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Modeling the Impact of Vaccine Dose Prioritization Strategies During the 2022 Mpox Outbreak

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Abstract

Early in the 2022 mpox outbreak, the U.S. recommendation was to administer two doses of the JYNNEOS[®] vaccine 4 weeks apart. However, because of limited vaccine supply, New York City (NYC) prioritized single dose vaccination. We estimated mpox cases averted by this strategy compared to strategies that prioritized 2-dose vaccination for a smaller portion of the population. We fit a network transmission model to incident mpox cases in NYC. Model output consisted of predicted cases over time when vaccine doses were administered with the ‘first-dose priority’ strategy, compared with counterfactual simulations where doses were administered to those eligible for a second dose ahead of those waiting for a first dose (‘intermediate’ strategy), or where individuals were pre-allocated full courses of the vaccine (‘second-dose priority’ strategy). We estimate that NYC’s strategy averted 66% [IQR:47%–78%] of potential mpox cases compared to no vaccination. This ‘first-dose priority’ strategy averted 0.6% [IQR:–11%–9.8%] more cases than the ‘intermediate’ strategy, and 17% [IQR:2.9%–38%] more cases than the ‘second-dose priority’ strategy. Thus, for the 2022 mpox outbreak in NYC, pre-allocating vaccine doses to ensure full vaccination in a high-priority subset of the population would have increased the size of the outbreak.

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Keywords

mpox; epidemic; STI; vaccination; mathematical modeling; JYNNEOS; network

Over 30,000 individuals in the United States were diagnosed with mpox in 2022, with initial cases occurring in May, and daily cases peaking on August 1st. CDC guidance was to administer two doses of the JYNNEOS[®] vaccine 4 weeks apart to people who are at increased risk of mpox (including, but not limited to, gay, bisexual, and other men who have sex with men (GBMSM), with multiple recent sexual partners) [1]. During this period of increasing daily cases, demand for vaccination exceeded available doses of the JYNNEOS[®] vaccine and the capacity for administration in many jurisdictions. Given the rapidly increasing number of cases in New York City (NYC) and the resultant need to protect people who were at increased risk of mpox as quickly as possible, NYC and other jurisdictions focused their vaccination campaign on widespread, 1-dose vaccination, (a ‘first-dose priority’ strategy), with plans to administer second doses when supply and demand allowed. This decision contrasted with official CDC recommendations that were based on FDA approval of a 2-dose series for mpox use, and which would have resulted in earlier 2-dose vaccination in a narrower portion of the population [2]. Due to the urgency of the outbreak, NYC Health was required to make this decision with limited data on the effectiveness of 2-dose vs. 1-dose vaccination.

Understanding the relative impact of prioritizing 2-dose vaccination in a relatively narrow portion of the population (referred to as narrow, 2-dose vaccination) compared to a ‘first-dose priority’ strategy (referred to as widespread, 1-dose vaccination) may inform vaccination strategies in future mpox outbreaks [3]. This analysis is timely given the World Health Organization’s declaration of the Clade I *Monkeypox Virus* (mpxv) outbreak in the Democratic Republic of the Congo and neighboring countries as a public health emergency of international concern, and the CDC’s recent work to increase U.S. preparedness for clade I mpxv [4]. We used vaccine administration and case report data from NYC to calibrate a dynamic network model of mpxv infection among GBMSM. We then estimated the number of mpox cases averted by vaccine administration in NYC over one year. We further estimated the effectiveness of strategies that focused on administering single doses of the vaccine to a widespread portion of the eligible population, as happened in NYC (the “first-dose priority” strategy), compared to an administration strategy of pre-allocating a full course of doses to a narrow portion of the eligible population (the “second-dose priority” strategy), as well as a vaccine strategy of not pre-allocating doses, but choosing to administer vaccines to those eligible for a second dose ahead of completely unvaccinated individuals (the “intermediate” strategy).

