^2 test).

[b]Differences in proportions between years of visits with testing for coccidioidomycosis: 2018 versus 2019, $P = .041$; 2019 versus 2020, $P < .0001$; 2020 versus 2021, $P = .0001$ (χ^2 test).

The changes occurred broadly across BUCS (Figure 1). For example, the percentage of clinics ordering more than 50 tests per 10^4 visits per year increased from 11% in 2018% to 78.0% in 2021. Similarly, the percentage of clinicians ordering more than 2 tests per year increased from 14.5% to 38.8%.

As seen in Figure 2, the monthly rate of ordering coccidioidal tests during the study period varied no more than 2-fold, ranging from 0.1% to 0.2% of visits each month. Positivity rates were highest in August, November, and December. In a pairwise comparison of all 12 months using a 5% false discovery rate, the proportion of positive tests for the month of November is statistically significantly different from the proportion of positive tests in the months of June, July, and September.

ICD-10 codes that were associated with positive coccidioidal tests, with tests done, and for all BUCS visits are shown in Table 2. The ICD-10 codes for pneumonia were the most frequently associated with positive tests and, other than for cough, were associated with the greatest number of visits where coccidioidal tests were performed. Also of note were the findings with *E nodosum*. Although L52 was not a common code, the percentage of associated tests that were positive was 61.4%, the highest percentage positive of any ICD-10 code commonly associated with positive tests.

Subanalyses of Testing Patterns With *International Classification of Diseases, Tenth Revision* Codes for Pneumonia or *Erythema Nodosum*

Because CM is described as a cause of pneumonia [17], and because ICD-10 codes for pneumonia (J18.1 or J18.9) were most frequently associated with positive coccidioidal serologic tests, we analyzed that relationship further. The age, gender, and SIRE characteristics for BUCS patients without pneumonia, with pneumonia, and with CM tests for their pneumonia, and with positive test results are shown in Table 3. Patients were older with pneumonia or with pneumonia and tested for CM ($P < .0001$). Fewer females had pneumonia ($P < .0001$) and were less frequently tested for CM ($P = .027$). In addition, pneumonia was less frequent in African Americans and Hispanic/Latin patients ($P < .0001$). In other respects, testing for CM or the proportion of tests that were positive did not appear to be significantly different.

Table 4 demonstrates the changes in testing practices for pneumonia patients during the study. The overall increase in testing of pneumonia patients is in keeping with the increase in testing overall during visits (Table 1). Of note, the practice of testing for CM on a first visit increased as testing on the second visit decreased. In 2018–2019, tests were done only on the first visit in 71 of 352 patients (20.2%), whereas in 2020–2021, this rose to 1105 of 1513

