



Transmission Analysis of COVID-19 Outbreaks Associated with Places of Worship, Arkansas, May 2020–December 2020

Mallory Jayroe¹ · Daniela Ramirez Aguilar¹ · Austin Porter^{1,2} · Mike Cima¹ · Sandra Chai¹ · Kimberly Hayman¹

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Abstract

The purpose of this study was to describe a statewide COVID-19 transmission involving places of worship (POWs) during the early phase of the pandemic. During the period of May 2020–December 2020, this analysis evaluated COVID-19 cases in Arkansas reported in REDCap for overall cases associated with POWs, cluster detection, and network analysis of one POW utilizing Microbetrace. A total of 9904 COVID-19 cases reported attending an in-person POW service during the early phase of the pandemic with 353 probable POW-associated clusters identified. Network analysis for ‘POW A’ showed at least 60 COVID-19 cases were traced to at least 4 different settings. The pandemic gave an opportunity to observe and stress the importance of public health and POWs working closely together with a shared goal of facilitating worship in a manner that optimizes congregational and community safety during a public health emergency.

Keywords COVID-19 · Communicable disease control · Public health

Introduction

On March 13, 2020, the United States declared the novel SARS-CoV-2 virus a national emergency (American Journal of Managed Care, 2020). Based on scientific understanding of disease transmission and in an effort to mitigate COVID-19 spread, public health and medical professionals communicated preventative measures including stay-at-home practices, hand washing, social distancing, and usage of face masks (Schuchat,

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✉ Mallory Jayroe
Mallory.Jayroe@arkansas.gov

Extended author information available on the last page of the article

2021; Wilson et al., 2020). These safe practice measures were important in places where socialization often occurred such as restaurants, schools, and places of worship (POWs) (e.g., churches, synagogues, mosques.)

Prior studies have shown religiosity, or involvement in a religious feeling or belief, intensifies during major events, such as pandemics and other events with mass casualties (Ai et al., 2005; Osheim, 2008; Poulin et al., 2005; Torabi & Seo, 2004). Examples include the Black Death in medieval Europe, the 1918 flu pandemic in South Africa, smallpox in India, and the September 11, 2001 attack in the United States, which all elicited a greater level of religiosity (Ai et al., 2005; Osheim, 2008; Poulin et al., 2005). Given the historical association between religiosity and mass casualties, COVID-19 is no exception in triggering an increase in religious involvement, while also altering the expressions of those traditions (Baker et al., 2020; Osheim, 2008; Wilson et al., 2020). Studies have noted that during times of unexpected public health and natural emergencies, higher mortality salience also triggers religiosity, increasing an individual's need for community support via in-person services and gatherings (Baker et al., 2020; Schuster et al., 2001; Thunström & Noy, 2019). Response to the guidance or directives can differ, such as an increased reliance on an individual's divine belief potentially reducing compliance with public health recommendations or reacting against any directives that restrict in-person services and gatherings (DeFranza et al., 2021). Unfortunately, this has also resulted in multiple instances of COVID-19 spread associated with in-person religious gatherings in the United States including Washington, Oregon, California, West Virginia, and Arkansas (Bizjak et al., 2020; Cline, 2020; Hamner et al., 2020; James et al., 2020; Nazaryan, 2020). Shortly before the state COVID-19 public health emergency declaration, a place of worship (POW) cluster was identified from a couple who attended a POW-related event from March 6 to March 8, 2020. From this in-person event of 92 attendees, 35 tested positive for COVID-19 of whom 3 died (James et al., 2020). Through contact tracing efforts, at least 26 additional COVID-19 cases within the community reported contact with an attendee from this event. A secondary contact from this gathering was hospitalized and later died.

On May 4, 2020, guidelines for POWs were proposed by the Arkansas Department of Health (ADH) encouraging gatherings via online platforms. However, if in-person gatherings were still an option, recommendations included usage of face masks inside the building and throughout the service, social distancing from other congregants, and limiting contact with non-household members (Chai, 2020; Schmidt, 2020). In support of these recommendations, multiple reports and guidelines highlighted that large gatherings involving POWs pose a risk for COVID-19 transmission. The aim of this study is to describe statewide COVID-19 transmission involving POWs during the early phase of the pandemic.

