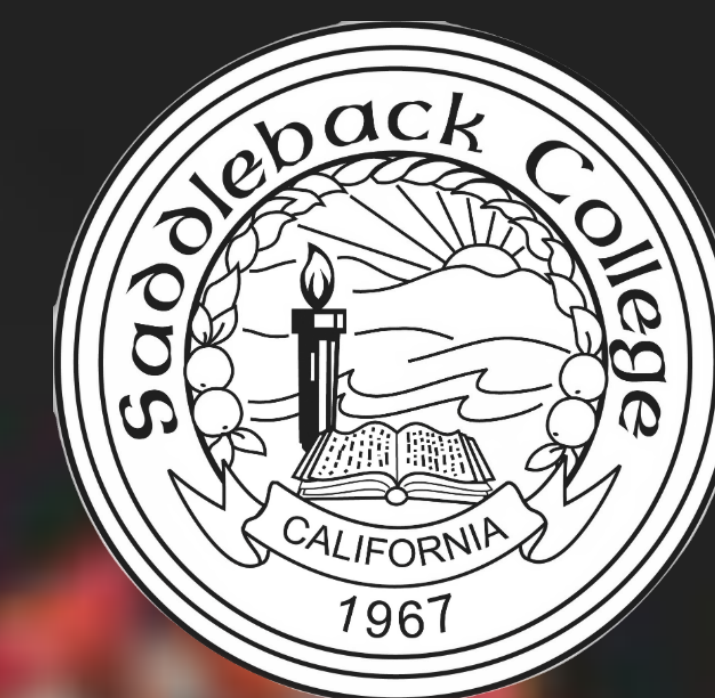


# Males and Females have Different COVID-19 Infection and Fatality Rates in New York City (Spring 2020)



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## INTRODUCTION

The novel coronavirus disease (COVID-19) is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and is an enveloped, positive-sense RNA virus that infects the respiratory tract. SARS-CoV-2 is the seventh coronavirus, with predecessors such as the viruses that caused SARS (SARS-CoV-1) and MERS (MERS-CoV) (Jin *et al.*, 2020)

It is understood that neonates, the elderly, and those with underlying illnesses are more susceptible to contracting the virus. By determining further at-risk demographics who are more prone to obtaining the virus, it will better enable professionals to assess these populations' infection survival and identify potential treatments.

Initial COVID-19 infections occurring in China indicated the presence of differences between the sexes with males accounting for 60% of infections, and an initial study in Wuhan, China depicted a male to female fatality ratio of 2.7:1.

The objective of this study was to determine whether there was a significant difference in the COVID-19 infection and fatality rates between the sexes in New York, New York. Based on other early pandemic studies, we expected a difference in infection rate and a difference in fatality rate.

## METHODS and RESULTS

Data describing cumulative numbers of male and female infections and fatalities of and due to COVID-19 were collected daily (22 March to 30 April 2020) from the New York City Health website.

Infection rate and fatality rate was normalized to each sex:

$$\text{male or female infection rate} = \frac{\text{male or female COVID - 19 infections}}{\text{citywide male or female population}}$$

