

# Pandemics in Hawai'i: 1918 Influenza and COVID-19

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**Abstract**—The COVID-19 pandemic has impacted the health, finances, and lives of citizens across the world. COVID-19 continues to evolve and create "waves" impacting countries at different time points. In this paper, we examine the transmission of COVID-19 between the continental United States and the State of Hawai'i and how that mirrors past influenza pandemics. Firstly, we introduce a summary of the 1918-1920 Influenza Pandemic. We then give an overview of facts and a timeline of government response to COVID-19. In addition, comparisons to the 1918-1920 Influenza Pandemic and 2018-2019, 2019-2020 Influenza seasons are provided. We conclude by addressing open challenges and possible future research directions for studying COVID-19 in Hawai'i.

**Keywords**— COVID-19; Influenza; Pandemic 1918; SIR Model.

## I. INTRODUCTION

The COVID-19 pandemic is far from the first infectious disease that Hawai'i had to deal with. During the 1918-1920 Influenza Pandemic, the Hawaiian islands were not spared as the disease ravaged through the whole world. It is reasonable to ask whether any lessons can be learned from Hawai'i's experience during the 1918-1920 influenza pandemic which could potentially be useful in the fight against COVID-19. It is also sensible to look at the recent influenza activity in the state. While the two diseases are different, mitigation against one of the maladies may prove effective against the other. The goal of this paper is to investigate how the dynamics of COVID-19 pandemic in Hawai'i and its relation to the pandemic in mainland US compares to the previous influenza activity.

In Section II, we present a summary of the 1918-1920 Influenza Pandemic in Hawai'i. In Section III, we present a timeline of government response to and facts of COVID-19 in Hawai'i. In Section IV-B, we discuss COVID-19 and its relation to the 1918-1920 Influenza Pandemic and 2018-2019, 2019-2020 Influenza seasons. The data we present for COVID-19 was gathered from the Centers for Disease Control and Prevention (CDC) [1] and Hawai'i Department of Health (DOH) [2]. The data we present for 2018-2020 Influenza seasons was gathered from the Hawai'i Department of Health [3]. We conclude by addressing challenges and future research for studying COVID-19 in Hawai'i.

## II. 1918–1920 INFLUENZA PANDEMIC

In this section we summarize the findings in [4] discussing the 1918–1920 Influenza Pandemic that killed more than 21 million

people, including over 675,000 Americans and more than 2,300 people in Hawai'i. The global timeline of this worldwide pandemic can be seen in Fig. 1. There are three types of influenza (A, B, C), of which Influenza A is considered the type of virus that produced the 1918 epidemic in Hawai'i. The first cases seen on Oahu were at the island's military and naval bases at the end of June 1918. The first wave of the 1918 pandemic quickly rolled over Oahu, lasting through July and into August. The second wave occurred December and January. There were severe shortages of physicians due to World War I, along with shortages of hospital beds, nurses, and other medical personnel and facilities. Although mainland communities had closed schools, theaters, and churches as public health measures during the pandemic, Island officials resisted similar measures arguing the closure would have little or no effect on death rates. Eventually some businesses and institutions temporarily closed, and indoor public gatherings were prohibited.

Statistics of the pandemic are difficult to find. Morbidity statistics were largely unavailable before October 21, 1918, on which date influenza became a reportable disease. However, the authors do have morbidity statistics before this date as seen in Fig. 2, Fig. 3, and Table I. Influenza morbidity has typically been subject to proportionately more under reporting than flu mortality. Many states were not yet part of the U.S. death registration area. Hawai'i, a territory at the time, was omitted from national totals and reported in separate tables until being admitted to the death registration area in 1917. Another statistical problem is that morbidity figures generally omit cases of pneumonia, which were often the ultimate outcome for influenza patients.

Fig. 2 shows the death rates for the U.S. death registration area and the territory of Hawai'i for 1917-1920. Note that Hawai'i's flu-related deaths peaked in 1920, two years after the mainland; the reasons for this lag remain unclear.

Death rates were highest for children under 5 years of age as seen in Table. I, lowest for those between five and nineteen. Flu deaths were exceptionally high for Japanese and pure Hawaiians as seen in Fig. 3 and Table I while male and female rates were about the same.

