COVID-19 Exposure Tracking Within Public Health & Safety Enterprises: Findings to Date & Opportunity for Further Research

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Abstract

Where there is limited access to COVID-19 tests, or where the results of such tests have been delayed or even invalidated (e.g., California and Utah), there is a need for scalable alternative approaches—such as a heuristic model or “pregnancy test for COVID-19” that can factor in the time denominator (i.e., duration of symptoms). This paper asks whether infection among these public health and safety agencies is a "canary in the coal mine," litmus test, or microcosm (pick your analogy) for the communities in which they operate. Can COVID-19 infection counts and rates be seen “moving around” communities by examining the virus’s effect on emergency responders themselves?

The troubling question of emergency responders becoming “human indicator values” is relevant to maintaining the health of Mobile Medicine (EMS and Fire) personnel, as well as Police, who are an under-attended population, because without these groups our collective resiliency would crash. It has further implications for policies regarding, and investments in, exposure tracking and contact tracing, PPE acquisition, and mental and physical wellness.

Design: We aggregated data from four (4) different EMS documentation systems across twelve (12) states using the MEDIVIEW BEACON Prehospital Health Information Exchange. We then outputted lists of charts containing critical ICD-10 values that had been identified by the WHO, the CDC, and the Los Angeles County Fire Department’s EMS Bureau as inclusion criteria for possible signs, symptoms, and clinical impressions of COVID-19 infection.

Results: Three important results emerged from this study: (1) a demonstration of frequent exposure to possible COVID-19 infection among Mobile Medical (EMS & Fire) care providers in the states whose data were included; (2) a demonstration of the nervousness of the general population, given that calls for help due to possible COVID-19 based on symptomology exceeded the number of responses with a correlating “provider impression” after an informed clinical assessment; and (3) the fact that this study was empowered by a public-private partnerships between a technology startup and numerous public health and public safety agencies, offers a template for success in rapidly implementing research and development collaborations.

Limitations: This study incorporates data from only (a) twelve (12) states, and (b) four (4) Mobile Medical documentation systems. We sought to combat these limitations by ensuring that our sample crosses agencies types, geographies, population demographics, and municipal environments (i.e., rural vs. urban).

Conclusions: Other studies have noted that EMS agencies are tasked with transporting the “sickest of the sick.” We found that PPE is particularly essential where the frequency of encounters between potentially—or actually—infected patients is high, because from Los Angeles County to rural Texas, without sufficient protection, public health and public safety agencies have become microcosms of the communities they are meant to protect. Indeed, data from the first six months of the declared pandemic in the U.S.A. show that intra-departmental spread is one of (if not the) riskiest sources of infection among Mobile Medical professionals.

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Introduction

As the COVID-19 pandemic mingles with other mimicking syndromes—from the common cold, to seasonal allergies, to influenza—myriad government and healthcare organizations from hospitals to insurers to so-called "startup incubators" have wished for a way to tell these overlapping conditions apart, so that the hospital sector stays safe of collapse under the weight of overutilization due to signs and symptoms that "might" indicate COVID-19 but also could be any of the aforementioned. The data presented here show that, despite media buzz for and against masks and social distancing, Americans in twelve (12) states are more likely to self-assess their ailments as COVID-*like* than to have medical professionals identify their symptoms as COVID-*related*.

In October 2020, the President and First Lady of the United States, and several of their colleagues, were diagnosed with COVID-19, thrusting back into the spotlight the value and deficiency of current exposure tracking and contact tracing efforts. Shortly before this occurred, lawsuits were announced targeting companies, governments, and schools, accusing each of insufficient efforts to identify and isolate persons with suspected—or even confirmed—COVID-19 infection. Insurance companies, small business "incubators" and "accelerators", and universities have launched efforts (sometimes called "challenges") to identify means of exposure tracking and contact tracing that can be rapidly deployed and quickly succeed in a cost-effective manner, with two key objectives:

(1) identify those most likely to have—or carry—the coronavirus, and
(2) eliminate, to the maximum degree possible, false negatives.

The latter are particularly dangerous, because when individuals are falsely identified as uninfected, they may lower their guard and unwittingly become "super-spreaders." False positives can be expensive and cause psychological stress, however, false negatives can create public health havoc.

Unfortunately, COVID-19 tests are supply-constrained in many locations. Elsewhere, results are delayed [1]. California's H&HS Secretary Mark Ghaly was cited as referencing "a major reporting issue…[such that] state and county health officials no longer have a clear idea of how the state's cases are trending. For days, California hasn't received full counts on the number of tests conducted nor the number that came back positive for COVID-19." According to Santa Clara County (CA) Health Officer Sara Cody: "This lack of data doesn't allow us to know where this epidemic is heading." [2] Public-private partnerships ("P3") flourish in struggling, fractured bureaucracies. This paper summarizes the success of one P3 between a startup specializing in data science and several public enterprises. It suggests ways to expand the collaboration and create a repository that can be mined securely, in real-time, while maintaining patient privacy and agency autonomy.

