

Delays in Coccidioidomycosis Diagnosis and Relationship to Healthcare Utilization, Phoenix, Arizona, USA¹

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We developed an electronic records methodology to programmatically estimate the date of first appearance of coccidioidomycosis symptoms in patients. We compared the diagnostic delay with overall healthcare utilization charges. Many patients (46%) had delays in diagnosis of >1 month. Billed healthcare charges before diagnosis increased with length of delay.

Coccidioidomycosis (also known as Valley fever) is an endemic fungal infection (1,2). In Arizona, USA, it is responsible for one quarter of all community-acquired pneumonia (CAP) (3,4). Although accurate diagnosis requires specific laboratory tests (5), such testing was only ordered in ≤13% of patients with CAP in Phoenix, Arizona (6), raising the possibility that delays in accurate diagnosis might be extensive. We report a retrospective analysis from the coccidioidomycosis-endemic region of Phoenix to estimate diagnostic delays and healthcare utilization before and after a coccidioidal diagnosis was confirmed.

The Study

This study focused on cases recorded at clinics operated by Banner Health in the Phoenix area, using programmatic use of data from NextGen (<https://www.nextgen.com>). This electronic medical record system was used during the study period by most of Banner Health's clinics but not its hospitals. We programmatically searched the system for all patients ≥18 years of age who were seen from January 1, 2011, through December 31, 2014, whose records showed codes from the International Classification of Diseases, 9th Revision (ICD-9), that indicated

coccidioidomycosis (114.*). The earliest diagnosis of coccidioidomycosis served as the diagnosis date for each patient. We excluded patients with a coccidioidomycosis diagnosis in 2011 who also had a coccidioidomycosis diagnosis in the prior 12 months. We corroborated all diagnoses by a programmatic identification of any positive coccidioidal serologic test result (5) <30 days before or >60 days after the date of diagnosis.

To estimate the date when patients first sought medical attention for their illness, we used a set of ICD-9 codes that represented an expansion of codes previously associated with early coccidioidal illnesses that were used in a Phase I independent chart review of 37 patients performed by 2 physicians in training and an internist (7). For our study, an internist and a medical student independently reviewed all ICD-9 codes occurring 6 months before the coccidioidomycosis diagnosis and included only those that they both judged to be similar to the original set from the previous Phase I study. An infectious disease specialist settled cases of nonconcordance. We removed 3 Phase I symptoms that were deemed erroneous. This process resulted in a total of 121 ICD-9 codes (Appendix Table, <https://wwwnc.cdc.gov/EID/article/25/8/19-0019-App1.pdf>). We defined the date of first presentation (i.e., the date signs and symptoms were first clinically noted) as the earliest record in which ≥1 of the expanded ICD-9 codes were recorded, within 6 months before the diagnosis date. We calculated the delay in diagnosis as the difference between the date of first presentation and the diagnosis date.

Healthcare charges represented total healthcare utilization. Billing data were available for ambulatory care from NextGen and for Banner Health's hospitalizations from MedSeries4 (Siemens Medical Solutions USA, Inc., <https://www.siemens.com>). We defined healthcare utilization as the total charges, for any cause, from the date of first visit to 6 months after the diagnosis date. We distinguished total charges from actual reimbursement amount because the total is only 1 aspect of a complicated financial billing system.

We used the SAS Enterprise Guide Software Suite version 7.13 (SAS Institute Inc., <https://www.sas.com>) for

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data retrieval and analysis. The Banner Health Institutional Review Board approved this study.

We identified newly diagnosed coccidioidal infections in 139 patients. The mean patient age was 49.2 years (SD ± 15.3 years) (Appendix Figure 1), and 52% of patients were female.

The 3 most frequently occurring coccidioidal ICD-9 codes were unspecified (114.9, 47%), primary pulmonary (114.0, 37%), and pulmonary unspecified (114.5, 8%) (Appendix Figure 2). Confirmatory serologic tests were recorded within 15 days before or after the date of diagnosis in 81% of patients (Appendix Figure 3).