Methods

Case Identification

During the period of May 2020–December 2020 all persons in Arkansas who were tested for COVID-19 using Reverse-Transcription Polymerase Chain Reaction (PCR)

or antigen testing methods at any laboratory were entered into a surveillance system, utilized by ADH, known as Research Electronic Data Capture (REDCap). ADH and case investigators (CIs) used a standardized questionnaire during interviews of COVID-19 cases to collect pertinent epidemiologic and clinical information, including their 14-day, in-person activities/attendance since COVID-19 symptoms started or since their positive COVID-19 result, whichever came first. The questionnaire collectively asked about any community exposures to retail store settings (grocery stores, department stores), dining/restaurants, bars, indoor fitness centers/athletic training facilities, outdoor athletic facilities/pools, casinos, barbershops/salons/beauty shops, health and wellness facilities (dental office, medical office, massage & spa), daycare(s), outdoor venues (concerts, fairs, national/state parks, hotel/motel, private/public educational settings and extracurricular activities (PreK-12, higher education), group/institutional settings (assisted living facilities, nursing homes, rehabilitation centers, prison/jail), occupational settings (healthcare setting, poultry facility), travel history, place(s) of worship, and an open section for other settings not listed. Close contacts of patients with laboratory-confirmed cases of COVID-19 were also interviewed and enrolled in an active symptom monitoring system.

Cluster Investigation

Clusters were defined as five or more positive cases who reported attending a POW within the 14 days prior to their illness and had a positive test result (Furuse et al., 2020). The POWs team continuously monitored the dataset to identify potential clusters associated with POWs throughout the state. Once clusters were identified, ADH staff would attempt to contact the leadership at the impacted POW to provide education.

Network Analysis

After evaluating POWs cluster data, one POW cluster emerged for network analysis. This POW cluster was chosen based on its large, reported number of positive cases having attended the POW, community cases, and availability of corresponding detailed CI information that showed the majority of cases attending the same service then infection arising days after. A network analysis was conducted to demonstrate the spread of COVID-19 through a POW and the community in which the POW was located. To better understand this transmission, this study used the network analysis tool, Microbe-trace. This instrument has been used in many other COVID-19 studies and is retooling molecular epidemiology for rapid public health response (Campbell et al., 2021).

Results

POW Cases in Arkansas

From May 2020 to December 2020, there were 9904 COVID-19 positive cases that either reported attending at least one event held at a POW within two weeks of

receiving a confirmed positive COVID-19 test or were cases mentioned in CI notes of the positive cases (Table 1). There were more females (55.67%) than males and nearly a third of the cases were between the ages of 45 and 64 years. Most cases were among whites (85.51%) and non-Hispanic ethnicity (90.80%). These cases resulted in 530 hospital admissions with 135 people admitted to the intensive care unit. Of the 9904 cases, 79 people died due to complications from COVID-19.

Clusters

Clusters associated with POW were identified in 63 of the 75 counties in Arkansas (84%). From May 2020 through December 2020, 353 probable clusters associated with POWs were identified in Arkansas. There were four POWs that had more than

Table 1 Demographics of COVID-19 positive cases attending a POW for May 1, 2020–December 31, 2020 (N=9904)

Characteristics	n	%
<i>Sex</i>		
Male	4283	43.25
Female	5514	55.67
Missing/unknown	107	1.08
<i>Age group (in years)</i>		
0–17	1223	12.35
18–24	842	8.50
25–44	2354	23.77
45–64	3261	32.93
65+	2223	22.45
Missing	1	0.01
<i>Race</i>		
American Indian/Alaskan native	18	0.18
Asian	31	0.31
Black	882	8.91
Native Hawaiian/Pacific Islander	65	0.66
White	8469	85.51
Other	257	2.59
Missing/Unknown	182	1.84
<i>Ethnicity</i>		
Hispanic	588	5.94
Non-Hispanic	8993	90.80
Missing/unknown	323	3.26
<i>COVID-19 Reported Outcome</i>		
Reported hospitalization	530	5.35
Reported ICU admission	135	1.36
Reported death	79	0.80
Missing	9160	92.49

one cluster during this period. Additionally, there were 30 POWs that had a cluster of more than 20 cases.