## III. COVID-19

We summarize some important facts and events of COVID-19 in Hawai'i. A detailed timeline can be found in Fig. 4. The first confirmed COVID-19 case was reported on March 6, 2020 [2]. As of September 22, 2020, there have been 11,522 COVID-19 cases, with the majority of them occurring during a large second wave, starting in the first week of June and peaking mid August. During the first

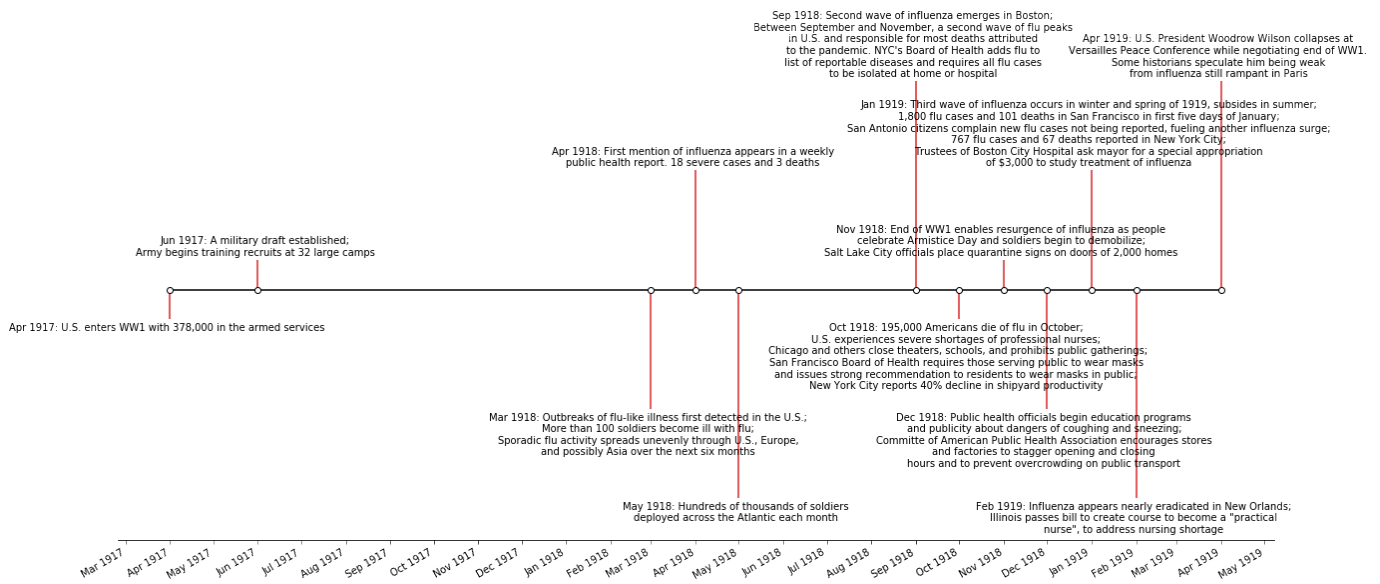


Fig. 1. Influenza (flu) Pandemic Events and Dates 1917-1919

wave of COVID-19 cases, the major contributing factor was due to tourists, prompting the shut down of air and sea travel. However, the overwhelming cause of cases during the second wave can be attributed to wide community spread [5]. As of September 22, 2020, there has been 749 hospitalizations and 120 deaths from the disease [2], a death rate of approximately 1.04%. Fig. 5 shows a plot of

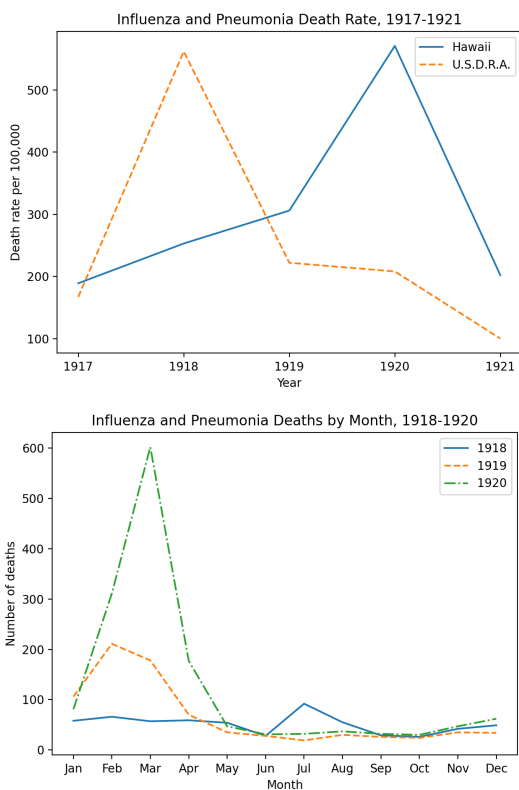


Fig. 2. Up: Deaths from Influenza and Pneumonia for Hawai'i, 1918-1920. Bottom: Comparing Death for Hawai'i and U.S. death registration area. Data available from [4].

average daily cases and deaths.