The expanded set of ICD-9 codes failed to identify an initial presentation date for 20 patients. Of the 119 patients with an identified presentation date, 16 (13%) received a diagnosis on the day of presentation, 24% within 1 week of first presentation, 46% within 1 month, and 54% from 30 days to 6 months after presentation (Figure).

We queried total charges for all 139 patients from the date of first visit (the coccidioidomycosis diagnosis date, if no initial presentation date was available) until 6 months after the diagnosis date. By cross-referencing patient identifiers, we found 66 (47%) patients to have hospitalization billings, which were included in the total healthcare cost. Median healthcare charges seemed to increase as diagnosis delays increased (Table). When we compared diagnosis delay to the log-normal of total charges, we found a significant, positive, linear relationship for overall charges ($R^2 = 0.07$, $p = 0.003$), attributable to those occurring before ($R^2 = 0.16$, $p \leq 0.0001$) but not to those on or after the diagnosis date ($R^2 = 0.01$, $p = 0.2748$). Although we saw issues with data normality because of our small sample size, we assumed normality for linear regression analysis (Appendix Figures 4–6).

Conclusions

For this retrospective study, we developed a set of ICD-9 codes to use as a surrogate indicator for the date coccidioidomycosis patients were first seen within Banner Health clinics for signs or symptoms of their infection. This list expanded on an initial set of codes discovered through a manual chart review (7). Many of the codes are common and are unlikely themselves to be predictive of diagnosis. Previous studies have been unable

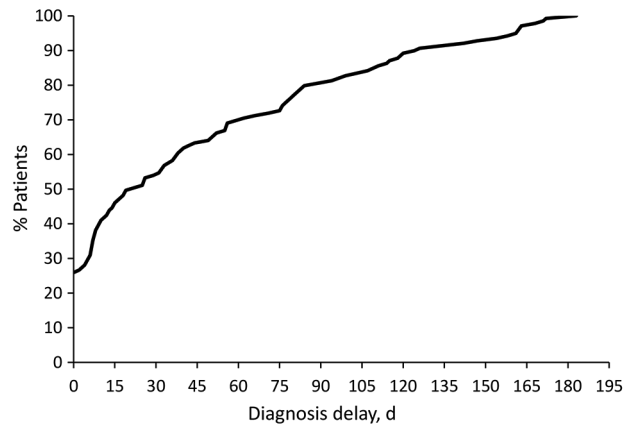


Figure. Cumulative distribution of coccidioidomycosis patient population in relation to diagnosis delay for cohort of patients in Phoenix, Arizona, USA. At 30 days of delay, ≈55% of the population had received a diagnosis.

to meaningfully distinguish presenting syndromes of coccidioidomycosis in patients from other overlapping etiologies (3,4,8). However, this code set was useful to computationally establish the date of first healthcare contact for these patients. If this analytic method is validated and perhaps improved in future studies, it could allow for automated monitoring of diagnostic delay as a metric of quality assessment, without the need for expert chart review.

Of the 139 patients analyzed in this study, 20 did not have an eligible ICD-9 code, and 16 others had their initial presentation code recorded on the same day as their coccidioidomycosis diagnosis. Factors leading to these problems might include failure of a clinician to record sufficient diagnostic information or use of codes that are not sufficiently comprehensive. Future studies could manually examine the full patient records to further expand the code set. It is also possible that patients entered the Banner Health electronic system with a diagnosis of coccidioidomycosis from elsewhere or that the coccidioidal infection was truly without symptoms.