POW A and POW B

POW A held regular, in-person services in late September 2020 and, over a period of 3 weeks, continuous spread occurred throughout Sunday services. This resulted in a total of 21 primary cases (●) shown in the network analysis (Fig. 1). According to information collected by CIs and contact tracers, at least 15 2nd degree exposure cases (♣) had a household association or attended the same work location as a primary case (Fig. 1).

The network analysis found possible spread between 2 POWs (★) (Figs. 1 and 2). The probable transmission may have occurred when a primary case, who attended POW A, went to their place of work (▲) during their infectious period. Based on contact tracing, this case attended the same place of work as two 2nd degree exposure cases (♣). These 2nd degree exposure cases subsequently both attended POW B (★) during their infectious period. POW B was later determined as a COVID-19 POW cluster, with 18 members testing positive. These cases were identified as 3rd degree exposure cases (●).

Two 3rd degree exposure cases from POW B reported attending the same place of work during their infectious period, resulting in a possible COVID-19 exposure to a 4th degree exposure case (●). These three cases then attended a community event, which was reported to have at least 100 people in attendance (●) (Fig. 1).

Furthermore, separate probable community spread may have also developed from POW B, identified as 4th degree exposure cases (●) (Fig. 1). This community spread includes a family gathering held by two 4th degree exposure cases where the attendance from members outside of the state (●) would later result in a COVID-19 case status.

In total, 60 cases were identified as probable associations within this network analysis (Fig. 1, Table 2).

Discussion

Throughout our study analysis, a total of 9904 COVID-19 cases reported attending an in-person POW service during May 1, 2020–December 31, 2020 with 353 probable POW-associated clusters identified. Historically, network technique tools have been useful in studying the diffusion of infectious diseases. Considering the limited knowledge of COVID-19 at the time, the network analysis tool used, Microbetrace, was purposeful in studying COVID-19 spread where at least 60 cases from POW A were traced to at least 4 different settings, including a secondary POW (POW B) (Campbell et al., 2021; Laumann et al., 1989; Maheshwari & Albert, 2020).

During the time period when the cases and clusters occurred in POW A and POW B, COVID-19 was widespread in Arkansas, with approximately 6800 active cases across the state. While it may be difficult to definitively identify the source of