We have listed the COVID-19 deaths by age, sex, and race in Table II. COVID-19 death victims tend to be older in age, and it also appears to affect males more than females. The DOH data for race breakdown seems to be incomplete, as the total number of deaths categorized by race do not add up to the total number of deaths reported at that time (total of 119). We have included Native Hawaiian, Chinese, Black, and Other in the "Unreported" category as groups with fewer than 5 deaths are not reported. We have also plotted the race breakdown as seen in Fig. 6. With the information given, we can observe that Pacific Islanders are disproportionately affected by COVID-19 even though they make up only about 4% of Hawai'i population. On the counterpart, data suggests that Native Hawaiians are less impacted.

Fig. 7 displays the daily new cases as well as a fit obtained using a standard discrete compartmental model. This model divides the population into four compartments: Susceptible (not currently infected), Exposed (infected with no symptoms), Infected (infected with symptoms), Removed (recovered or deceased), i.e., an SEIR model

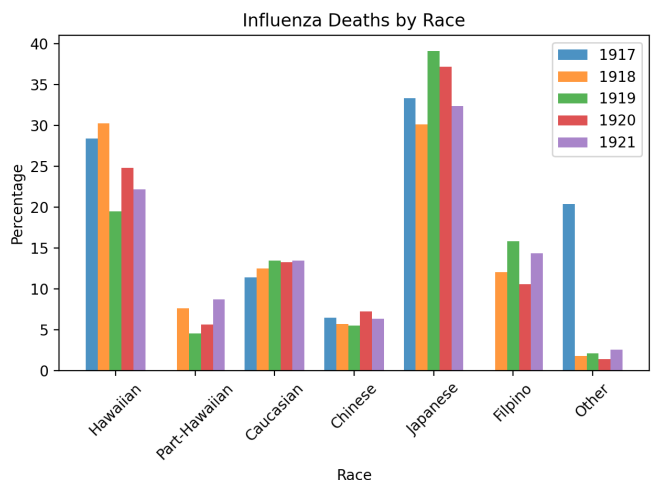


Fig. 3. Deaths from Influenza and Pneumonia by Race for Hawai'i, 1917-1921. Part-Hawaiians and Filipinos were included in "Other" for 1917. Data available from [4].