This investigation identified a prolonged diagnosis delay for much of the population; 46% had a delay >1 month (Figure). With increased delays, total healthcare charges increased substantially. However, this study was

Table. Median charges by monthly range of diagnostic delays before and after the date of coccidioidomycosis diagnosis for cohort of patients in Phoenix, Arizona, USA*

Time from presentation to diagnosis, mo	No. patients	Before diagnosis		After diagnosis		Combined	
		Median	Total	Median	Total	Median	Total
<1	55	\$373	\$30,081	\$637	\$239,681	\$749	\$269,762
1–3	37	\$791	\$217,662	\$2,707	\$436,233	\$2,492	\$653,895
4–6	27	\$915	\$338,810	\$1,199	\$710,911	\$2,680	\$1,049,720
No recorded symptoms	20	NA	NA	\$4,172	\$854,597	\$4,172	\$854,597
Overall	139	\$637	\$586,553	\$875	\$2,241,422	\$1,231	\$2,827,974

*NA, not applicable.

not limited to coccidioidomycosis-related charges; any diagnosis delay could result in increased healthcare utilization, regardless of relationship to coccidioidomycosis. In addition, data gaps may have occurred because of difficulty in cross-referencing identifiers or visits by patients to a non-Banner facility. However, our findings are consistent with the simple concept that diagnostic delays in a protracted coccidioidal illness would result in additional testing, visits, and possible use of empiric antibacterial treatments until a precise diagnosis is achieved.

Our study investigates only patients with confirmed coccidioidomycosis and not patients who never received a correct diagnosis. Previous studies indicate that appropriate testing for coccidioidomycosis is often not done in Phoenix and Tucson (6,9,10). Thus, the costs of delayed coccidioidal diagnosis probably underestimates the situation for this clinical practice within a coccidioidomycosis-endemic region. A recent study of coccidioidomycosis diagnosed outside endemic regions also showed substantial delays (11), making our research relevant to those with a recent travel history to endemic regions.

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About the Author

Ms. Ginn is a data science analyst at Banner Health's Centralized Analytics team. Her interests include data visualization, hierarchical data modeling, and infectious diseases.

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Appendix

Appendix Table. Expanded ICD-9 code list used to define the initial presentation date in study of delays in coccidioidomycosis diagnosis.

ICD-9 code	Diagnosis	Phase I symptoms*	Phase II expansion†	No. initial symptoms‡	No. total symptoms§
780.79	Malaise and fatigue	Yes	Yes	29	61
786.2	Cough	Yes	Yes	27	86
486	Pneumonia	No	Yes	10	43
493.90	Unspecified asthma, uncomplicated	No	Yes	8	13
692.9	Unspecified contact dermatitis, unspecified cause	No	Yes	7	11
782.1	Rash and nonspecific skin eruption	Yes	Yes	7	13
465.9	Acute upper respiratory infection, unspecified	No	Yes	6	9
477.9	Allergic rhinitis, unspecified	No	Yes	5	11
724.2	Low back pain	No	Yes	5	6
782.3	Edema, unspecified	No	Yes	5	19
V79.0	Encounter for screening for other disorder	No	Yes	4	4
461.9	Acute sinusitis, unspecified	No	Yes	3	7
473.9	Unspecified sinusitis (chronic)	Yes	Yes	3	3
719.41	Pain in unspecified shoulder	No	Yes	3	8
780.60	Fever, unspecified	Yes	Yes	3	10
784.0	Headache (facial pain)	Yes	Yes	3	6
786.50	Unspecified chest pain	Yes	Yes	3	12
079.99	Other viral agents as the cause of diseases classified elsewhere	No	Yes	2	3
415.19	Other pulmonary embolism without acute cor pulmonale	No	Yes	2	18
462	Acute pharyngitis	Yes	Yes	2	4
466.0	Bronchitis	No	Yes	2	8
490	Bronchitis	No	Yes	2	5
496	Chronic obstructive pulmonary disease, unspecified	No	Yes	2	7
708.9	Urticaria, unspecified	No	Yes	2	4
714.9	Inflammatory polyarthropathy	No	Yes	2	7
719.00	Effusion, unspecified joint	Yes	Yes	2	3
719.40	Pain in unspecified joint	Yes	Yes	2	4
719.43	Pain in unspecified wrist	No	Yes	2	3
719.47	Pain in unspecified ankle and joints of unspecified foot	No	Yes	2	3
719.49	Pain in unspecified joint	No	Yes	2	5
722.4	Other cervical disc degeneration, unspecified cervical region	No	Yes	2	6
724.5	Dorsalgia, unspecified	No	Yes	2	4
729.1	Myositis, unspecified	No	Yes	2	6
733.90	Disorder of bone, unspecified	No	Yes	2	6
780.4	Dizziness and giddiness	No	Yes	2	3
786.05	Shortness of breath	No	Yes	2	13
786.52	Chest pain on breathing	No	Yes	2	2
786.59	Chest pain	Yes	Yes	2	4
V12.09	Personal history of other infectious and parasitic diseases	No	Yes	2	3
288.60	Elevated leukocyte count, unspecified	No	Yes	1	2
382.9	Otitis media, unspecified, unspecified ear	No	Yes	1	1