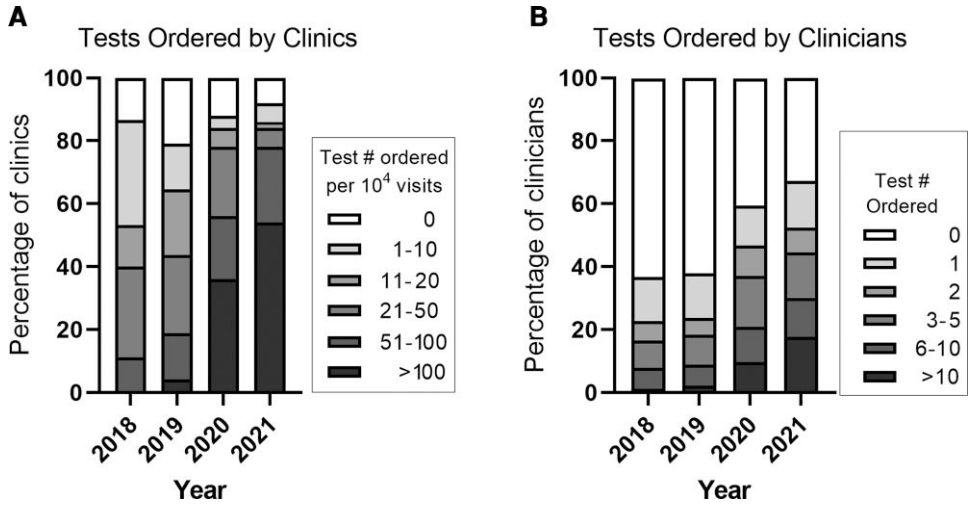

Figure 1. (*A*). Proportions of clinics ordering different numbers of tests for years 2018–2021. Differences in proportions between successive years: 2018 versus 2019, $P = .679$; 2019 versus 2020, $P < .001$; 2020 versus 2021, $P = .042$ (Kruskal-Wallace). (*B*) Proportions of individual clinicians ordering different numbers of tests for years 2018–2021: 2018 versus 2019, $P = .795$; 2019 versus 2020, $P < .001$; 2020 versus 2021, $P = .053$ (Kruskal-Wallace). PNA, pneumonia.

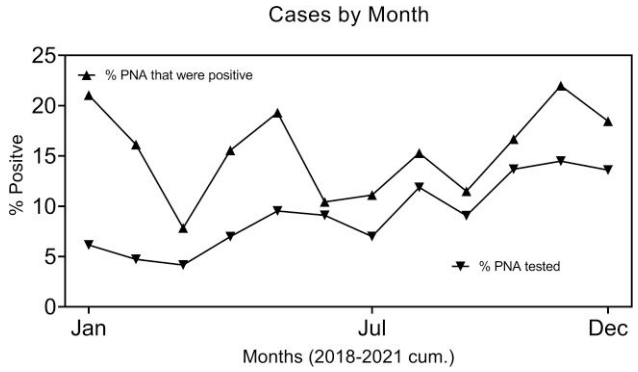

Figure 2. Frequency of testing for coccidioidomycosis in all Banner Urgent Care Services visits (inverted triangles) and percentage of tests that were positive (upright triangles) by month for the years 2018–2021.

patients (73.0%). In addition, the practice of conducting a second test if the first test was negative also increased substantially and increased the number of patients who were found to have CM as the cause of their pneumonia. The year-to-year variation of CM as a percentage of all pneumonia patients tested ranged from 17.3% to 26.0%, not significantly different from each other and in good agreement with previously published smaller prospective Arizona studies [13, 14].

We also analyzed the association of the other codes shown in Table 2 for visits that did not contain ICD-10 codes J18.1 or J18.9 (Supplementary Appendix Table 1). In general, the number of visits with other ICD-10 codes were reduced substantially when not accompanied by a pneumonia code. A striking exception was the number of *E nodosum*-coded visits was only reduced 3.4%, from 176 to 170. Of those 170 patient visits with *E nodosum*, only 84 had 1 or more additional ICD-10 codes, 135 codes total. With such small numbers, there was little significant additional associations between *E nodosum* and other codes (Supplementary Appendix Table 2) except that 7.7% also had the code for fever (R50.9).

Table 2. Frequency of ICD-10 Codes for High Association With Positive Coccidioidal Serologic Tests and Their Frequency Associated With Those Where Coccidioidal Tests Were Ordered and All BUCS Visits

Diagnoses and ICD-10 Codes		Positive Tests (% of Tested)	Tested Visits (% of All Visits)	All BUCS Visits
Pneumonia	J18.1, J18.9	187 (17.1%)	1092 (8.8%)	12 364
Cough	R05, R05.9	174 (13.0%)	1342 (1.4%)	95 704
Fever	R50.9	63 (15.1%)	416 (0.9%)	44 308
URI, bronchitis	J06.9, J40, J20.9	46 (9.0%)	510 (0.2%)	219 232
Shortness of breath	R06.02	44 (12.6%)	349 (1.4%)	25 374
Rash	R21	33 (23.2%)	142 (1.1%)	12 877
Erythema nodosum	L52	27 (61.4%)	44 (25.0%)	176
Chest pain	R07.9	11 (18.0%)	61 (0.4%)	15 664

Abbreviations: BUCS, Banner Urgent Care Services; ICD-10, *International Classification of Diseases, Tenth Revision*; URI, upper respiratory infection.