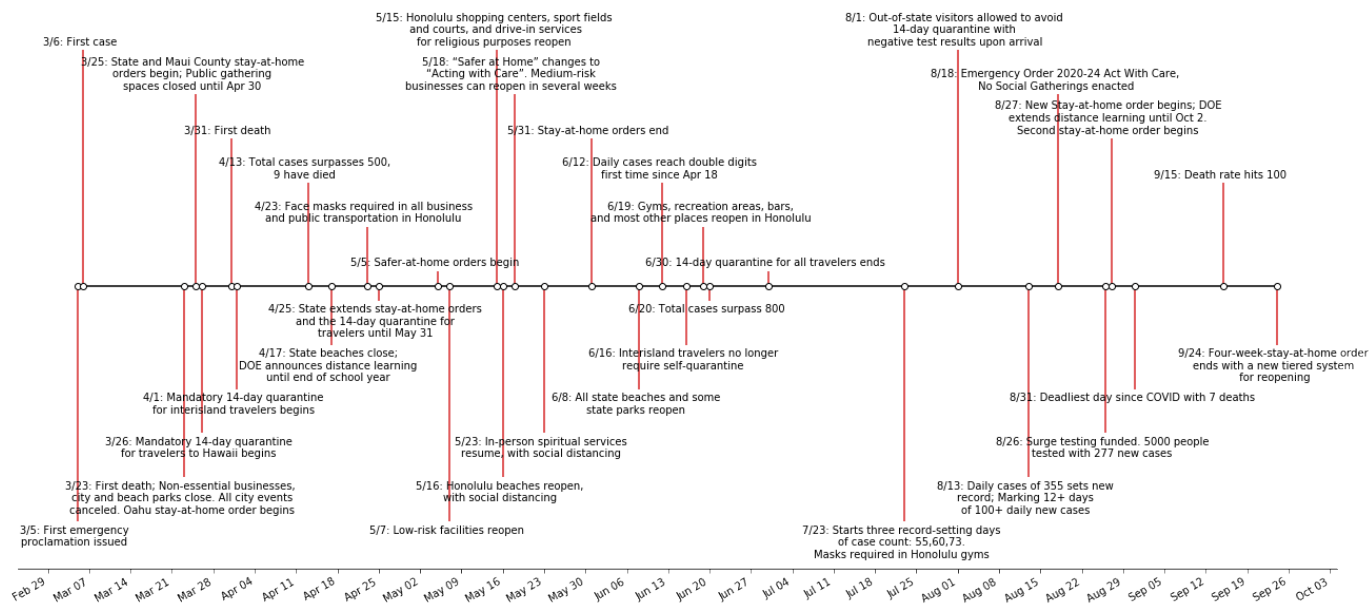


Fig. 4. COVID-19 Hawai'i Events and Dates 2020

(see e.g., [6], [7]). Denoting the populations in these compartments at time  $t$  by  $S(t)$ ,  $E(t)$ ,  $I(t)$ ,  $R(t)$ , respectively, the dynamics can be described by the following equations:

$$S(t + 1) = e^{-\lambda(t)}S(t) \tag{1}$$

$$E(t + 1) = (1 - e^{-\lambda(t)})S(t) + (1 - p)E(t) \tag{2}$$

$$I(t + 1) = pE(t) + (1 - r)I(t) \tag{3}$$

$$R(t + 1) = rI(t) + R(t), \tag{4}$$

where  $\lambda(t)$  is the hazard rate that is computed as  $\lambda(t) = \beta(I(t) + \varepsilon E(t))$ . Here,  $\beta$  is the baseline transmission rate,  $\varepsilon$  is the transmission reduction factor for asymptomatic transmission,  $p$  is the rate for onset of symptoms and  $r$  is the removal (recovery or death) rate. The transmission rates for the fit are described in Table III. Fig. 5 displays

on the same graph both the daily cases and the death to highlight the delay of the onset of deaths compare to the increase in daily cases.

Next, we compare the situation in Hawai'i to the entire United States. As of September 22, 2020 the United States has had a total of 199,462 deaths out of 6,825,697 cases [1]. The death rate in Hawai'i is approximately 1.04%, which is lower than the current national average of approximately 2.92%. Fig. 8 represents the daily cases and death per capita for the State of Hawai'i compared to the United States. Note that the data collected for the US also includes Hawai'i data. A delay can be observed between the US and Hawai'i peaks in the number of cases. The number of deaths appears to be rising for Hawai'i.

#### IV. DISCUSSION

##### A. 1918-1920 Influenza Pandemic versus COVID-19

It may be too early to compare the 1918-1920 Influenza Pandemic and COVID-19 Pandemic, and data for the 1918-1920 Influenza Pandemic are limited to deaths and not daily cases, whereas in the

TABLE I  
INFLUENZA AND PNEUMONIA DEATHS BY AGE, SEX, AND RACE IN HAWAII, 1917-1921<sup>a</sup>

Subject	1917	1918	1919	1920	1921
Total	447	615	796	1,489	550
Age					
Under 5 years	294	360	274	482	364
5 to 19 years	24	34	86	146	27
20 to 39 years	38	96	86	146	27
40 to 59 years	44	74	112	247	57
60 years and over	47	50	54	85	36
Age	—	—	—	2	1
Sex <sup>b</sup>					
Male	273	346	440	940	—
Female	174	269	356	649	—
Race <sup>c</sup>					
Hawaiian	127	187	155	369	122
Part-Hawaiian	—	47	36	84	48
Caucasian	51	77	107	197	74
Chinese	149	185	311	553	178
Filipino	—	74	126	157	79
Others	91	11	17	21	14

<sup>a</sup> Data available from [4].

<sup>b</sup> Sex was not recorded for 1921.

<sup>c</sup> Part-Hawaiians and Filipinos combined with "Other" in 1917.