ICD-9 code	Diagnosis	Phase I symptoms*	Phase II expansion†	No. initial symptoms‡	No. total symptoms§
461.0	Acute maxillary sinusitis, unspecified	No	Yes	1	3
461.8	Acute pansinusitis, unspecified	No	Yes	1	1
477.8	Other allergic rhinitis	No	Yes	1	3
482.89	Pneumonia	No	Yes	1	2
511.0	Pleural condition, unspecified	No	Yes	1	3
518.89	Other diseases of lung	Yes	Yes	1	3
695.2	Erythema nodosum	No	Yes	1	6
698.9	Pruritus, unspecified	No	Yes	1	1
709.9	Disorder of the skin and subcutaneous tissue, unspecified	No	Yes	1	6
719.07	Effusion, unspecified ankle	No	Yes	1	2
719.42	Pain in unspecified elbow	No	Yes	1	1
719.46	Pain in unspecified knee	No	Yes	1	2
722.93	Discitis, unspecified, lumbosacral region	No	Yes	1	1
723.1	Cervicalgia	No	Yes	1	2
729.5	Pain in unspecified limb	No	Yes	1	7
733.6	Chondrocostal junction syndrome [Tietze]	No	Yes	1	5
739.2	Segmental and somatic dysfunction of thoracic region	No	Yes	1	2
780.99	Other general symptoms and signs	No	Yes	1	2
782.2	Localized swelling, mass and lump, unspecified	No	Yes	1	3
785.6	Enlarged lymph nodes, unspecified	No	Yes	1	5
786.07	Wheezing	No	Yes	1	1
786.09	Dyspnea and respiratory abnormality	Yes	Yes	1	5
995.3	Allergy, unspecified, initial encounter	No	Yes	1	1
V74.1	Encounter for screening for respiratory tuberculosis	No	Yes	1	4
057.9	Unspecified viral infection characterized by skin and mucous membrane lesions	No	Yes	0	1
288.3	Eosinophilia	Yes	No	0	0
289.3	Nonspecific lymphadenitis, unspecified	No	Yes	0	1
307.81	Tension-type headache, unspecified, not intractable	No	Yes	0	1
478.19	Other specified disorders of nose and nasal sinuses	No	Yes	0	2
478.70	Other diseases of larynx	No	Yes	0	3
480.0	Pneumonia	No	No	0	0
480.1	Pneumonia	No	No	0	0
480.2	Pneumonia	No	No	0	0
480.3	Pneumonia	No	No	0	0
480.8	Pneumonia	No	No	0	0
481	Pneumonia	No	No	0	0
482.0	Pneumonia	No	No	0	0
482.1	Pneumonia	No	No	0	0
482.2	Pneumonia	No	No	0	0
482.32	Pneumonia	No	No	0	0
482.39	Pneumonia	No	No	0	0
482.40	Pneumonia	No	No	0	0
482.41	Pneumonia	No	No	0	0
482.42	Pneumonia	No	No	0	0
482.49	Pneumonia	No	No	0	0
482.82	Pneumonia	No	No	0	0
482.83	Pneumonia	No	No	0	0
482.9	Pneumonia	No	Yes	0	1
483.0	Pneumonia	No	No	0	0
483.1	Pneumonia	No	No	0	0
483.8	Pneumonia	No	No	0	0
484.7	Pneumonia	No	No	0	0
485	Pneumonia	No	No	0	0
487.0	Pneumonia	No	No	0	0
487.1	Pneumonia	No	No	0	0
487.1	Bronchitis	No	No	0	0
491.0	Bronchitis	No	No	0	0
491.1	Bronchitis	No	No	0	0
491.8	Bronchitis	No	No	0	0
491.9	Bronchitis	No	No	0	0