METHODS

We used a previously described dynamic network model of sexually transmitted mpxv in GBMSM [3,5,6], with parameters updated based on national surveys of sexual behavior among GBMSM [7]. This model simulates a network of partnerships between the estimated 167,000 GBMSM living in NYC. We model three types of sexual partnerships: individuals

can have 0 or 1 ‘Main’ partners (enduring sexual partners who took priority over others), between 0 and 3 ‘Casual’ partners (enduring sexual partners besides the main partner), and 0 or 1 ‘one-time’ partners per timestep (partners without repeat sexual contact). For each timestep, enduring partnerships have a probability of forming and dissolving, and individuals have a probability of engaging in one-time partnerships based on their assignment to one of 6 groups stratified by sexual partnership rates, with group 1 representing the lowest sexual activity level (40% of the population, < 0.1% chance of engaging in one-time partnerships) and group 6 representing the highest sexual activity level (1% of the population, 37% chance of engaging in a one-time partnership per day, Appendix S1, Table S1).

We used a modified SEIR (susceptible, exposed, infectious, resistant) model [8]. Individuals start in the susceptible (S) class. An infectious individual has a probability of infecting a susceptible partner given by the probability of sexual contact per timestep multiplied by the probability of infection per sexual contact (μ). Upon acquiring infection, individuals enter a pre-symptomatic non-infectious state (E), after which they have a probability per day of entering the pre-symptomatic and infectious state (P), then the symptomatic and infectious state (I), and finally the recovered and resistant state (R). Individuals can also be vaccinated with 1 ($V1$) or 2 ($V2$) doses of the vaccine, with effects described below. We assume symptom onset reduces sexual contact rate with ‘main’ and ‘casual’ partners by 50% and causes individuals to move to one lower sexual activity level until they recover. A proportion of individuals, (ρ), will seek treatment γ days after they develop symptoms, with γ based on the date-varying time between reported symptom onset and mpox tests in case data. We assume that among GBMSM in NYC, individuals seeking treatment for mpox symptoms would be tested for mpox and reported as a diagnosed cases, hereafter referred to as *cases*. After a positive mpox test, individuals abstain from sexual activity until recovery. Individuals who learn their infection status sustain contact with their ‘main’ partner such that they have a 10% chance of infecting their ‘main’ partner over the duration of the infection, reflecting estimates of household transmission [9].

We initiated the model by introducing 5 exposed individuals into the three groups representing the most active 15% of population on May 14th, 2022. This produced a median of 5 cumulative cases in the model on May 31st, matching case data from NYC.

Our network does not account for potential periods of increased transmission associated with GBMSM gatherings (e.g., Pride festivals) throughout the summer. Additionally, our model does not account for the impact of importation of mpox cases from outside NYC. Thus, we model a ‘surge period’ during the initial period of our simulations in which we add extra-network transmission to the model to represent transmission occurring during GBMSM gatherings, and import infections into the network to represent travel related infection. We assume that these extra infections occur among individuals in the three highest sexual activity groups. For extra-network transmission, we assume an additional number of infections per day equal to

$$S_H \frac{P_H + I_H}{N_H} \beta$$

Where S_H is the number of high-activity individuals (activity groups 4–6), P_H and I_H are the number of pre-symptomatic and symptomatic infectious high-activity individuals, N_H is the total number of high activity individuals, and β is the extra-network transmission rate. For importation, we randomly select high-activity individuals to enter the E state at a constant rate, ϵ . β , ϵ , and the length of the surge period are determined by our fitting procedure, described below.

During each simulation, individuals decrease their probability of one-time partnerships and their rate of sexual contact with casual partners as a function of perceived mpox risk [10]. We parameterize this perceived risk based on frequency of mpox discussion on online forums over time, as discussed by Clay et al. [6], and fit the magnitude of this behavioral adaptation to incident case report data (fitting procedure).