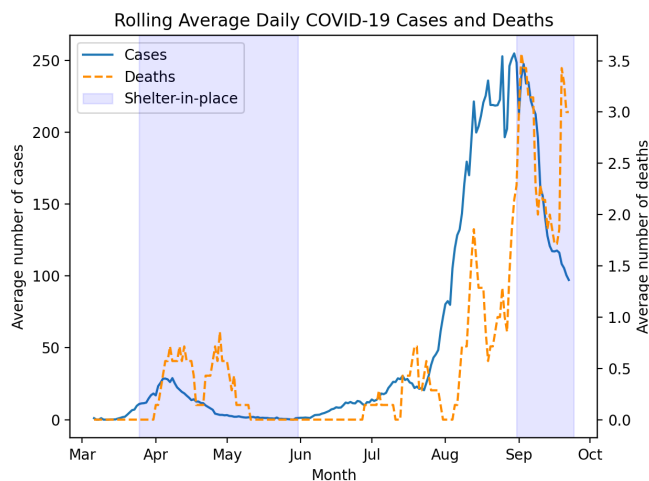


Fig. 5. 7-day rolling average daily cases and deaths for Hawai'i. Data available from the CDC.

TABLE II  
COVID-19 DEATHS BY AGE, SEX, AND RACE<sup>a</sup>

Age	Deaths	Sex	Deaths	Race	Deaths	State Population
30-39 years	1	Male	79	Caucasian	8	25%
40-49 years	5	Female	40	Native Hawaiian	<5	21%
50-59 years	12	Total	119	Pacific Islander	21	4%
60-69 years	19			Filipino	19	16%
70-79 years	37			Japanese	18	15%
80+ years	45			Chinese	<5	4%
Total	119			Other Asian	7	4%
				Black	<5	2%
				Other	<5	8%
				Unreported	46	
				Total	119	

<sup>a</sup> Data available from the Hawai'i DOH up until September 18, 2020.

case of COVID-19 pandemic we have access to much more complete data. We do however note some similarities and differences between the two pandemics.

First, let us compare the deaths using Tables I and II and Figs. 3 and 6. Current data show that the demographic perspectives on the mortality of 1918-1920 Influenza Pandemic and COVID-19 Pandemic differ with the early pandemic affecting younger individuals under the age of 5 while COVID-19 is almost exclusively affecting individual older than 60 years old. Both pandemic seem to be dominantly impacting male versus female. In terms of race, there is some variations due to a different racial distribution of the individual making up the Hawai'i population, however in both cases socio-economic minorities are being disproportionately affected. Hawaiian and Japanese (then a minority) made a large percentage of deaths in the 1918-1920 influenza pandemic, while COVID-19 is dominantly affecting Pacific Islanders. Japanese also make up a large percentage of deaths for the COVID-19 pandemic, although it appears that other groups are at higher proportion versus Japanese groups, e.g., Pacific Islanders.

An interesting comparison between 1918-1920 Influenza Pandemic

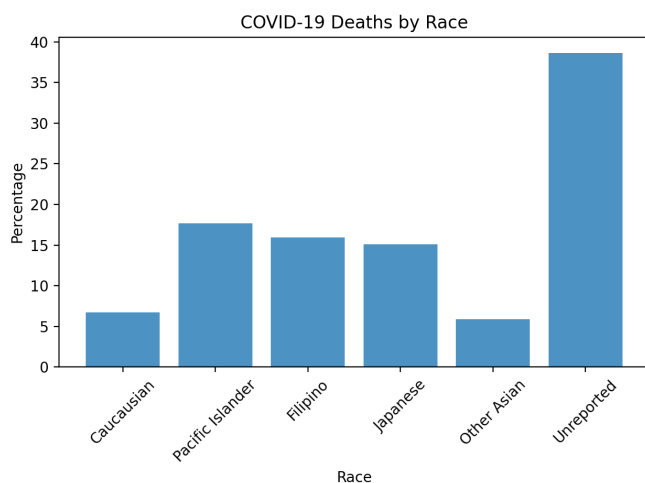


Fig. 6. COVID-19 deaths by race. Native Hawaiian, Chinese, Black, and Other races are included in the "Unreported" category. Data available from the Hawai'i DOH.