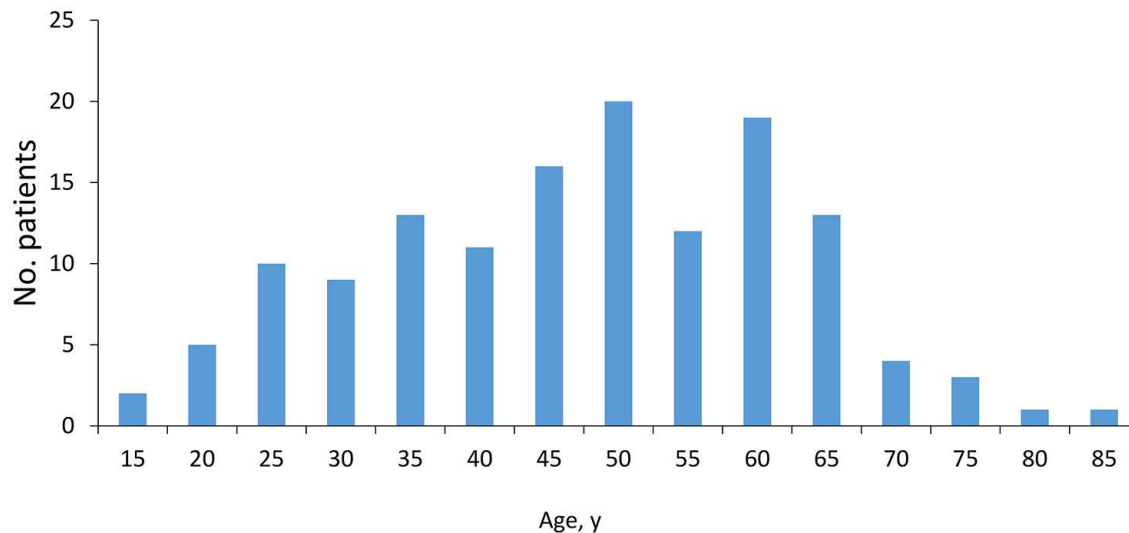
ICD-9 code	Diagnosis	Phase I symptoms*	Phase II expansion†	No. initial symptoms‡	No. total symptoms§
493.92	Unspecified asthma with (acute) exacerbation	No	Yes	0	1
514	Pneumonia	No	No	0	0
695.11	Other erythema multiforme	No	Yes	0	1
708.0	Allergic urticaria	No	Yes	0	1
719.45	Pain in unspecified hip	No	Yes	0	2
724.1	Pain in thoracic spine	No	Yes	0	1
729.89	Other symptoms and signs involving the musculoskeletal system	No	Yes	0	1
780.64	Chills (without fever)	No	Yes	0	1
780.8	Generalized hyperhidrosis	Yes	Yes	0	2
780.96	Pain, unspecified	Yes	No	0	0
784.2	Localized swelling, mass and lump, head	No	Yes	0	1
786.02	Orthopnea	No	Yes	0	1
786.30	Hemoptysis, unspecified	Yes	Yes	0	1
786.6	Localized swelling, mass and lump, trunk	No	Yes	0	6
786.9	Other abnormalities of breathing	No	Yes	0	1
793.11	Nonspecific abnormal findings on radiological/other examination of solitary pulmonary nodule	Yes	Yes	0	6
793.19	Other nonspecific abnormal finding of lung field	No	Yes	0	10
796.4	Other general symptoms and signs	No	Yes	0	2
807.00	Closed fracture, unspecified rib(s)	Yes	No	0	0
829.0	Fracture of unspecified bones, closed	Yes	No	0	0

*These ICD-9 codes originated from the Phase I chart review. These are subject to the study design and conditions therein.