Vaccination

We ran four vaccination scenarios (Figure 1). We first ran a scenario where the first and second doses administered per week matched those reported by NYC through March 18, 2023. This scenario is our baseline ‘first-dose priority’ strategy, as prioritizing widespread, 1-dose vaccination was the goal of NYC’s vaccination campaign. Second, to estimate the number of cases averted by vaccination over a year, we ran a scenario with no vaccination. Third, we ran a counterfactual scenario where the total doses administered per week matched those in our ‘first-dose priority’ strategy, but during each timestep doses were administered first to individuals who were due for a second dose, and first doses were only given once there were no individuals waiting for a second dose (‘intermediate’ strategy). Finally, we ran an additional counterfactual scenario where individuals receiving their first dose were pre-allocated a second dose to be administered five weeks later, reflecting average time between doses in other jurisdictions (Appendix S2, Figure S1). In this scenario, the number of individuals who received their first dose every day was equal to the number of total doses given that day under the ‘first-dose priority’ strategy, divided by two. Thus, every individual completed their course on time, but total dose administration was slowed (‘second-dose priority’ strategy). The cumulative number of cases averted by vaccine administration was calculated as the cumulative number of cases in the ‘no vaccination’ scenario minus the cumulative cases in a scenario with vaccine administration. We compared the number of cases averted by the baseline scenario to the number of cases averted by the counterfactual vaccination scenarios.

While certain non-GBMSM adults with multiple sexual partners were initially eligible for mpox vaccination, we only model GBMSM due to availability of sexual network data [7]. According to a 2020 citywide population-based survey, GBMSM made up 82% of eligible adults in NYC with 2+ sexual partners over a 12-month period [11]. Thus, we assume that 82% of mpox vaccines administered in NYC were administered to GBMSM.

As vaccines were originally intended for selected groups, including individuals with multiple recent sexual partners [12], only individuals in the three groups with highest sexual activity receive vaccines for the first two weeks of vaccination. The group with the fourth highest sexual activity level is eligible for vaccination starting in week three, and the group with the fifth highest sexual activity level is eligible for vaccination starting in week

seven. We assume that a proportion of the population ($1 - \rho$) distributed evenly across all activity groups will not receive the vaccine due to barriers to healthcare. Susceptible (S) and pre-symptomatic (E , P) individuals are eligible for vaccination. However, vaccination does not prevent individuals in the E or P class from becoming infectious. Individuals are eligible for second doses of the vaccine if they have received their first dose at least four weeks in the past. In the case of breakthrough infections (i.e., infections of vaccinated individuals), we assume these individuals enter the pre-symptomatic (E) class, i.e., prior vaccination has no effects on subsequent contagiousness or pathogenicity.

Several studies have estimated the effectiveness of the JYNNEOS vaccine, i.e., the proportional reduction in infection probability due to vaccination over a given period of time [13, 14]. However, vaccination in our model is implemented as vaccine *efficacy*, i.e., the per-exposure reduction in transmission probability due to vaccination. We thus rely on values of vaccine efficacy estimated by fitting models to vaccine administration and case data from 42 U.S. counties [15]. This method estimates values of 68% for first-dose efficacy and 83% for second-dose efficacy. Whether prioritizing first or second dose vaccination will avert more cases partially depends on the increase in vaccine efficacy of 2-dose vs. 1-dose vaccination ('incremental VE'). We thus additionally run our analysis using lower incremental VE (1-dose VE = 72%, 2-dose VE = 81%) and higher incremental VE (1-dose VE = 64%, 2-dose VE = 85%), varying VE within the 95% confidence intervals estimated by Saldarriaga et al. [15]. In all scenarios, doses become effective two weeks after administration.

Fitting Process

Our model has five fit parameters: (1) the duration of the surge period ('surge duration'), (2) the importation rate of infections during the surge period ('importation rate'), (3) the transmission rate during extra-network GBMSM gatherings during the surge period ('surge transmission'), (4) the probability of transmission per exposure ('transmission probability'), and (5) the maximum percent reduction in probability of one-time or casual sexual contact per day in response to perceived risk of mpox ('behavioral adaptation'). We fit these parameters to incident daily cases in NYC using a 5-step process.

First, we used Latin Hypercube Sampling (LHS) to generate 1,000 unique parameter sets of our five fit values (Table 1). Second, we simulated a single run of outbreak dynamics under the baseline 'first-dose priority' strategy employed by NYC for each LHS-generated parameter set from May 14, 2022 to January 18, 2023 (250 simulated days). Third, we filtered out parameter sets which predicted a final cumulative case incidence outside of that observed in NYC $\pm 50\%$. Fourth, for each remaining parameter set, we calculated the likelihood that the simulated number of incident daily cases could generate the observed number of incident daily cases through January 18 using a negative binomial probability distribution. Finally, we drew 100 parameter sets (with replacement) with the calculated likelihood used as the relative draw probability for each parameter set. These 100 parameter sets represent the posterior distributions of our fit parameters.