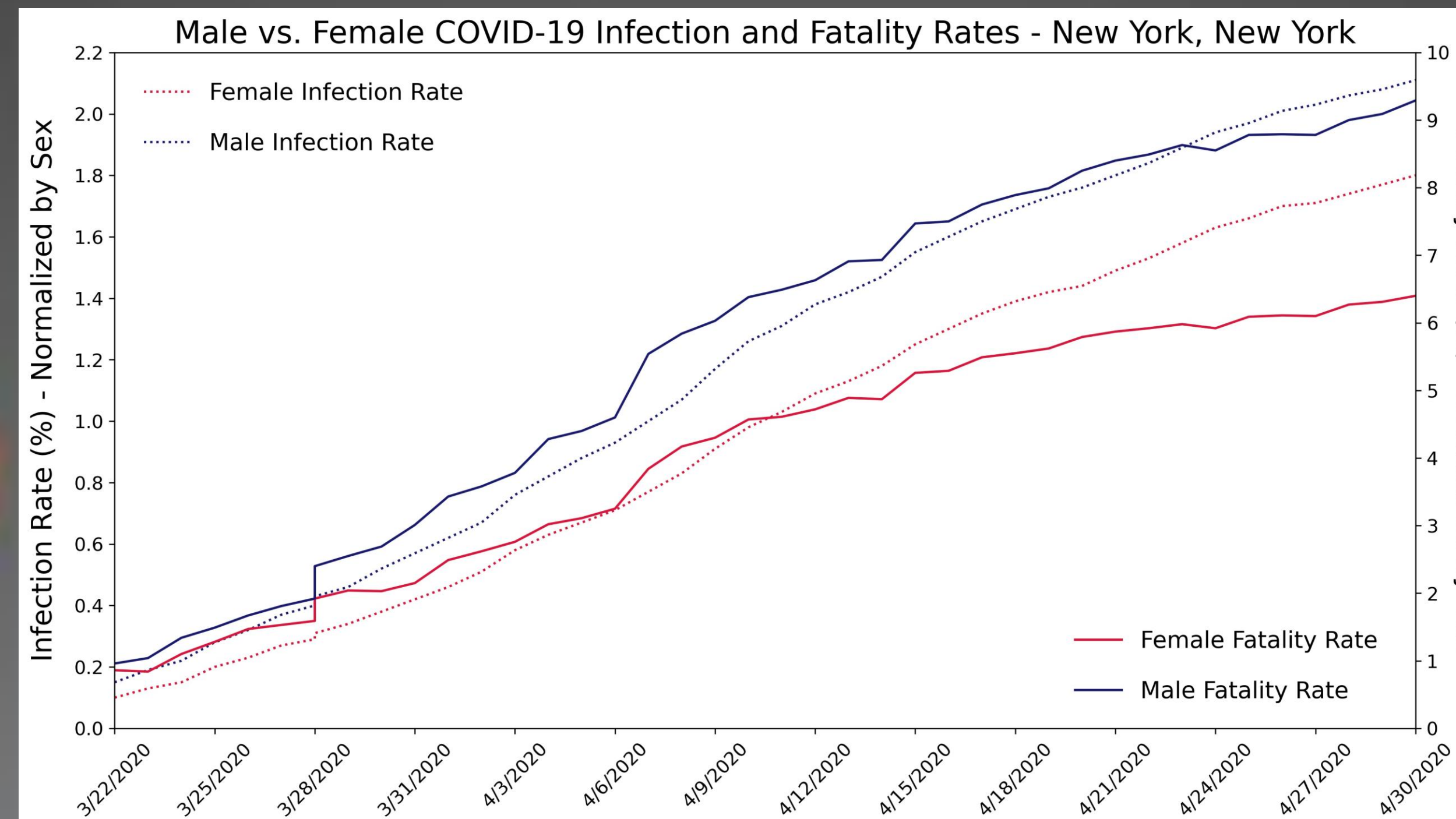
$$\text{male or female fatality rate} = \frac{\text{male or female COVID - 19 fatalities}}{\text{male or female COVID - 19 infections}}$$

A one-tailed z-test for independent proportions showed a significant association indicating that male and female infection rates of COVID-19 were significantly different (Figure 1).

A one-tailed z-test for independent proportions showed a significant association indicating that male and female COVID-19 fatality rates were significantly different. (Figure 1)

Curves of sex-normalized infections vs. sex-normalized fatalities (fatality rate by sex) were plotted and analyzed using a quadratic model of linear regression a significant association was found for each fatality rate model (female fatality rate:  $p < 0.0001$ ; male fatality rate:  $p < 0.0001$ , Table 1, Figure 2)

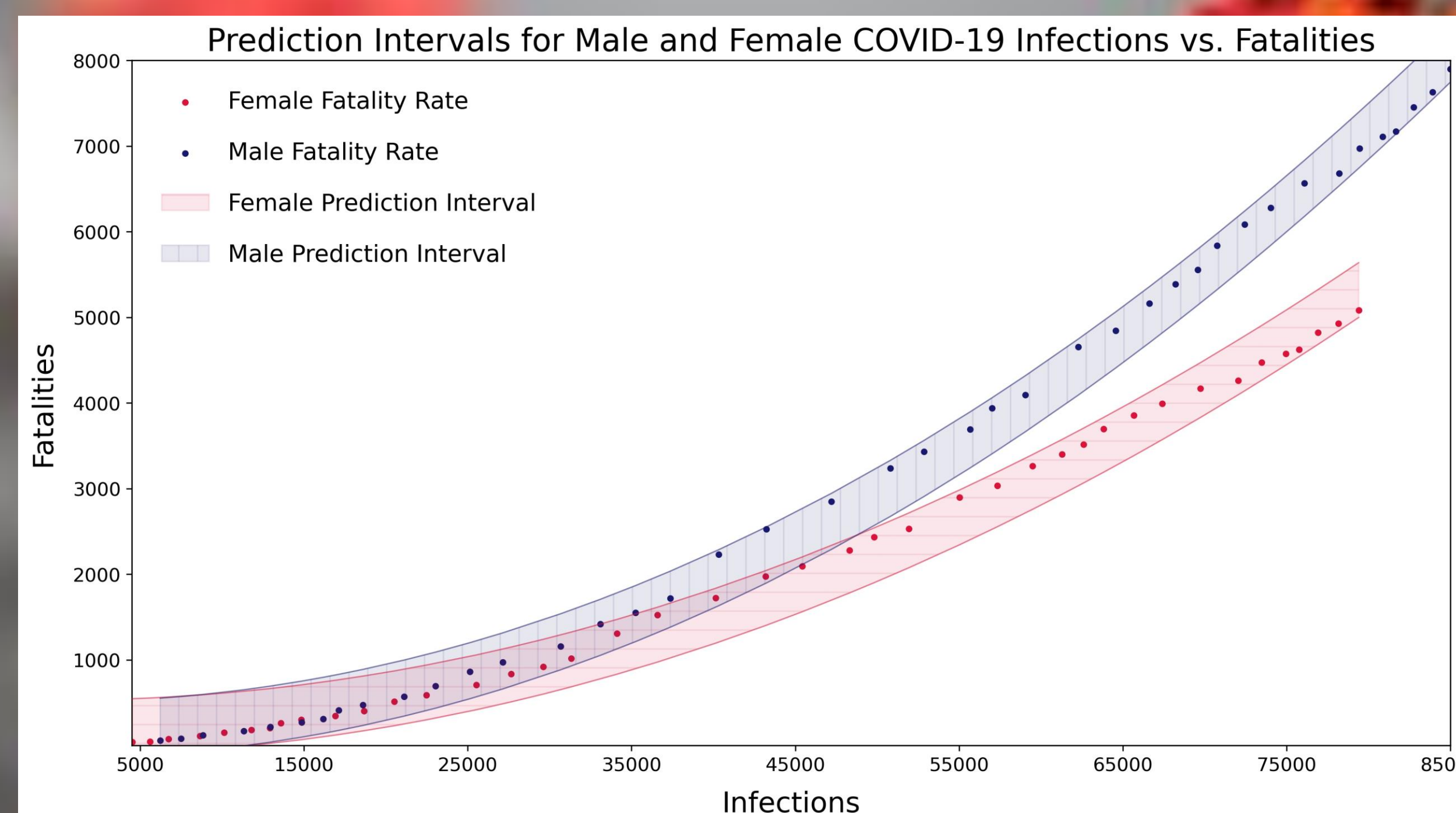
Precision of the models were analyzed using R-squared ( $R^2$ ) and the standard error of regression (S) and 95% prediction intervals were determined and plot, showing a significant difference between the male and female fatality rates. ( $p < 0.0001$ ; Table 1, Figure 2).