Methods

Beyond Lucid Technologies ("BLT"), a health-and-safety technology startup based in Concord, California, in San Francisco's East Bay, makes software for use by emergency medical service organizations of all types (including fire; public, private, and hospital-affiliated ambulances; and "community paramedic" or "mobile integrated health" organizations). The beneficiaries of BLT's data are these organizations as well as their hospital and public health partners. Early in the COVID-19 pandemic (i.e., March 2020), Cypress Creek EMS (CCEMS) near Houston conceived of a new way of aggregating data about care providers who were exposed to COVID-19, suggesting that BLT coopt an approach historically used for managing frequent users of EMS. BLT modified its software accordingly to track *personnel-as-patients*, and this method was quickly adopted elsewhere in the Houston area (i.e., Harris and Chambers counties), as well as in greater Hartford (Connecitcut), in Southern Arizona, and by the Los Angeles County Fire Department ("LACoFD"), which augmented the approach by automating exposure reporting and monitoring.

In addition to self-reporting, to reduce bias, we analyzed patient care charts captured in both 9-1-1 and Community Paramedic contexts—from four different EMS patient record systems (namely, Zoll RescueNet, Stryker HealthEMS, MEDS4 from the ambulance service American Medical Response, and Beyond Lucid Technologies's own MEDIVIEW ePCR). Incorporating charts completed outside of a longitudinal monitoring program was key because it shined light of the psychology of residents who suspect that they may have been exposed to, or diagnosed with, COVID-19. For example, the degree to which they assumed their signs and symptoms, as conveyed to EMS (i.e., "complaint"), were related to COVID-19, versus the degree to which the symptoms actually aligned with the disease presentation in a skilled caregiver's opinion (i.e., "provider impressions"). The relationship between these two criteria (complaint vs. impression) is "of the essence" as jurisdictions seek to craft processes and policies related social distancing, mask wearing, and testing.

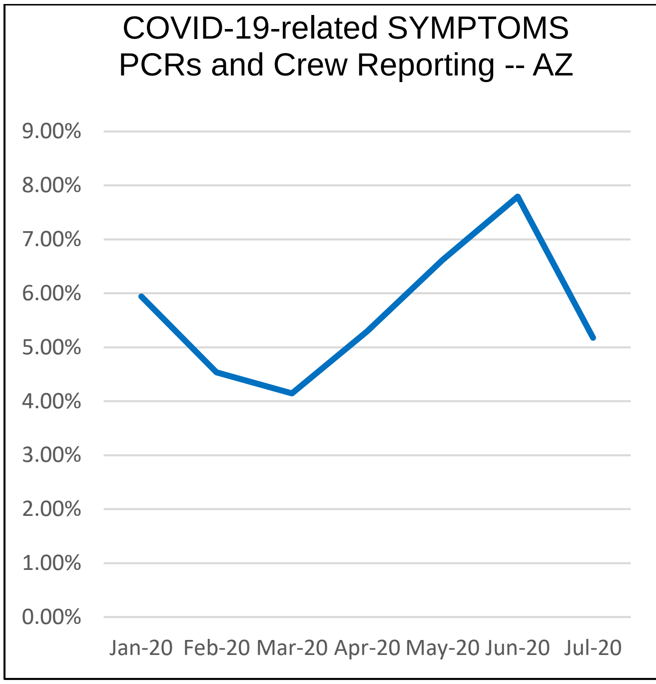
Results / Data Tables

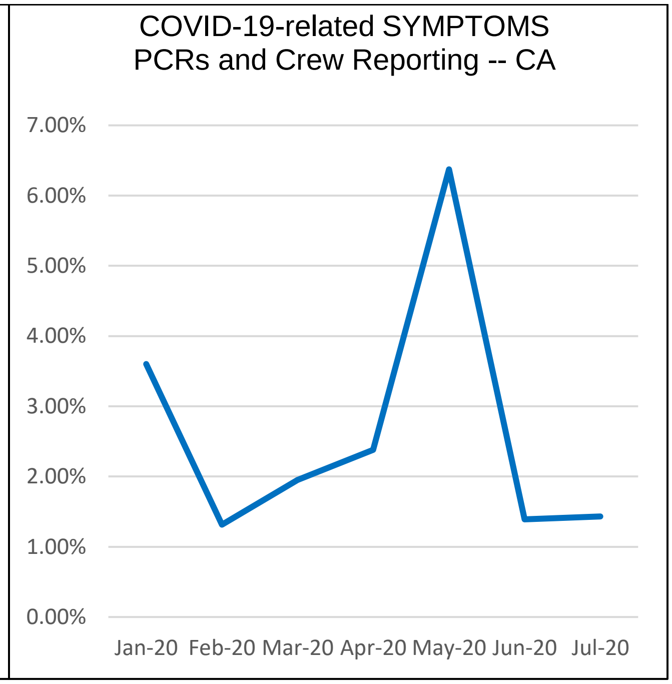
COVID-19-Related SYMPTOMS (State & Date)