TABLE III  
TRANSMISSION RATES FOR THE MODEL

Changes in the Value of $\beta$ .						
Mar 6	Apr 2	May 20	May 30	Jun 10	Aug 11	Aug 23
$\beta=0.43$	$\beta=0.02$	$\beta=0.01$	$\beta=0.21$	$\beta=0.15$	$\beta=0.11$	$\beta=0.05$

and COVID-19 Pandemic is the delay of the waves between the US and Hawai'i. It can be clearly seen from Fig. 2 and Fig. 6. The delay in the 1918 pandemic is much larger and we suspect it is due to the fact that traveling was more limited and tedious but the delay still exists today (few months). It is too early to know how the curves will evolve for COVID-19 and something that we will be following.

B. 2018-2020 Influenza Seasons versus COVID-19

At the beginning of the pandemic, COVID-19 was often dismissed as another variant of influenza. For the second part of our discussion, we attempt to compare and contrast data between COVID-19 and influenza, since both data tables are rapidly available to the public. We utilize the 2018-2019 influenza season as the control, while comparing it to both COVID-19 and the 2019-2020 influenza season.

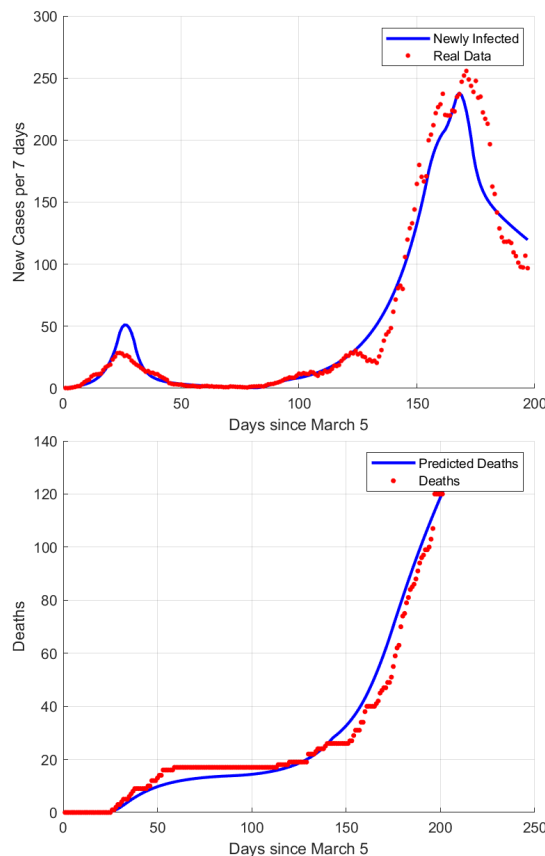


Fig. 7. Up: 7 days rolling daily cases. Dots are the actual data and the plain line represents the model. Bottom: Cumulative death cases as well as the fit from the model.

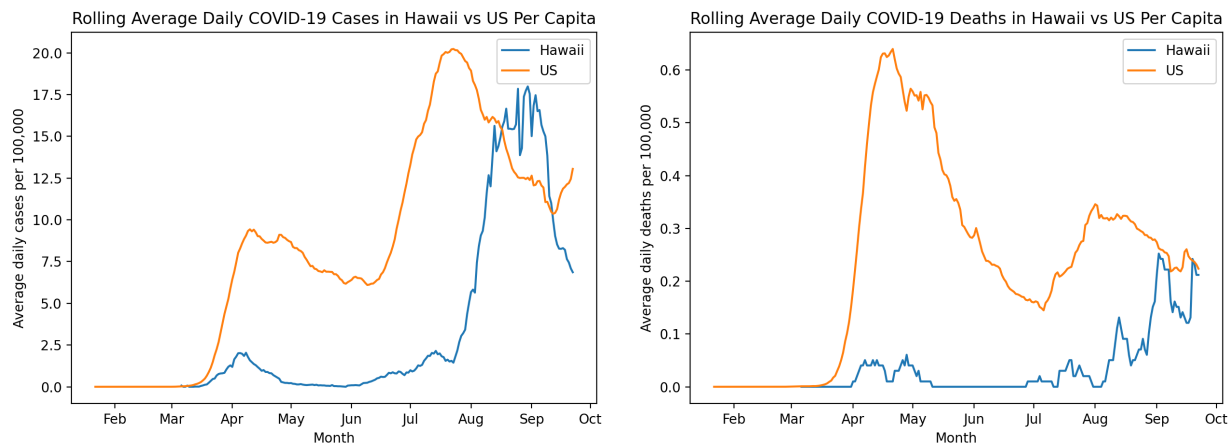


Fig. 8. The 7-day rolling average for daily cases (left) and deaths (right) in Hawai'i vs. the US. Date available from the CDC.