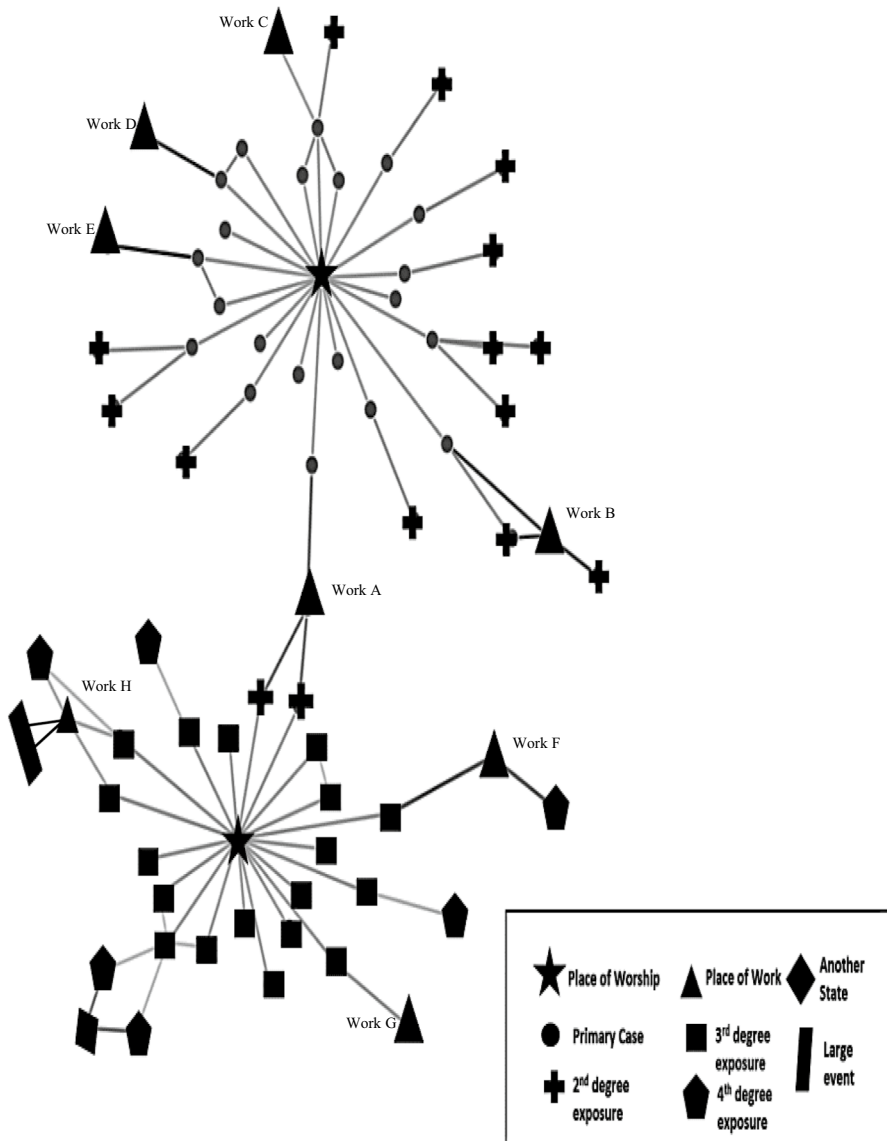


Fig. 1 Network analysis of COVID-19 outbreak

infection for any given case, a thorough examination of the CI notes for cases who identified as having attended these POWs allowed the researchers to highlight two particular patterns. First, at least 75% of the cases from both POWs reported to the CI that their most recent date of attendance fell within a 14-day period at each POW. Second, in both POW A and POW B, the confirmed primary positive cases all tested positive within one to two weeks of each other, with positive tests results starting toward the end of the 14-day cluster period at each POW. While there were some