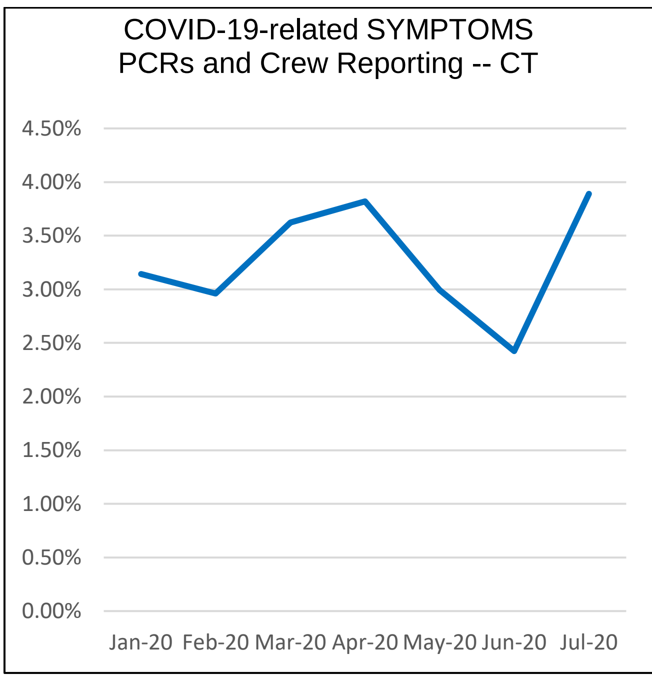
State	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
AZ	5.94%	4.54%	4.15%	5.30%	6.62%	7.79%	5.18%
CA	3.60%	1.32%	1.95%	2.38%	6.37%	1.39%	1.43%
CO	3.99%	3.91%	3.62%	2.70%	4.29%	3.67%	3.68%
CT	3.14%	2.96%	3.62%	3.82%	2.99%	2.42%	3.89%
IL	6.57%	9.52%	11.36%	*	*	*	*
KS	11.67%	8.78%	10.65%	12.94%	5.97%	7.92%	9.13%
MA	12.35%	12.38%	8.95%	16.06%	11.18%	9.25%	9.52%
MN	2.36%	8.96%	9.04%	8.39%	9.09%	8.82%	7.66%
MO	14.93%	18.59%	13.86%	16.96%	11.89%	11.05%	10.55%
NC	15.79%	0.00%	18.75%	7.14%	0.00%	10.00%	18.75%
OH	6.82%	12.70%	12.05%	5.80%	6.74%	4.00%	9.57%
OK	10.25%	10.15%	10.58%	11.28%	11.05%	11.27%	12.25%
PA	0.94%	5.77%	4.67%	8.22%	4.71%	0.89%	5.13%
SC	3.21%	3.16%	5.73%	5.56%	5.13%	5.79%	5.74%
TN	10.11%	6.41%	7.91%	8.22%	8.88%	9.79%	4.39%
TX	*	*	2.62%	4.84%	15.15%	58.70%	43.10%

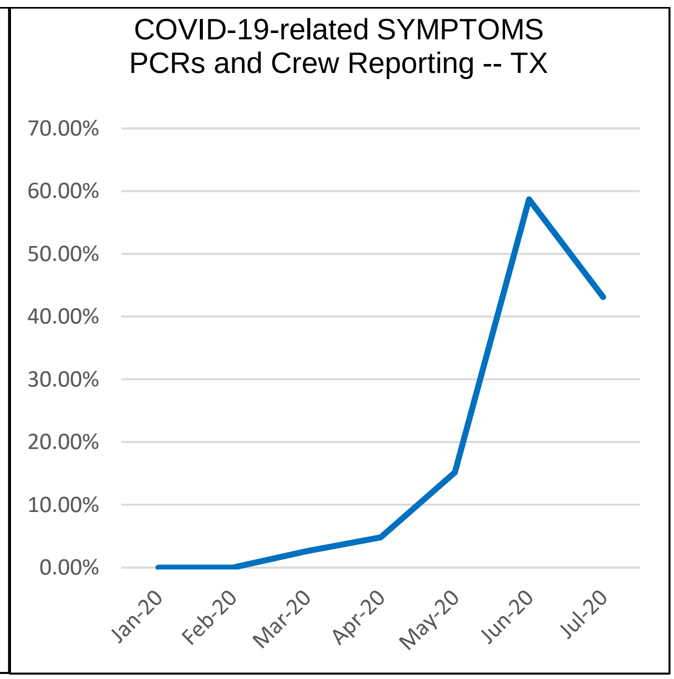
COVID-19-Related PROVIDER IMPRESSIONS (State & Date)

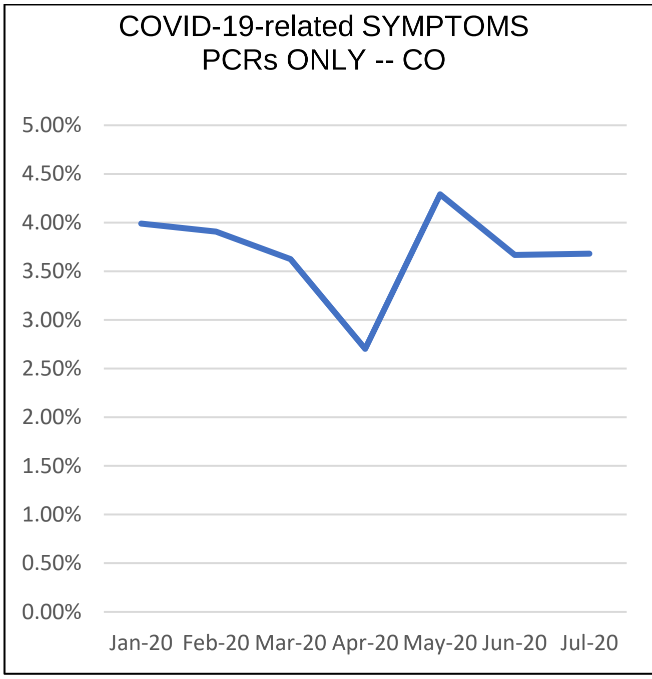
State	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
AZ	0.17%	0.28%	0.25%	0.42%	2.55%	6.48%	5.26%
CA	3.71%	2.57%	3.91%	3.37%	3.17%	3.55%	3.89%
CO	0.28%	0.00%	0.00%	0.00%	0.33%	0.33%	0.00%
CT	3.14%	3.10%	3.41%	4.24%	2.42%	2.19%	2.44%
IL	4.38%	0.95%	3.41%	*	*	*	*
KS	2.33%	1.15%	3.04%	1.99%	1.00%	2.26%	1.19%
MA	0.41%	0.99%	0.53%	5.84%	1.18%	0.58%	1.06%
MN	1.42%	2.36%	0.56%	3.50%	1.07%	1.76%	0.45%
MO	3.48%	2.51%	1.98%	1.17%	0.00%	0.00%	0.50%
NC	0.00%	0.00%	12.50%	0.00%	9.09%	0.00%	0.00%
OH	2.27%	3.17%	1.20%	1.45%	3.37%	1.00%	0.00%
OK	1.46%	1.86%	2.41%	1.74%	1.36%	0.84%	0.62%
PA	0.00%	0.00%	0.00%	0.00%	4.71%	0.89%	0.00%
SC	0.12%	0.13%	0.30%	0.60%	0.56%	0.40%	0.87%
TN	1.37%	0.32%	2.26%	0.00%	1.15%	1.78%	1.81%
TX	*	*	*	*	*	*	*