For each of these 100 parameter sets, we ran each of our vaccination scenarios (Figure 1) from May 14, 2022 to May 14, 2023 and compared median and interquartile ranges of cumulative cases over time for each vaccine administration strategy.

Sensitivity Analyses

NYC was allocated a high number of JYNNEOS doses per high-priority individual compared to many other jurisdictions. Thus, we reduced the number of doses administered in the NYC model by 50% to estimate whether the optimal vaccine administration strategy would differ if NYC had been allocated fewer doses.

Given the World Health Organization's recent public health emergency declaration for clade I mpvx [20], we ask whether the results of our manuscript will apply to future outbreaks. Due to higher pathogenicity, clade I mpvx generally results in more hospitalizations than the Clade II mpvx which caused the 2022 mpox outbreak [4,21]. However, we do not know the relative transmissibility of clade I vs clade II mpvx. To inform possible worst-case scenarios, we reran our analysis while increasing the per-exposure transmission probability by 20%.

RESULTS

Our fitting procedure selected for a distribution of surge duration with a median of 89 days [IQR: 69 – 109], a distribution of importation rate with a median of 1.7/day [IQR: 0.99 – 2.4], a distribution of surge transmission with a median of 18% [IQR: 12% – 24%], a distribution of transmission probability with a median of 67% [IQR: 40% – 81%], and a distribution of behavioral adaptation with a median of 49% [IQR: 16% – 63%] (Figure 2A, Table 1). The fit parameters are generally negatively correlated with one another (Appendix S3, Figure S2). Thus, these parameter estimates should not be used in other contexts.

Our model estimates that there would have been 10,600 cumulative cases [IQR: 6,280 – 16,800] by May 14, 2023 in the scenario with no vaccination. Our model further estimates that the baseline 'first-dose priority' strategy averted 67% [IQR:47% – 78%] of these cases (Figure 2B).

We estimate that the 'first-dose priority' and 'intermediate' strategies would have averted a similar number of cases, and that both strategies would have averted more cases than the 'second-dose priority strategy'. We estimate that the 'intermediate' strategy would have averted 68% [IQR:46% – 78%] of cases and the 'second-dose priority' strategy would have averted 55% [IQR:38% – 68%] of cases. We further estimate that the baseline 'first-dose priority' strategy employed by NYC would have averted 0.61% [IQR:-11% – 9.8%] more cases than the counterfactual 'intermediate' strategy, and would have averted 17% [IQR:2.9% – 38%] more cases than the counterfactual 'second-dose priority' strategy (Figure 3A) after 1 year. Note that we calculate percent differences in cases averted for each fit parameter set and then calculate the median of those differences, rather than calculating the percent difference in median cases averted by each strategy.

Reducing the number of available doses does not change which vaccine administration strategies would have averted the most cases. We estimate that the baseline 'first-dose

priority' strategy would have averted 7.0% [IQR: -12% – 24%] more cases than the counterfactual 'intermediate' strategy, and would have averted 33% [IQR: 17% – 76%] more cases than the counterfactual 'second-dose priority' strategy (Figure 3B).

We find that neither increasing incremental vaccine efficacy, decreasing incremental vaccine efficacy, or increasing per-exposure probability of transmission changes our qualitative results (Appendix S4, Appendix S5, Figure S3, Figure S4).

DISCUSSION

During the 2022 mpox outbreak, demand for vaccines initially outpaced supply, preventing 2-dose vaccination for the entire population at increased risk of mpox [2,22]. Thus, NYC prioritized administration of first doses to reach a large portion of the impacted population as quickly as possible. In this analysis, we modeled the strategy focusing on widespread, 1-dose vaccination employed by NYC, compared to counterfactual strategies focusing on 2-dose vaccination in narrower portions of the population. We estimated that the NYC vaccine rollout prevented 66% of potential mpox cases. We further estimated that prioritizing narrow, 2-dose vaccination would have averted a similar number of cases as prioritizing widespread, 1-dose vaccination as long as doses were not pre-allocated (i.e., held in reserve to ensure that individuals received the full vaccine course on schedule).