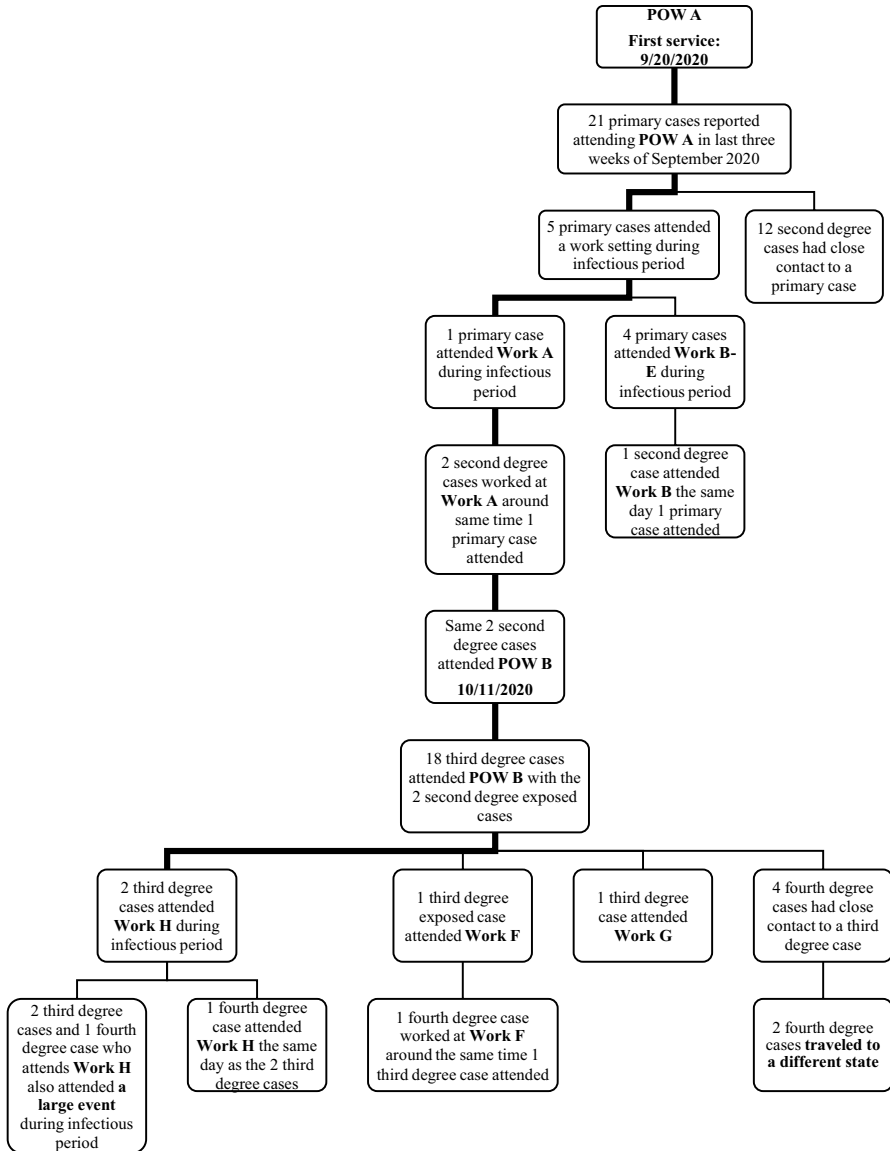


Fig. 2 Flow chart of network analysis based on CI notes intake (American Journal of Managed Care, 2020)

instances of multiple positive cases from households within the POWs, it was clear that these clusters occurred across many households, further suggesting that transmission was not limited to household spread.

It has been reported that people are less likely to wear masks while attending religious services (DeFranza et al., 2021). During the COVID-19 pandemic, evidence has steadily mounted for infected aerosols as the primary mode of SARS-CoV-2

Table 2 Summary of network analysis

Setting	<i>n</i>
★POWs	2
▲Work	8
▮Event	1
◆Other (out of state residents)	1
Total	12
Cases by degree of exposure	
●Primary cases (1st degree cases)	21
✦2nd degree exposure cases	15
■3rd degree exposure cases	18
◆4th degree exposure cases	6
Total	60

viral transmission (Echternach et al., 2020; Katelaris et al., 2021). It is also well-documented that a significant proportion of infected individuals are asymptomatic but can still be highly contagious (Moghadas et al., 2020). Although recognition of variation of the size and quantity of respiratory droplets with different expiratory activities (e.g., quiet breathing, heavy breathing, speaking, shouting, singing, coughing and sneezing) is not new, we have come to a much clearer understanding that the smallest respiratory droplets (aerosols) can travel much farther than six feet (Katelaris et al., 2021; Morawska et al., 2009). Recent studies have demonstrated the effectiveness of masks in reducing the dispersion of respiratory particles during singing, even with loud singing by professional singers (DeFranza et al., 2021). Alsved et al. (2020) demonstrated that wearing an ordinary surgical mask while singing reduced the amount of measured respiratory particles to levels comparable to that of unmasked normal speech. From our preliminary investigation, we observed that POWs that practiced universal masking throughout worship services (including during congregational singing) had a much lower incidence of clusters compared to POWs where masks were either not worn or were removed for singing.