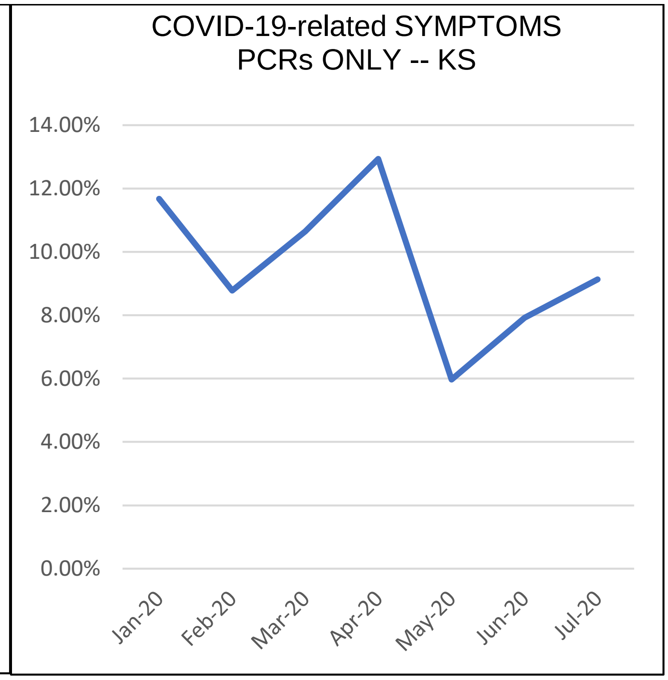

COVID-19-related SYMPTOMS
PCRs and Crew Reporting -- AZ
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20

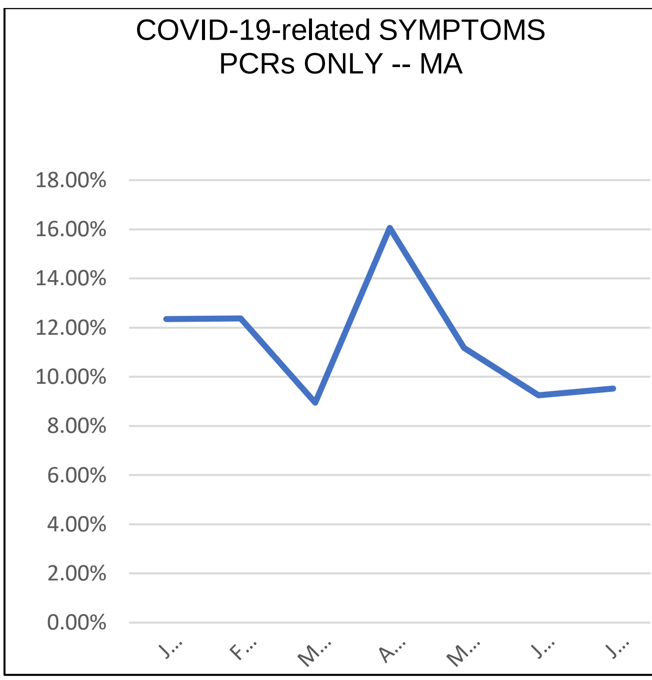

COVID-19-related SYMPTOMS
PCRs and Crew Reporting -- CA
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20