COVID-19 is mostly transmitted via airborne droplets, similarly to Influenza [8]. However, additional research has shown COVID-19 can be transmitted via aerosol [9].

Historically, a major contributor to influenza season in Hawai'i is due to tourists escaping winter, explaining why Hawai'i does not have a traditional flu season compared to the rest of the United States.

As seen in Fig. 9, the 2019-2020 influenza season was very similar to the 2018-2019 influenza season up until the shelter-in-place order for COVID-19, in which the number of cases for the 2019-2020 influenza season plummets significantly. COVID-19 cases similarly decreased during the shelter-in-place order. Further, the number of weekly cases for the 2019-2020 influenza appear to not rise after the shelter-in-place order was lifted, unlike the COVID-19 cases which saw a drastic increase. The peak in number of weekly cases for COVID-19 is more than double of the peaks for the influenza seasons. The reasons for this observations are unclear, it can be due to confirmation bias due to surge testing and other aggressive testing measures for COVID-19 while influenza testing is limited to surveillance and individual seeking medical help for influenza like illness. It can also be due to longer infectious period for COVID-19 compare to influenza. Note that as it was observed when comparing the 1918 pandemic to COVID-19, the two diseases target different age demographic: the influenza virus targets individuals under 20, while COVID-19 targets individuals over 20.

We now direct our attention to testing for the influenza seasons and COVID-19. The 2018-2019 influenza had an average positivity

rate of 17%, the 2019-2020 influenza has an average positivity rate of 13.7%, and COVID-19 has an average positivity rate of 2.2%. Fig. 10 reflects the effect of the COVID-19 pandemic as it forces stronger testing. The increase in testing resulted in more negative tests for the 2019-2020 influenza season versus the 2018-2019 influenza season. In Fig. 11, the number of tests for the 2019-2020 influenza season increased significantly before the shelter-in-place order, but then decreased during shelter-in-place. We are not sure of the reason for this but one hypothesis could be that those exhibiting influenza like illness avoided their PCP out of fear from contracting COVID-19 and therefore did not get tested. Finally, Fig. 12 displays the counts for weekly death for the 2018-2019 and the 2019-2020 influenza as well as COVID-19 for the state of Hawai'i. The shelter in place did occur at a time the number of death for influenza in 2018-2019 was decreasing anyway and we see a similar behavior for influenza 2019-2020 with slightly less cases but striking is the different behavior for the weekly count of deaths for COVID-19. It is extremely hard at this stage to anticipate how influenza and COVID-19 are going to interact in the coming Fall and Winter.

### V. CONCLUSION AND FUTURE WORK

This paper depicts the current situation in the State of Hawai'i regarding the current COVID-19 pandemic. This data analysis needs to be pursued further to continue monitoring the evolution of the spread of COVID-19. It is still very early with the new pandemic to draw definitive conclusions, but there are some similarities that seem

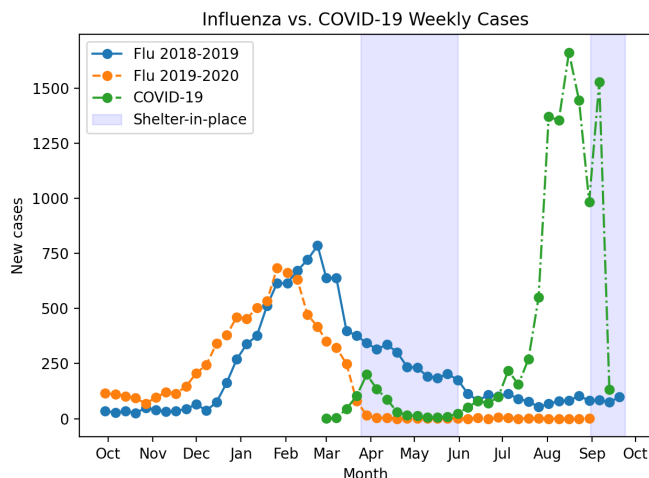


Fig. 9. Weekly cases for influenza and COVID-19. Each dot represents the weekly case. Data available from the Hawai'i DOH.