Increasing vaccine coverage will decrease the probability and size of future mpox outbreaks [3]. Thus, CDC recommends continued vaccination for those who are at increased risk of mpox to prevent future outbreaks [23]. While current vaccine demand may be low due to low-perceived risk of mpox infection and the widespread availability of the JYNNEOS vaccine, demand for mpox vaccines could increase in the future, e.g., due to the increased activity of clade I mpoxv in the Democratic Republic of the Congo and surrounding countries [4]. In this situation, if vaccine availability is limited, local and state health departments may consider whether to focus on prioritizing narrow, 2-dose vaccination, or widespread, 1-dose vaccination. Our analysis shows that in NYC, prioritizing narrow, 2-dose vaccination would have resulted in additional cases if vaccine doses were pre-allocated. However, prioritizing widespread, 1-dose vaccination or narrow, 2-dose vaccination without pre-allocation would have averted a similar number of cases. Thus, if needed, local and state health departments may be able to avert the most cases by choosing whichever strategy allows them to administer doses to impacted populations most quickly.

One strength of prioritizing widespread, 1-dose vaccination that our model does not consider is that this strategy can improve vaccine equity. Groups who have historically faced systematic barriers to accessing healthcare often receive few initial vaccine doses during outbreaks (for example, during the initial COVID-19 outbreak [24]). Narrow, 2-dose vaccination strategies, which focus on concentrating all vaccine doses in the individuals who were able to access vaccine doses first, may thus exacerbate health inequities. This is particularly problematic as individuals are most likely to have close sexual contact with individuals of the same race or socioeconomic status [25]. Narrow, 2-dose strategies may thus lead to uncontrolled transmission in groups already facing a disproportionate burden of most health problems, exacerbating health disparities.

Vaccination can yield greater health benefits when the selection of vaccine administration strategies considers heterogeneity in immune function. People with HIV (PWH) make up 19% of GBMSM [26,25], but 55% of clade II mpox cases in the United States among people with known HIV status. For these cases, coinfection between HIV and mpox can lead to severe, life-threatening outcomes in individuals not receiving antiretroviral therapy and who had low CD4 counts [26]. Further, JYNNEOS[®] vaccination has reduced overall efficacy but higher incremental efficacy (increase in protection from 2-dose compared to 1-dose vaccination) in individuals living with immunocompromising conditions, including uncontrolled HIV [13]. Thus, because PWH may be more likely to acquire clade II mpox, are more likely to experience severe symptoms, and benefit more from receiving a second vaccine dose than others [13, 26–28], future vaccination strategies may benefit from giving PWH 2-dose vaccine courses as quickly as possible, even if the larger vaccine strategy is for widespread, 1-dose vaccination. This strategy could be paired with further efforts to connect people living with uncontrolled HIV to HIV services, given that increased CD4 counts may increase vaccine efficacy and reduce severity of mpox [29].

Our study is limited in that the strategies in our model may not reflect some of the practical considerations of vaccine logistics. First, we parameterized our ‘first-dose priority’ strategy using first and second doses administered by NYC, as this was the strategy explicitly used during the outbreak [2]. However, in early September, as demand decreased and vaccine supply improved, NYC began offering second doses to those who were eligible, based on time since vaccination (first to those whose first dose was administered more than 10 weeks previously, then moving to anyone who received their first dose at least 4 weeks previously). Thus, in practical terms, the ‘first-dose priority’ strategy in our model, which was parameterized via NYC vaccination records, was a sequential implementation of two strategies, and a more rigorous ‘first-dose priority’ strategy may have averted more cases. Second, we assume in our ‘intermediate’ and ‘second-dose priority’ scenarios that individuals will always choose to receive a second vaccine dose if available. However, jurisdictions will experience losses to follow up, with individuals choosing not to receive a second dose, or individuals may delay their second dose. In the ‘intermediate’ strategy, those doses would be used as first doses for eligible individuals, but in the ‘second-dose priority’ strategy, those doses would be wasted, leading to an increase in cases. Thus, our results must be interpreted while considering the logistic constraints of local jurisdiction and understanding that vaccination programs are not static and will change and adapt to the situation and realities on the ground. Our results are further limited by uncertainty around single dose vaccine effectiveness. We relied on modeled estimates of per-act efficacy for this study. However, empirical estimates of one dose vaccine effectiveness range from 33% to 86%, indicating large levels of uncertainty around these estimates [30]. Finally, our results are limited by the lack of available data on behavioral adaptations to mpox infection. We reasonably assumed that individuals would reduce their number of sexual partners upon developing mpox symptoms. However, we may have under or overestimated the magnitude of this behavioral adaptation, and thus may have under or overestimated the contact rate of infectious individuals.