Table 3. Demographic Characteristics of BUCS Patients Between 2018 and 2021 Without ICD-10 Coding for Pneumonia, With Coding for Pneumonia, Patients With Pneumonia Serologically Tested for CM, and the Percentage of Tested Patients With Positive Tests

Characteristic	Without Pneumonia	With Pneumonia	Pneumonia and Tested	Tests Positive
Number of patients	1 469 768	11 704	2181	371
Average age in years	44.8	54.0	50.4	49.6
%Female	60.0%	54%	50%	53%
Race/ethnicity				
White/Caucasian	69.2%	78%	75%	70%
Hispanic/Latino	18.2%	15%	14%	14%
African American	5.5%	4%	4%	5%

Abbreviations: BUCS, Banner Urgent Care Services; CM, coccidioidomycosis; ICD-10, *International Classification of Diseases, Tenth Revision*.

NOTES: Differences between the results in each of the 4 columns for age, percentage female, or percentage common race/ethnicity were where information was available. Significance of differences in group ages was estimated by *t* test and all other characteristics by test of proportions. For all characteristics, patients with and without pneumonia, $P < .0001$. The significance of other differences is described in the results.

DISCUSSION

In this report, we document that an increased training focus on appropriate testing of urgent care patients with pneumonia for CM was associated with a significant increase in the proportion of such patients tested. Overall, testing of patients with pneumonia ICD-10 codes increased approximately 3-fold, from 352 of 4659 (7.6%) in 2018–2019 to 1513 of 7031 (21.5%) (Table 4). This changing practice appeared to be system-wide in that increases were seen across many of the BUCS clinics and among many of the clinicians (Figure 1). Also of note, testing of pneumonia patients for CM on the first visit and repeat testing if the first visit's test was negative were both more frequent as recommended by the education program. Patients with pneumonia were significantly older than other BUCS patients and less frequently female (Table 3), statistics that are in keeping with those of CAP in general [22]. It is of particular interest that testing for CM was more frequent in older patients, because this may provide a partial explanation for the age-related frequency of CM diagnosed in Arizona [23]. That CAP was more frequently diagnosed in White/Caucasian SIRE may reflect healthcare utilization patterns of different population segments. However, when pneumonia was diagnosed, SIRE demographics of those tested and the proportion of tests that were positive remained similar. That only 7.2% to 22.0% of patients with pneumonia were tested for CM corroborates the preliminary CDC estimates of 6- to 14-fold CM underdiagnosis [9].

Despite the measured increase in testing patients with pneumonia for CM, over three quarters of patients with CAP were not tested for CM despite the instituted educational program.

Table 4. Changes in Testing Patterns for CM in BUCS Patients With Pneumonia From the Years 2018 Through 2021

	Year			
Groups	2018	2019	2020	2021
All BUCS patients with pneumonia (J18.1, J18.9)[a]	2094	2565	3473	3558
Number of pneumonia patients (% of total) tested for CM[b]	150 (7.2%)	202 (7.9%)	732 (21.1%)	781 (22.0%)
1st visit number tested (%positive)[c]	21 (29%)	45 (29%)	478 (20%)	543 (13%)
2nd visit number tested (%positive)	129 (14%)	157 (18%)	254 (31%)	238 (16%)
Both visits number tested (%positive)	2 (100%)	3 (0%)	39 (41%)	45 (62%)
Percentage of tested patients with positive tests (95% confidence intervals)	17.3% (10.8%–25.2%)	20.8% (14.6%–27.8%)	26.0% (20.3%–29.7%)	17.5% (14.5%–20.7%)

Abbreviations: BUCS, Banner Urgent Care Services; CM, coccidioidomycosis.

[a]Differences in successive numbers of patients with pneumonia: $P < .0001$ for all 3 comparisons (Kolmogorov-Smirnov 2-sample test).

[b]Differences between years in the proportion of pneumonia patients tested for CM: 2018 versus 2019, $P = .30$; 2019 versus 2020, $P < .0001$; 2020 versus 2021, $P = .032$ (χ^2 test).