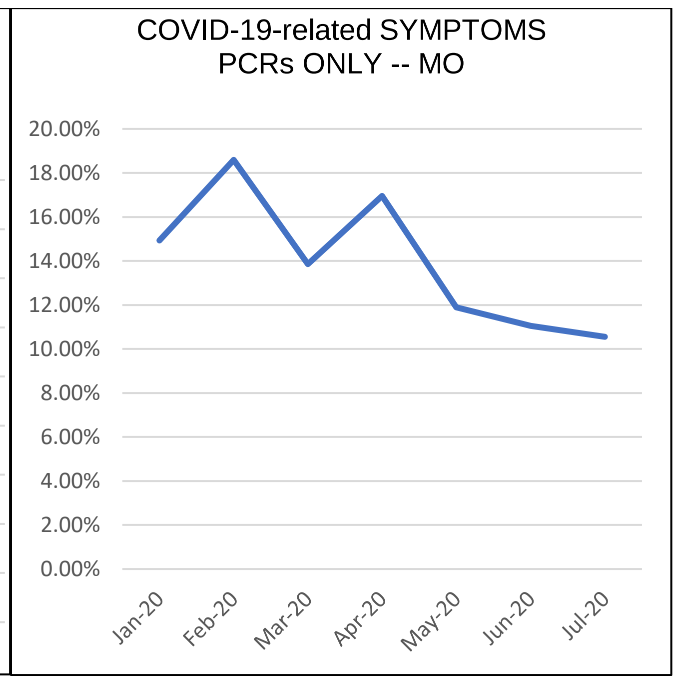

COVID-19-related SYMPTOMS
PCRs and Crew Reporting -- CT
4.50%
4.00%
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20

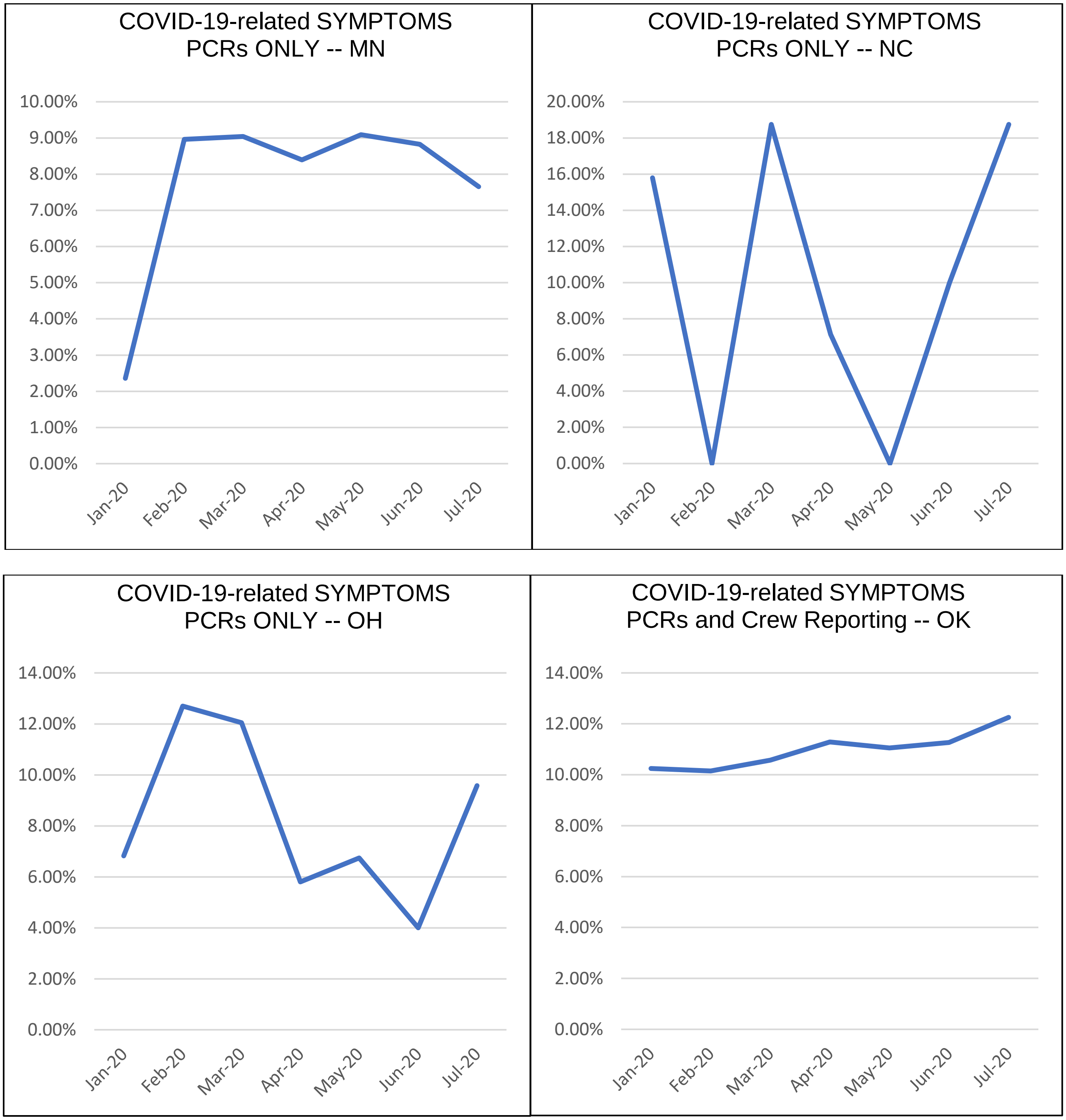

COVID-19-related SYMPTOMS
PCRs and Crew Reporting -- TX
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20