Choosing whether to prioritize a multi-dose course in a narrow portion of the population or widespread, 1-dose vaccination will arise in future outbreaks of other diseases, whenever

vaccination involves multiple doses [31]. Most notably, models employed during the COVID-19 pandemic lead to countries such as England delaying second-dose administration in favor of more widespread first-dose administration [32,33]. When choosing between vaccination strategies during an outbreak, public health agencies need to quickly make decisions with limited data. Mathematical modelers can conduct studies before those outbreaks occur, that will allow public health officials to make informed decisions during the initial stages of an outbreak. The optimal vaccine strategy outbreak will depend on the incremental effectiveness of first vs. second doses, the population contact network, vaccine supply and administration capacity, and the epidemic growth rate. Modeling studies can explore how these parameters shift the optimal vaccination strategy, while connecting these parameters to pre-existing data (e.g., the population contact network), or data that can be easily collected in the early stages of an outbreak (e.g., epidemic growth rate). Results from these studies can inform decisions for public health officials, leading to quick, evidence-based public health leadership.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data Availability Statement:

All data and code are available at https://github.com/patrickaclay/mpox_stergm

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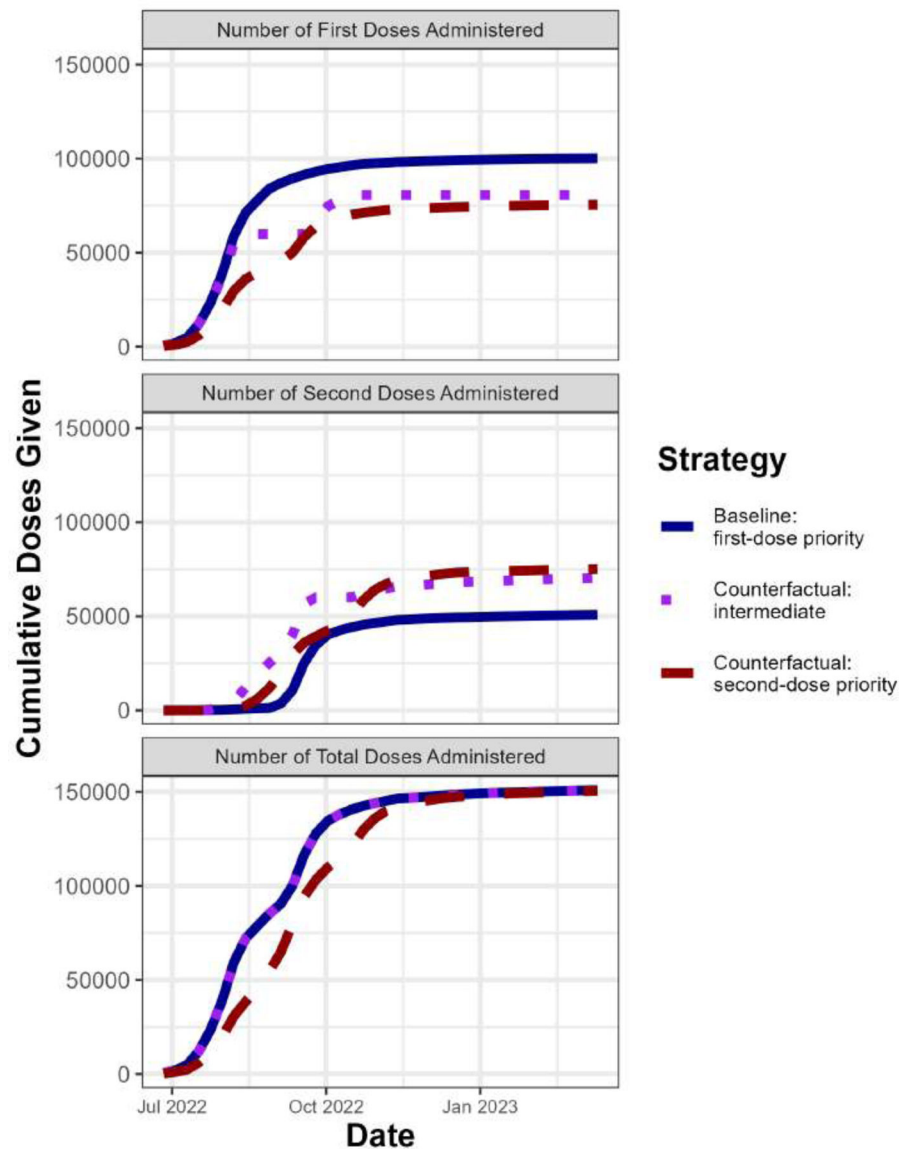