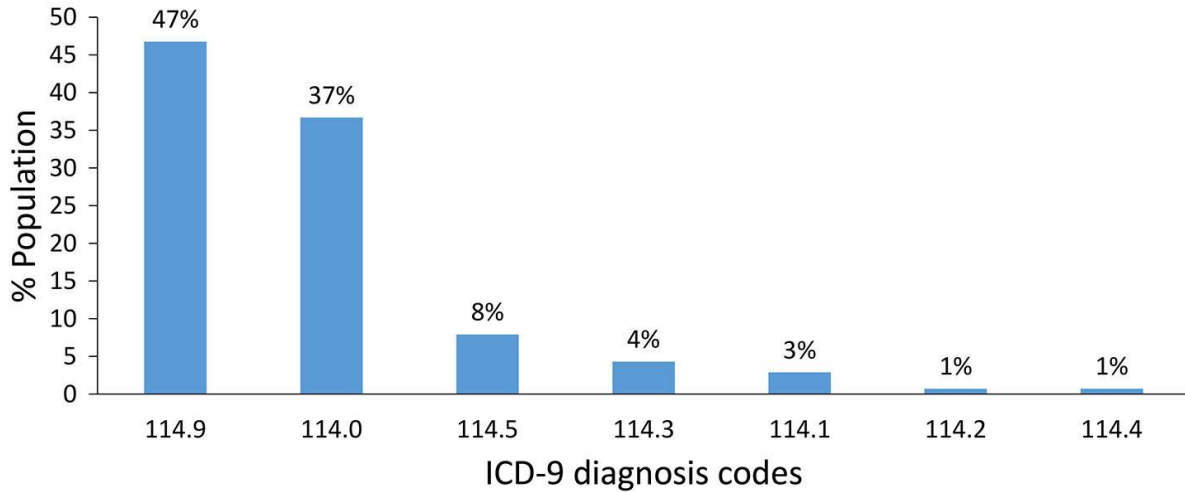
†Expanded Phase II symptoms are based on 6-month diagnosis history, before the diagnosis dates for coccidioidomycosis. These were determined to be similar to the Phase I symptoms by the review process described in the article. Thus, they are dependent on the results of the Phase I study, but served to provide a wider array of ICD-9 codes to capture the Phase I concepts.

‡Includes the ICD-9 codes that were found on the earliest symptom date for the population, 6 months before the date of diagnosis for coccidioidomycosis. The earliest symptom date was used to calculate the diagnosis delay in conjunction with the diagnosis date. It is possible for 1 patient to have multiple symptoms on a day, which would increase the total aggregate of these values.

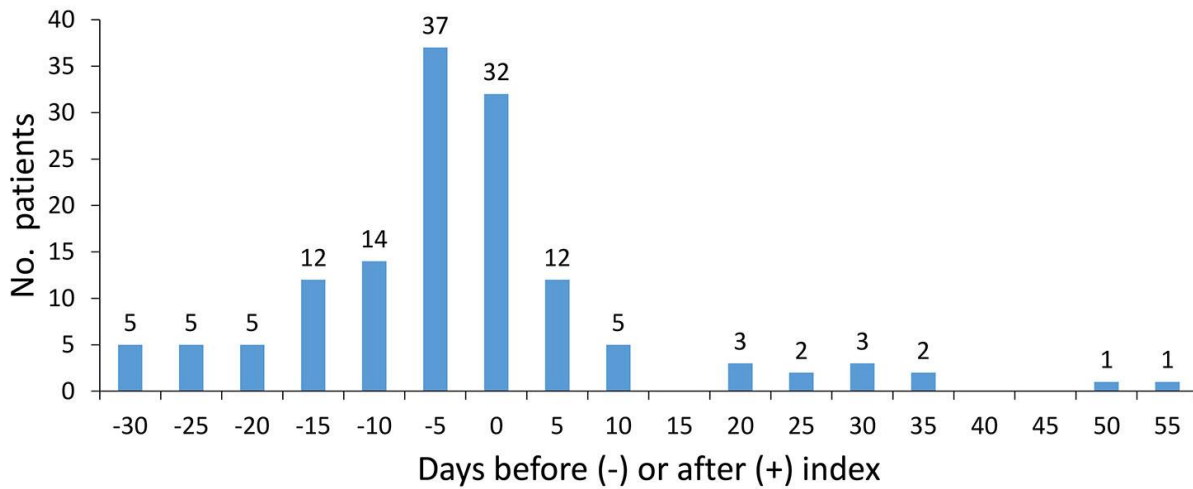
§Total number of symptom diagnoses 6 months before coccidioidomycosis diagnosis dates for the population. Only a fraction of these served as the initial symptom.



