



Rapidity of Coccidioidomycosis Diagnosis and its Effect on Healthcare Utilization

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Aim

The objective of this study was to investigate the diagnostic delay and related healthcare utilization surrounding Coccidioidomycosis.

We hope to provide insight into the healthcare burden and possible future interventions to lessen costs, as well as potentially new methodologies for research using the electronic medical record (EMR).

Background

- Coccidioidomycosis, also known as Valley Fever or "desert rheumatism", is an infection caused by the fungal *Coccidioides* species.¹
 - Common to parts of Mexico, Central and South America, and the arid southwestern United States, with Arizona claiming nearly 70% of yearly reported cases (Figure 1).²



Figure 1. Shaded areas indicate suspected coccidioidomycosis distribution in the Western Hemisphere.²

- A dimorphic fungus, *Coccidioides* species (spp.) survive as mycelia in the soil, growing and forming into brittle, easily distributed arthroconidium to be inhaled and establish an infection.³
- Recognizing and diagnosing Coccidioidomycosis is often difficult—of those exposed 60% never have symptoms.
 - If symptomatic, typically nonspecific symptoms: fatigue, cough, fever, shortness of breath, headache, night sweats, muscle-joint aches, and rash.
 - Significant amount of cases of community-acquired pneumonia (CAP) in endemic regions are likely to be misdiagnosed and truly caused by *Coccidioides* spp.⁴⁻⁶
 - In Arizona, at least 25% of all CAP diagnoses in ambulatory patients are truly caused by *Coccidioides* spp.
 - Despite recommendations to test CAP patients for Coccidioidomycosis, fewer than 13% are evaluated for possible *Coccidioides* spp. infection.
- Misdiagnosis and diagnostic delay can lead to:
 - Inappropriate antibacterial treatment, blood tests, chest X-rays, CT scans, PET scans, bronchoscopies, percutaneous fine needle aspirations, and even thoracotomies
 - Increased community antibacterial resistance due to incorrect therapies, and increased healthcare costs.
 - Emotional and psychosocial strain on patients.

- Diagnostic delay is a critical component arising from misdiagnosis and contributes to healthcare costs. There are many definitions for diagnostic delay⁷, however the definition this study will refer to is that of total diagnostic delay comprised of patient delay and health system delay (Figure 2).

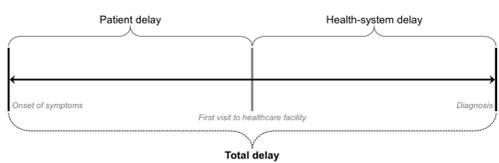


Figure 2. Illustration of patient, health system and total delay.⁸

- This study will refer to and define the health system delay portion as "diagnostic delay".

Methods

Setting:

- Banner Health is a non-profit health system operating 28 hospitals and numerous ambulatory facilities across six states in the western United States—headquartered in Phoenix, Arizona.⁹
- Banner Health serves the population most commonly diagnosed with Coccidioidomycosis and with its large network of physicians and connected EMR, advanced analytics of this large population is possible.

A two-phase project was designed:

- Phase 1 focused on manual chart review to identify disease markers and symptom-diagnosis onset¹⁰
 - Phase 2 revolved around programmatically pulling and analyzing data from a hospital-based EMR to assess total healthcare utilization.*
- *phase 1 completed, focus will be placed on phase 2

Population:

- Patients of at least 18 years of age with a Coccidioidomycosis diagnosis from January 1st, 2011 to December 31st, 2014 were included, and the earliest diagnosis date was used.
- Patients were excluded if they did not have a positive coccidioid serologic test 30 days prior to or 60 days after diagnosis date.
- To authenticate the first date or "index date" at which a diagnosis was made, patients were excluded if they had a prior Coccidioidomycosis diagnosis recorded within one year of the index date.
- Final population of **139 patients**.

Diagnostic delay:

- Patient records were searched for compatible symptoms occurring within 6 months of the index date.
- The entire record of symptoms for all patients 6 months prior to their index date was retrieved and reviewed by an expert medical team for validity.

Healthcare utilization:

- Healthcare charges were used to represent this measure; billing data was available in the ambulatory EMR and hospital-based EMR (66 patients of 139 had hospital data).
- We defined healthcare utilization as the total charges from the earliest symptom date recorded to 6 months after the index date (Figure 3).
- If no symptom was recorded for the patient, then the index date itself was used as the first-time point.

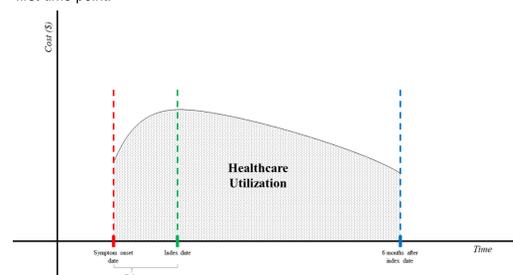


Figure 3. Example distribution of healthcare utilization; utilization expected to increase during delay and decrease given appropriate medical attention.