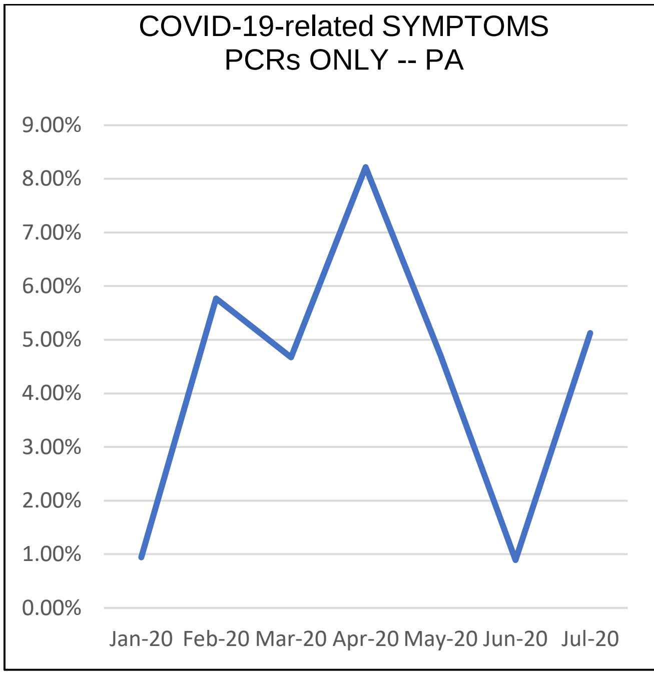

COVID-19-related SYMPTOMS
PCRs ONLY -- CO
5.00%
4.50%
4.00%
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20

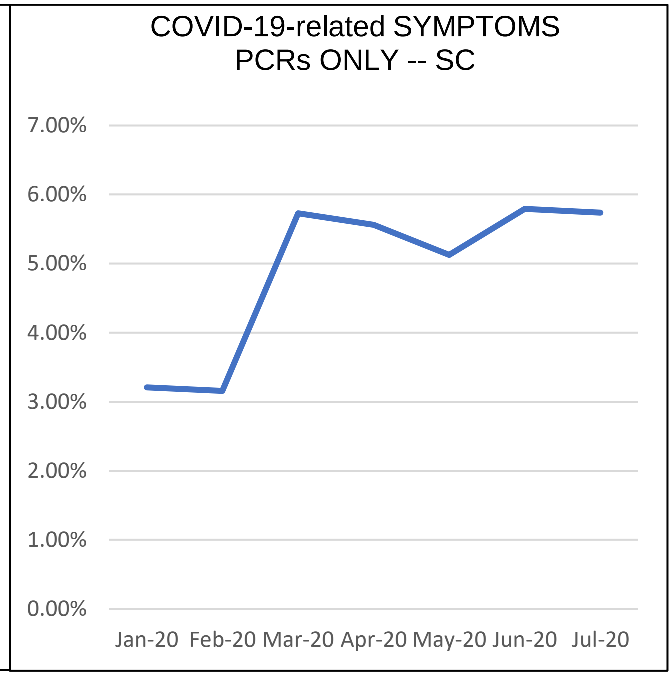

COVID-19-related SYMPTOMS
PCRs ONLY -- KS
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20

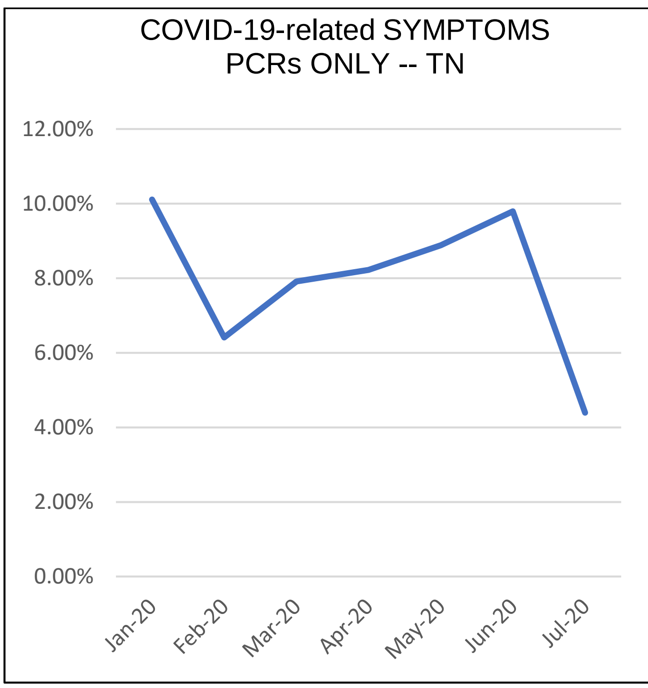

COVID-19-related SYMPTOMS
PCRs ONLY -- MA
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
J...
F...
M...
A...
M...
J...
J...