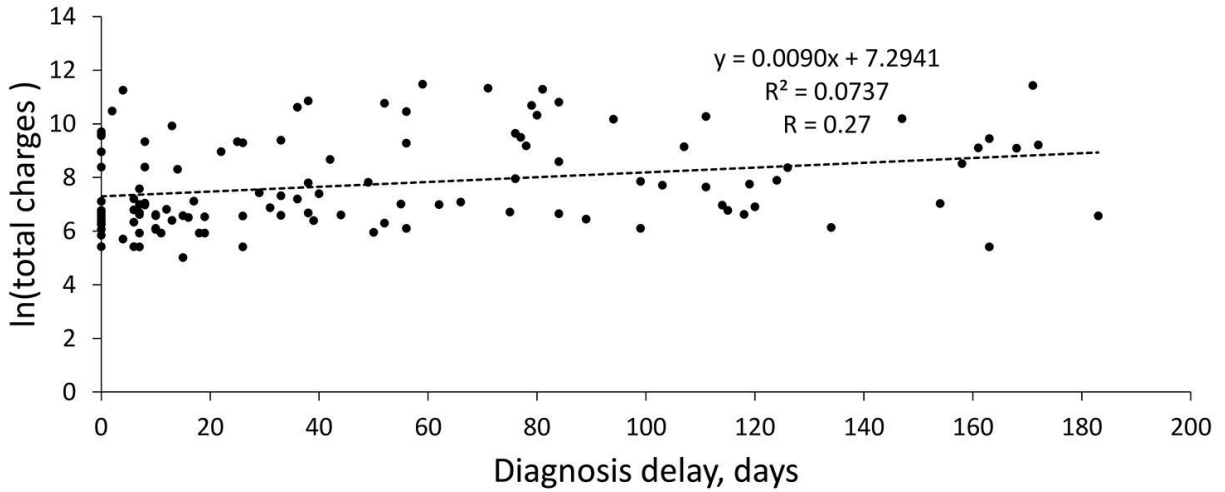
Appendix Figure 1. Age distribution of the population of a study of delayed coccidioidomycosis diagnosis, Arizona, USA.



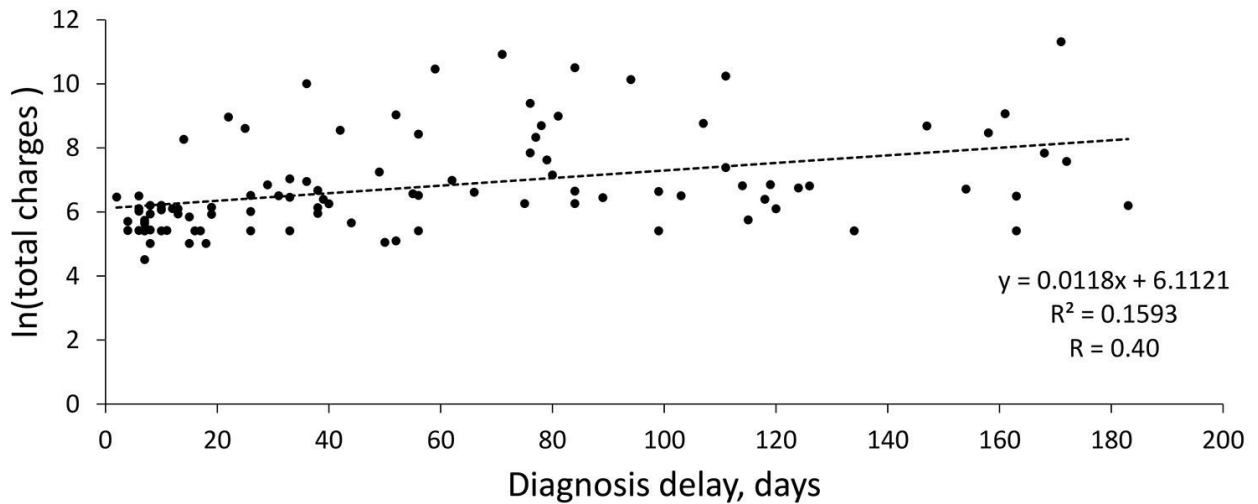
Appendix Figure 2. Distribution of diagnosis codes used to identify date of coccidioidomycosis diagnosis in patients in Arizona, USA.