Results

- Of the 139 patients in the final population, the age distribution was relatively normal: female 52% and male 48%.
- Seven unique diagnoses and their corresponding ICD-9 codes were used to formally indicate a *Coccidioides* spp. infection (Figure 4).

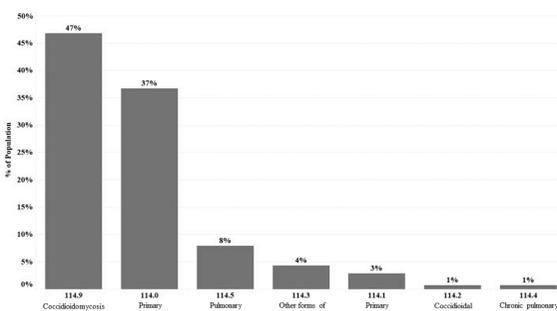


Figure 4. Distribution of patients by diagnostic category and related ICD-9 code.

- The vast majority of positive coccidioid serologic confirmation tests were conducted and reported before or on the index date (Figure 5).

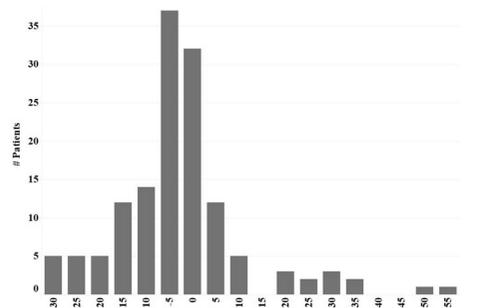


Figure 5. Distribution of positive coccidioid confirmation dates as compared to the index date.

- The set of symptoms assembled through phase 1 influence and subsequent expert review expanded the symptom list and the relevant ICD-9 codes from 23 to 89.

- This expanded list allowed for 120 out of the 139 selected population to have a coded symptom onset date before the index date (refer to Figure 3).

- 19 patients did not have a symptom code in their record, and programmatically their initial onset date was equivalent to the index date.
 - This group differs from 16 other patients that had a symptom recorded on the same day of their diagnostic index date.

- Diagnosis delay and healthcare utilization measures were arranged by periods of thirty days and showed a trend of the mean toward increasing total charges as the number of delay days increased (Table 1).

- The 95% confidence intervals however intersected between the time period categories, with upper cost values nearing at in some instances seven-times the mean.

- Most time periods included less than 30 patients with the exception of the time period of diagnostic delay between 0 and 30 days.

Diagnosis Delay Days	Mean	95% CI		# Patients	Median	Min	Max
		Lower CI (Mean)*	Upper CI (Mean)*				
no symptom	\$41,386	\$14,720	\$68,052	19	\$2,751	\$209	\$432,049
0-30	\$6,273	\$0	\$21,806	56	\$770	\$150	\$81,541
31-60	\$14,342	\$0	\$39,124	22	\$1,572	\$384	\$96,353
61-90	\$22,558	\$0	\$52,570	15	\$9,667	\$629	\$83,310
91-120	\$6,501	\$0	\$40,055	12	\$2,167	\$446	\$28,974
121-150	\$78,896	\$26,914	\$130,878	5	\$4,293	\$463	\$360,378
151-183	\$57,724	\$20,967	\$94,480	10	\$8,917	\$223	\$437,221

Table 1. Data arranged by time groups with respect to diagnostic delay days. *assumes normal distribution

Discussion

- Overall the small final population size and difficulties encountered due to the innate properties of the electronic medical record preclude robust and meaningful statistical analysis.

- The majority of confirmatory, positive coccidioid serologic tests taking place before or on the index date may represent a clinician's suspicion that the underlying disease process may very well be Coccidioidomycosis, but there is a logical level of unwillingness to label the patient's disease before laboratory confirmation.
 - Additionally, the presence of these positive tests being recorded after the index date may represent a diagnosis of Coccidioidomycosis by other means: whether that be radiologic evidence, lumbar puncture, aspiration, biopsies or even highly consistent and classic patient history or compatible exposure.

- The billing aspect of the EMR need also be considered here, as laboratory test orders may need to be justified by a formal diagnosis—perhaps explaining partially the substantial number of positive tests on the index date itself.

- Demonstrating diagnostic delay for Coccidioidomycosis is possible, as shown in Table 1.

- Although no statistically significant comparisons can be made due to the limitations of patient numbers, mean and median healthcare utilization did somewhat increase as delay diagnosis times increased.

- The mean and median for 0-30 days delay was \$6,273 and \$770 respectively; this increased at 151-183 days of diagnostic delay to \$57,724 and \$8,917 respectively.

- Patients with no recorded symptom could have had a significant delay which may have simply not been captured by the database.

- The EMR itself also has innate difficulties that any investigation will have to uniquely address; Banner Health's data connection between ambulatory and hospital-based systems is imperfect.

- To the best of our knowledge, this is the first study of its kind to investigate healthcare utilization by assessing Coccidioidomycosis related diagnostic delays based on programmatic analysis.

- Using a two-phase study to first discern regional markers for a disease process and then expand the resultant set of ICD-9 codes with expert medical reviewers is an innovative approach.

- The study's methodology is novel and will be helpful for future improvements and endeavors.

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