Figure 1:

Allocation of doses over time for each vaccine administration strategy*. Y-axis shows number of doses given over time on the X-axis. Top two panels indicate number of first and second doses given, respectively, for each vaccine administration strategy while bottom panel indicates the sum of first and second doses given for each vaccine administration strategy. Colors indicate different vaccine administration strategies.

*First-dose priority: first and second doses in model are based on first and second doses administered by NYC. Intermediate: Individuals who are eligible for a second dose receive priority for available doses, but there is no preallocation. Second-dose priority: doses are preallocated to ensure that all individuals receive full course of the vaccine.

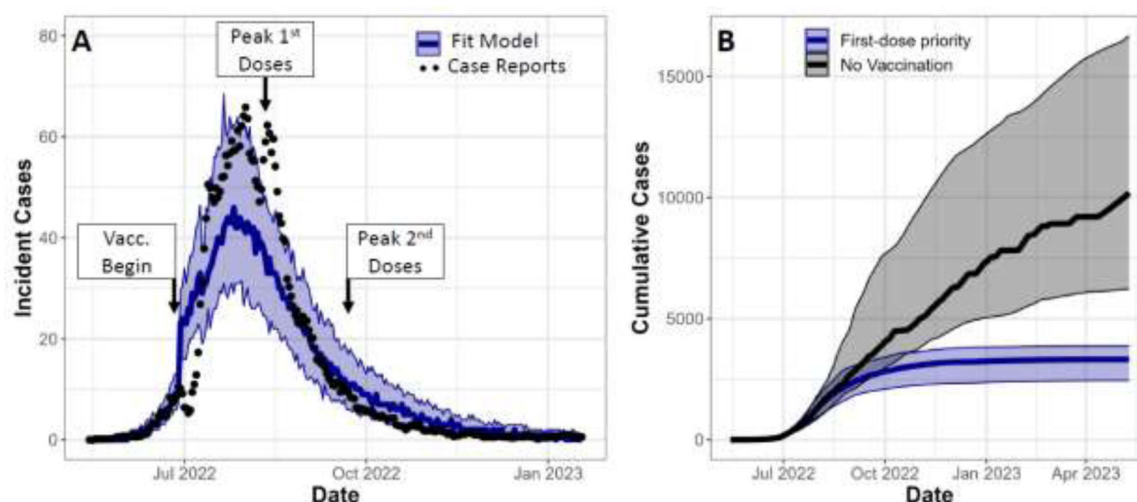


Figure 2:

(A) Mpxv model fit to data. Dots indicate the 1 week running mean of incident daily cases in NYC, used as our fitting target. The blue line represents median incident daily cases of model runs from the 100 parameter sets selected in our fitting procedure, with band representing interquartile range of model runs, assuming a ‘first-dose priority’ strategy. Labels indicate the beginning of pre-exposure vaccination on June 26th, peak administration of first doses, occurring the week of August 7th, and peak administration of second doses, occurring the week of September 18th. **(B)** Estimated cumulative cases over a year under the ‘first-dose priority’ strategy employed by NYC compared to a ‘no vaccination’ scenario.