It is possible that Arkansas had an underreported and undertested caseload of COVID-19 similar to a 2020 study examining US COVID-19 cases and testing. This may be due to overwhelmed medical facilities, limited access to a nearby testing center, insufficient medical cost coverage, and/or the reportability between a pathology laboratory and health department during the early of the pandemic (Lau et al., 2020). Still, this study is unique in its evaluation of POW-associated cases and focus on one POW and its resultant community exposures. Strengths of this descriptive study include the ability to describe cases associated with POW and community spread in the network analysis, and usage of Microbetrace in evaluating the probable association between POW cases and community spread. While this study was able to provide a general overview of

POW-associated COVID-19 cases, there were limitations identified relevant to biases. One limitation throughout the data collection process could be recall bias of the participants. Recall bias could affect the patient's accuracy or completeness of the recollection retrieved from the CIs. Interviews were done a week or more after their positive results where cases would be asked to recall their 14-day activity since their first date of symptoms or first positive COVID-19 result. In addition, there were also cases who withheld or omitted providing any information about their POW. This also would lead to underreporting of exposure among cases, therefore may have led to underestimating the effects. The other limitation is unable to interview all cases in the REDCap system. Due to the fluctuation of increased cases in the state within the study period, not all cases could be reached by a CI. Since not every single case was interviewed, there were cases from which community exposures and association with a POW remained unknown. This study was also susceptible to selection bias relevant to the target population. If an individual felt restricted of their religious freedom and/or if they have mistrust in science or their respective government officials regarding the existence of the pandemic, they may have reactionary effect to directives and guidance early in the pandemic (DeFranza et al., 2021). Therefore, it is possible our study did not capture cases who experienced mild COVID-19 symptoms and did not take a COVID-19 test. Additionally, this study is vulnerable to confounding bias. This study does not pinpoint POWs as the source of infection because exposure to infection may have derived from other social activities attended from the CI questionnaire. If individuals were willing to attend in-person services at a POW, then they may have also attended other in-person activities and events outside of their POW (DeFranza et al., 2021). Other than the surveillance of POW-associated COVID-19 cases analyzed for this study, when a cluster was identified, education was provided to POW leaders directly from the ADH COVID-19 Guidance for POWs. Part of the education included information on congregate singing with a mask on along with following other safety guidelines to help stop the spread of COVID-19. This allowed POW leaders and public health officials to work closely together. Pastors, faith leaders and congregants were part of the boots on the ground people at COVID-19 community-testing sites along with many POW-hosted testing sites, working alongside medical professionals and health department staff to serve their respective communities. They also prepared meals for the community and healthcare workers and sewed thousands of facemasks. As a resource, pastors and faith leaders have first-hand knowledge of what affects their communities and are trusted messengers, underlining the importance of a reciprocal relationship between local health agencies and faith leaders. For instance, faith communities can turn to public health leaders when they need their help and in turn, public health leaders can turn to the faith community when they need their help. Because of these relationships, when COVID-19 struck, public health agencies and POWs were able to collaborate in more ways during this crisis. This relationship needs to extend beyond the pandemic to other areas of public health and national emergencies.

Conclusion

This analysis has shown that exposure to COVID-19 can occur in POWs. One Sunday service resulted in 60 positive cases. However, the pandemic gave opportunity to see and stressed the importance of public health and POWs to working closely together with a shared goal of facilitating worship in a manner that optimizes congregational and community safety during a public health emergency.

Author Contributions All authors contributed to the study conception and design. Material preparation, data collection, writing, review, and analysis were performed by MJ and DRA. Review of data analysis and writing were performed by AP and MC. Literature review, writing, and review were performed by SC and KH. The first draft of the manuscript was written by MJ and DRA and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical Approval The University of Arkansas for Medical Sciences IRB designated this study as a non-human subjects research.

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Authors and Affiliations

Mallory Jayroe¹  · Daniela Ramirez Aguilar¹ · Austin Porter^{1,2} · Mike Cima¹ · Sandra Chai¹ · Kimberly Hayman¹

Daniela Ramirez Aguilar
daniela.ramirez-aguilar@arkansas.gov

Austin Porter
Austin.Porter@arkansas.gov

Mike Cima
Michael.Cima@arkansas.gov

Sandra Chai
Sandra.Chai@arkansas.gov

Kimberly Hayman
Kimberly.Hayman@arkansas.gov

¹ Arkansas Department of Health, 4815 W Markham St., Little Rock, AR 72205, USA

² Department of Health Policy and Management, Fay W. Boozman College of Public Health, University of Arkansas for Medical Sciences, 4301 West Markham, # 820, Little Rock, AR 72205, USA