**Figure 1.** Male and female COVID-19 infection and fatality rates (normalized by sex) in New York, New York from 22 March 2020 to 30 April 2020. Male and female COVID-19 infection rates in NYC were significantly different. ( $p < 0.0001$ , one-tailed z-test,  $z = 33.05$ ) and male and female COVID-19 fatality rates in NYC were significantly different. ( $p < 0.0001$ , one-tailed z-test,  $z = 21.74$ )

**TABLE 1** Results of Fatality Rate Regression Analysis

Population Demographic	S	$R^2$	p-value
Male	167	0.999	$6.53 \times 10^{-49}$
Female	163	0.998	$8.23 \times 10^{-42}$
Male vs. Female	165	0.995	$1.72 \times 10^{-28}$



**Figure 2.** Male and female fatality rates (normalized by sex) due to COVID-19 in New York, New York from 22 March 2020 to 30 April 2020. Male fatality rate indicated a significant association ( $p < 0.0001$ , regression analysis;  $R^2 = 0.999$ ;  $S = 167$ ). Female fatality rate indicated a significant association ( $p < 0.0001$ , regression analysis;  $R^2 = 0.998$ ;  $S = 163$ ). Male and female fatality rates were significantly different ( $p < 0.0001$ , regression analysis).

## DISCUSSION

If the virus were affecting males and females at equal rates, one would expect near identical COVID-19 infection rates and fatality rates. However, based on our results, males in NYC had both a higher infection rate (Figure 1) and higher fatality rate than females (Figure 2).

This agrees with recent studies: A recent study found that the number of males who died from COVID-19 was 2.4 times that of females. (Jin *et al.*, 2020) Another large, meta-analysis study consisting of 3.1 million global reported infections found that males had 2.84 times the odds of requiring intensive care treatment (ICT) due to COVID-19, and had 1.39 the odds of dying once admitted to the ICT. (Peckham *et al.*, 2020)

The same discrepancy in fatality rate by sex can be seen in previous coronavirus occurrences: The SARS epidemic in Hong Kong had a mortality risk ratio of 1.62 for males and the 2013 MERS outbreak in Saudi Arabia saw a fatality rate of 52% for males and 23% for females. (Peckham *et al.*, 2020)

Although women are more prone to underlying respiratory diseases, such as IPAH, COPD, LAM, etc. (Carey *et al.*, 2007), studies have shown that females have an increased resistance to viral, bacterial, fungal, and parasitic infections. Additionally, SARS-CoV-2 primarily enters the cells via the ACE2 receptor. ACE2. The circulating ACE2 is higher in males than females, which could contribute to the increased infection and fatality rates. Sex hormones may also play a role in the COVID-19 sex-bias, as females produce more T-cells than males and estrogen has been seen to increase immune response. (Kopel *et al.*, 2020)

More research is required to determine what plays a factor in the COVID-19 infection and fatality sex-biases we are seeing in this and other studies.

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