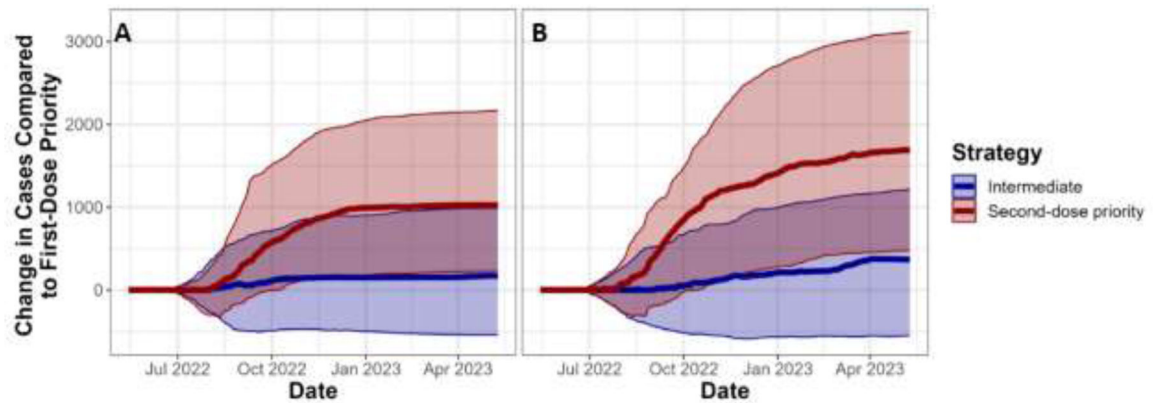


Figure 3:

Comparison of different vaccine administration strategies*. We show the difference in cases under the ‘intermediate’ or ‘second-dose priority’ strategy compared to the ‘first-dose priority’ strategy on the Y-axis, over time on the X-axis. Solid lines indicate median values across fit parameter sets, and transparent bands indicate interquartile ranges across parameter sets. Panel A uses vaccine administration numbers shown in Figure 1, while panel B cuts the number of doses given by 50% to emulate jurisdictions with lower dose availability.

*First-dose priority: first and second doses in model are based on first and second doses administered by NYC. Intermediate: Individuals who are eligible for a second dose receive priority for available doses, but there is no preallocation. Second-dose priority: doses are preallocated to ensure that all individuals receive full course of the vaccine.

Table 1:

Model parameters. Values marked ‘Prior’ represent the prior range of values for our fitting procedure. Values marked ‘Posterior’ represent the median and interquartile range of values fit to case data.

Parameter Description	Value	Source
Initial Conditions		
Population size	167,000	[16]
Initial number infectious individuals	5	Model Assumption
Date seeded with initial infections	May 14 th	Selected to align date of 5 cases in median model output and case reports
Surge Period Parameters		
Surge Duration (days)	Prior: [45 – 130] Posterior: 89 [69 – 109]	Fit to case report data
Importation Rate (importation rate of infections during the surge period)	Prior: [0 – 3] Posterior: 1.7 [0.99 – 2.4]	Fit to case report data
Surge Transmission (transmission rate due to extra-network MSM gatherings during the surge period)	Prior: [0 – 0.5] Posterior: 0.18 [0.12 – 0.24]	Fit to case report data
Natural History Parameters		
Transmission Probability (Probability of transmission per exposure)	Prior: 10% – 90% Posterior: 67% [40% – 81%]	Fit to case report data
Mean duration of post-exposure, pre-symptomatic period	7.6 days	[17]
Mean duration of pre-symptomatic infectious period	4 days	[8]
Mean duration of infectious period	27 days	[5]
Treatment Seeking and Vaccine Parameters		
Probability of seeking treatment/accessing healthcare (ρ)	0.8	[18]
Duration of infectious period if seeking treatment (time until medical attention post-symptoms)	15 days on first day of simulation, linearly decreases to 5.0 days on day 42 of simulation, stays at 5.0 days for rest of simulation.	Case Report Data
First dose per-exposure vaccine efficacy	68% (64% – 72% in sensitivity analysis)	[15]
Second dose per-exposure vaccine efficacy	83% (81% – 85% in sensitivity analysis)	
Minimum time between first and second dose	28 days	[19]
Behavior Change Parameters		
Behavioral Adaptation (Maximum percent reduction in daily probability of forming one-time sexual partnerships.)	Prior: 0% – 90% Posterior: 49% [16% – 63%]	Fit to case report data