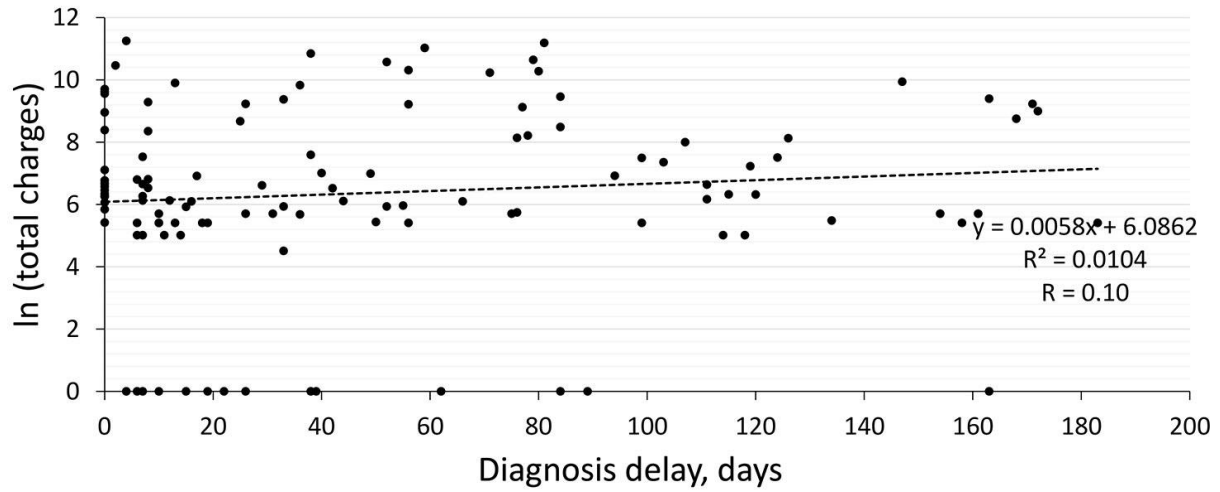
Appendix Figure 3. The time difference in days between the serology confirmation date and date of coccidioidomycosis diagnosis (index date), Arizona, USA.



Appendix Figure 4. Linear regression model, assuming normality, for diagnosis delay vs. the lognormal (ln) of total healthcare charges for patients with coccidioidomycosis diagnosis, Arizona, USA. Only overall total charges are shown. The dashed line represents the fitted linear regression model.



Appendix Figure 5. Linear regression model, assuming normality, for diagnosis delay vs. the lognormal (ln) of total healthcare charges for patients with coccidioidomycosis diagnosis, Arizona, USA. Only total charges before coccidioidomycosis diagnosis are shown. The dashed line represents the fitted linear regression model.



Appendix Figure 6. Linear regression model, assuming normality, for the diagnosis delay vs. the lognormal (ln) of total healthcare charges for patients with coccidioidomycosis diagnosis, Arizona, USA. Only total charges on or after CM diagnosis are shown. The dashed line represents the fitted linear regression model.