[c]Differences between years in the proportion of test for CM were performed on the first visit: 2018 versus 2019, $P = .032$; 2019 versus 2020, $P < .0001$; 2020 versus 2021, $P = .059$ (test of proportions).

A probable reason for low CM diagnostic testing rates, even in endemic areas and with repeated reminders, is that clinicians are often trained outside of endemic areas and may not consider the diagnosis [4]. For these clinicians, it is necessary to unlearn the treatment of CAP as solely a bacterial infection and to include CM as a significant part of the differential [24]. Trends in CM testing during this study period were potentially confounded by the coronavirus disease 2019 (COVID-19) pandemic because clinicians navigated frequent updates to clinical guidelines based on emerging epidemiologic trends and resource availability. However, in a study from another healthcare system of the time from onset of CM symptoms to the time of diagnosis, researchers found no difference in the year preceding (2019) and the first year (2020) of the pandemic [25]. Of note, the impulse to empirically prescribe antibiotics for respiratory infections intensified during the COVID-19 pandemic [26]. Improving diagnostic practices for CM could serve to raise awareness about inappropriate prescribing for nonbacterial respiratory infections in general. Another impediment to testing for CM in the ambulatory setting is that coccidioidal test results are not rapidly available, taking at least days and sometimes weeks to be returned to the ordering clinician from the performing reference laboratory. These delays require follow-up efforts if the tests are returned positive and make more attractive the option of simply prescribing antibiotics as a way of giving the patient something of perceived value during the visit [27]. Another concern for some clinicians is that testing for CM would incur a cost to the patient. However, the benefits of early coccidioidal diagnosis far outweigh the cost of the serologic testing [16], and a recent study indicated that coccidioidal testing is covered for insured patients in Arizona [12]. All of these deterrents to improve rates of testing CAP patients for CM where CM is common underscore the challenge that changing this clinical practice represents. As such, novel behavioral interventions [28, 29] might be fruitful approaches to improve compliance with the agreed upon clinical practice.

In a subanalysis of visits without pneumonia ICD-10 codes, most other codes showed little association with positive coccidioidal serologic results (Supplemental Table 1). A striking exception was that for *E nodosum* (L52), which coded separately from pneumonia in 170 of 176 visits, 97% of those shown in Table 2. Although L52 is an infrequent diagnosis, when tested for CM, the overall positivity was 61.4% (Table 2). *Erythema nodosum* is a very distinctive skin condition for which CM is a well known cause [30]. In a recent study, rash in general, which would include *E nodosum*, was identified as an indicator of CM [31]. Although the term "Valley fever" now is commonly used for any manifestation of CM, it was originally used to describe the triad of fever, *E nodosum*, and "an influenza-like illness," not explicitly pneumonia [32]. Although not investigated here, it is possible that some of the patients coded for *E nodosum* also had other respiratory symptoms of the triad. In any case, the finding of *E nodosum* in any patient with potential exposure to *Coccidioides* should suggest testing for CM.

Coccidioidal infections are more likely to occur during dry periods of the year [33] with diagnosis then coming weeks later after 1 to 3 weeks of before onset of symptoms, 1 to 2 weeks before seeking medical attention, and then not always tested on the first visit for the illness. In Arizona, dry periods occur in the early summer and late fall [34, 35]. Rates of test positivity found in this study which are weeks after the infections occur correspond to the previously published seasonal patterns, highest in August, November, and December (Figure 2). For this reason, we have arranged the training about appropriate testing for CM to occur before the fall peak. However, it should also be noted that new diagnoses of CM occurred in all months.

CONCLUSIONS

In summary, patients presenting with either pneumonia or *E nodosum* within highly endemic regions for CM have a high

likelihood of suffering from this disease and should be tested for this possibility. This is true for persons who have recently traveled to such areas in addition to residents [36]. Further education, possibly with innovative methods, appear to be needed to make this a standard practice in ambulatory clinics such as urgent care.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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