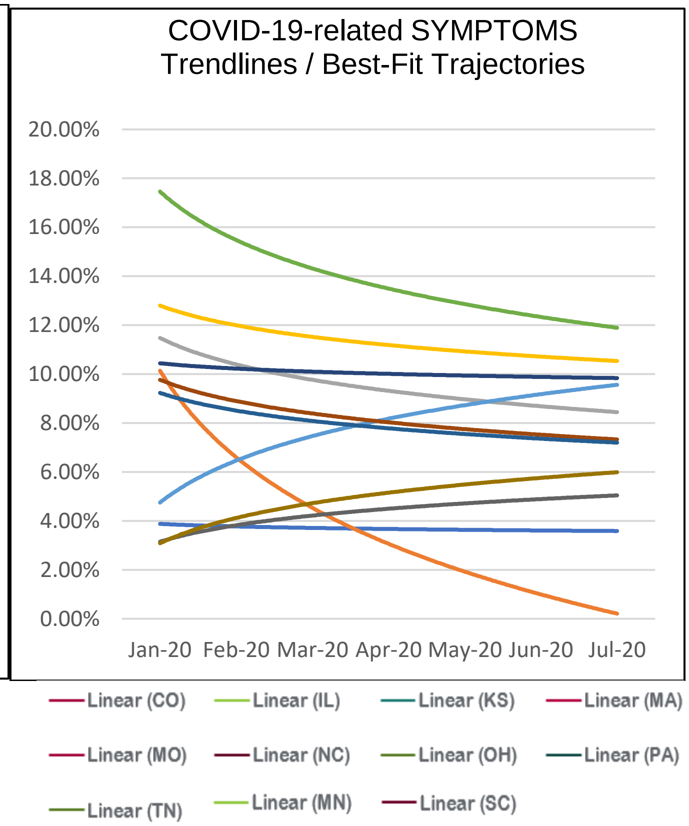

COVID-19-related SYMPTOMS
PCRs ONLY -- MO
20.00%
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20

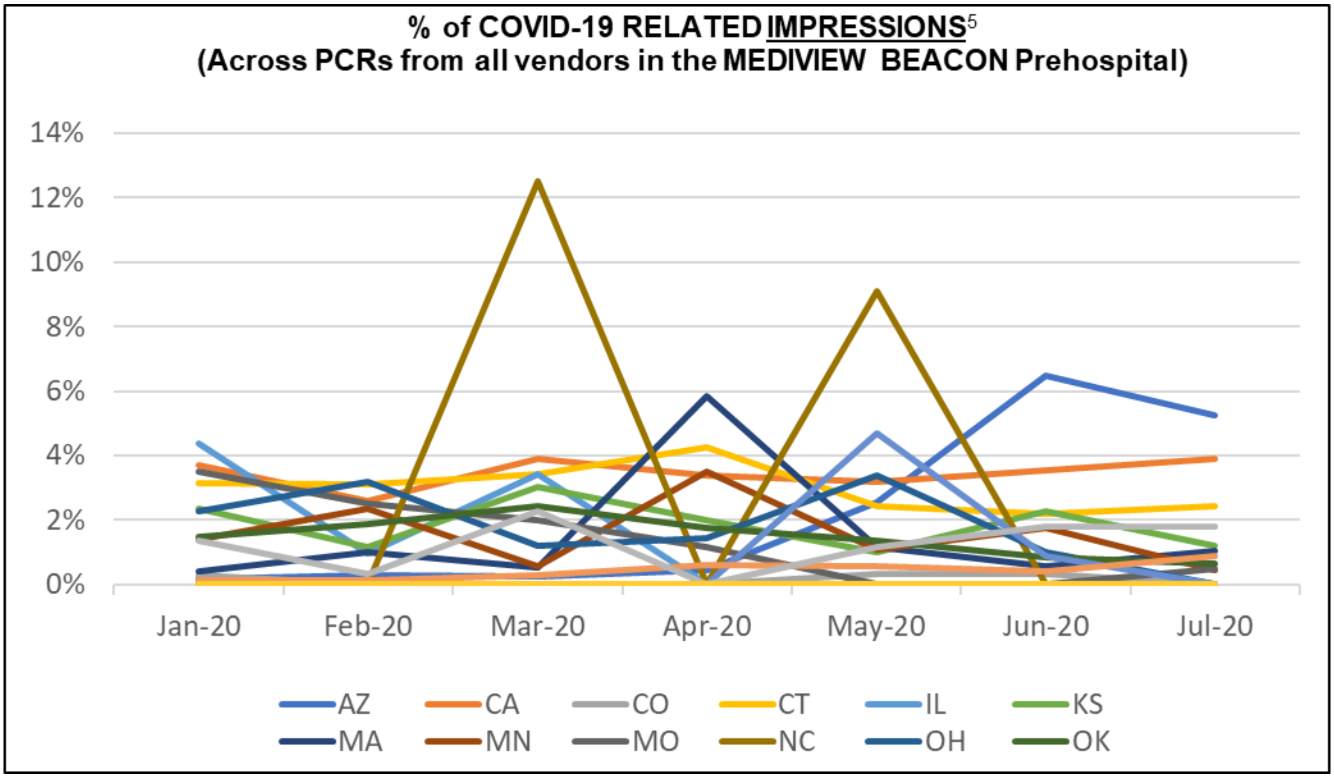

COVID-19-related SYMPTOMS
PCRs ONLY -- MN
10.00%
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
COVID-19-related SYMPTOMS
PCRs ONLY -- NC
20.00%
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
COVID-19-related SYMPTOMS
PCRs ONLY -- OH
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
COVID-19-related SYMPTOMS
PCRs and Crew Reporting -- OK
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20


COVID-19-related SYMPTOMS
PCRs ONLY -- PA
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20


COVID-19-related SYMPTOMS
PCRs ONLY -- SC
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20


COVID-19-related SYMPTOMS
PCRs ONLY -- TN
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20


COVID-19-related SYMPTOMS
Trendlines / Best-Fit Trajectories
20.00%
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Jan-20 Feb-20 Mar-20 Apr-20 May-20 Jun-20 Jul-20
Linear (CO)
Linear (IL)
Linear (KS)
Linear (MA)
Linear (MO)
Linear (NC)
Linear (OH)
Linear (PA)
Linear (TN)
Linear (MN)
Linear (SC)