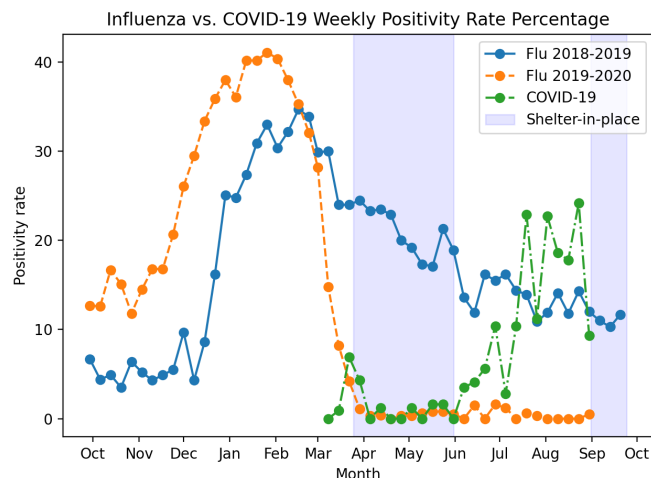


Fig. 10. Positivity rate percentages for influenza and COVID-19. Each dot represents the weekly rate. Data available from the Hawai'i DOH.

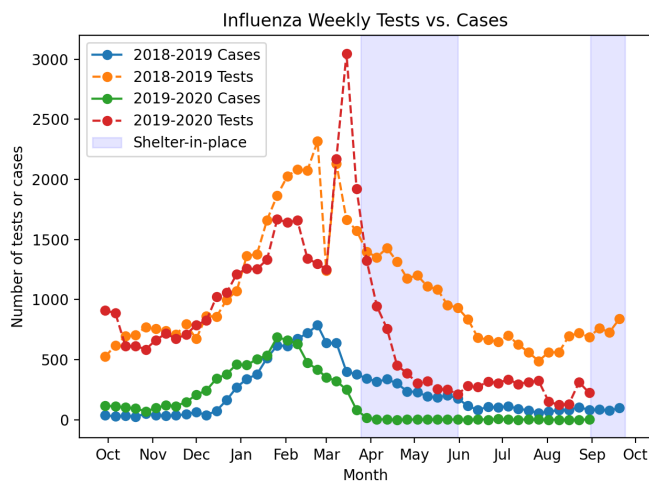


Fig. 11. Weekly influenza cases along with reported testing numbers. Each dot represents the weekly number of tests or cases. Data available from the Hawai'i DOH.

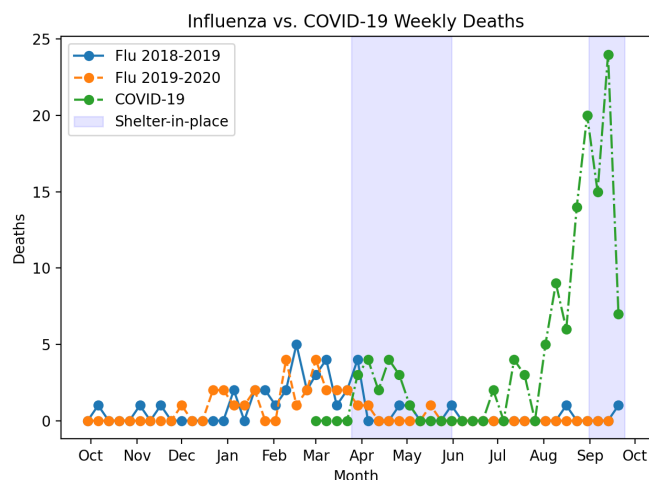


Fig. 12. Weekly deaths from influenza and COVID-19. Each dot represents the weekly number of deaths. Data available from the CDC.

to be highlighted with the data. Both cases (1918 and today) rely on non-pharmaceutical measures to contain the pandemic, at least for COVID-19 until a vaccine will be available. Transportation being much improved, especially over long distances, COVID-19 is difficult to contain. In 1918, it was World-War that was a major trigger for the spread of the disease, while now it is our lifestyle. In both cases, we see Hawai'i lagging behind the US mainland with regards to the waves of deaths related to the diseases.

There is much work to be done to understand the spread of the disease in Hawai'i. Moreover, with the State ready to reopen for travelers, and to have students going back to school in person, the next few weeks will be critical for the evolution of COVID-19. Influenza pandemic of 1918 exhibited three main waves spread over a three years period, and the primary concern for COVID-19 right now is an upcoming second wave.

From this investigation, we conclude that COVID-19 acts differently qualitatively and quantitatively from influenza virus; the danger of COVID-19 should be viewed seriously and not dismissed.

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