INCLUSION / EVALUATION CRITERIA (ICD-10 Codes)

Medical History	Impressions	Symptoms
U07.1	J12.89	R10.9
B97.29	J20.8	R19.7
	J40	R06.02
	J80	R05
	J22	R53.83
	J12.89	R50.9
	J98.8	R51
	A41.89	R43.9
	Z20.828	R43.8
	Z03.818	R53.81
		M79.1
		R11.0
		R11.2
		R11.10

Discussions

Using forms that were secure but captured no personally identifiable information, between March 23 and August 31, 2020, LACoFD's Health Programs Office (HPO) processed 23,888 forms, covering 6000+ line and support personnel [3]. The HPO identified 213 confirmed COVID-19 positive personnel who were placed in active monitoring. Such an expansive body of clinical data facilitated the identification of heuristic patterns that became valuable indicators of expected test results—i.e., “a pregnancy test for COVID” —enabling triage of tests where they were in short supply, delayed, or simply proven wrong. After six months, LACoFD reported a false negative rate of zero percent. A state-by-state compendium of aggregated data is presented above.

Chambers County EMS in Texas reported that the form-based process and algorithms “allowed us to follow up with COVID-19 exposures quickly…Being we are a small service this has freed up significant time from making phone calls to hospitals, public health and others to gather results. We are also able to receive outcome data on our patients that are transported which has improved our training and allowed us to focus on key factors of improvement and changes to protocols.” In adjacent Harris County, ESD #48 said: “The screening system is working great…we have way too many to track any other way.” [4]

Conclusions

Syndromic surveillance is a math problem: Statistics and calculus. It is vital to deduce the rate of change of the infection. However, politics—not math—are keeping America from conquering COVID-19, so Mobile Medicine (Fire & Emergency Medical Service agencies) must step up to lead...again. The results of this study show that while Mobile Medical professionals (MMPs) are wearing PPE and taking care to limit patient exposures, the concentration of COVID-19 symptoms (i.e., patients’ self-reported concerns), and provider impressions has followed the trajectory of the virus across the United States. This is important, because MMPs are like a bellwether species—they are like the proverbial “canaries in the coal mine.” MMPs’ rates of infection and recovery offer clues about the virus’s movement and impact for three reasons:

1. Unless PPE is available and used properly, essential personnel like Fire & EMS come into contact with potentially infected persons far more frequently than the average;

2. Mobile Medical professionals—like other public health and public safety teams—tend to live near the areas they cover. If a community is experiencing an outbreak, everyone who lives or works in the vicinity is by definition at higher risk;

3. Among the most dangerous contributors to infection inside Mobile Medical agencies is intra-departmental spread: PPE is not worn during dinner inside a station house.

Further Research

The higher rate at which Mobile Medical (EMS & Fire) agencies are called to respond to suspected COVID-19 cases underscores their risk as crews are being tasked to care for and transport patients whether or not they are later found to be infected with COVID-19. Mobile Medical Professionals therefore are not only critical to community resiliency, but possibly also "canaries in the coal mine": Without universal PPE, responders become microcosms of their localities as infection rates ramp, because they have limited ability to minimize exposure to infected patients. In Texas, as much as 30% of one EMS agency's personnel were quarantined—a rate correlated with, but higher than, the rural community it serves.

Due to an overlap of symptoms between allergy, influenza, and COVID-19, the algorithms resulted in over-triage, which cause result in unnecessary cost and isolation of personnel. But LACoFD reported that exposure tracking technology provided "a continuous, strategic view of the health of our workforce in the face of COVID-19. We now have the ability to track each of our personnel from the onset of exposure or illness, through their return to work." Further research, in additional geographies, will refine the algorithms to reduce false positives and adjust parameters for concurrent diseases with mimicking symptoms.

Limitations of This Study

The general *modus operandi* of studies pertaining to Mobile Medicine (i.e., emergency medical services, including fire) is to focus either on a local site and offer a detailed case example; or else to consult large deidentified datasets—e.g., the National EMS Information System (NEMSIS) or the National Fire Incident Reporting System (NFIRS)—but those face challenges of timeliness and accuracy, such as different states using different versions of the reporting standards (i.e., NEMSIS v3.3.4 and v3.4.0, both of which are presently considered "current"). In some cases, large "indices" containing millions of patient records have been published but their data have invariably been sourced by a single company using its own patient record system, so even a very large sample is confounded by selection bias (i.e., "a sample size of one").

This study's design was intended to combat each of these historical impediments by ensuring that multiple data systems used by Medical Medical organizations contributed to the knowledge base. The data incorporated were generated by: (1) four different electronic patient care record (ePCR) systems; (2) covering a varied geography including both urban and rural care providers; (3) varied agency types, including public EMS, private EMS, hospital-based EMS, fire-based EMS, community paramedic, and critical care; and (4) a defined set of investigable codes rather than a subjective text-based determination (i.e., the ICD-10 code was queried as opposed to language featuring the word "COVID-19").

Despite these safeguards, this study has important limitations: only twelve (12) states are sampled, and while significant population centers are represented, figures from thirty-eight (38) states [plus territories and Washington, D.C.] are not included. Moreover, though some of most widely used data systems are incorporated into the study, figures were unavailable from some software systems—including some with strong regional concentrations—whose figures are unavailable due to matters of technology or preference.

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