Appendix

Planning for Monkeypox on a college campus: a model-based decision-support tool

Model Differential Equations

The model structure is depicted in Figure 1 and the corresponding ordinary differential equations are shown below.

A. model with quarantine scenario:

$$\frac{dS_i}{dt} = -S_i\lambda_i - \theta - \eta * (1-\zeta) * Dx_{1,i} + \omega Qs_i$$

$$\frac{dE_i}{dt} = S_i\lambda_i + \theta - \gamma E_i - \eta * \zeta * Dx_{1,i}$$

$$\frac{dI_i}{dt} = \gamma E_i + \omega Qi_i - \delta I_i - \rho I_i$$

$$\frac{dQs_i}{dt} = \eta * (1-\zeta) * Dx_{1,i} - \omega Qs_i \qquad (1)$$

$$\frac{dQi_i}{dt} = \eta * \zeta * Dx_{1,i} - \gamma Qi_i - \omega Qi_i$$

$$\frac{dDx_{1,i}}{dt} = \delta I_i - Dx_{1,i}$$

$$\frac{dDx_{2,i}}{dt} = Dx_{1,i} + \gamma Qi_i - oDx_{2,i}$$

$$\frac{dR_i}{dt} = \rho I_i + oDx_{2,i}$$

B. model with vaccination scenario:

$$\frac{dS_i}{dt} = -S_i\lambda_i - \theta - VE_S(\eta * (1-\zeta) * Dx_{1,i})$$

$$\frac{dE_i}{dt} = S_i\lambda_i + \theta - \gamma E_i \ - VE_I(\eta * \zeta * Dx_{1,i})$$

$$\frac{dI_i}{dt} = \gamma E_i \ - \ \rho I_i - \ \delta I_i \qquad (2)$$

$$\frac{dDx_{1,i}}{dt} = \ \delta I_i - \ Dx_{1,i}$$

$$\frac{dDx_{2,i}}{dt} = \ Dx_{1,i} - oDx_{2,i}$$

$$\frac{dR_i}{dt} = \ \rho I_i + \ oDx_{2,i} + VE_I(\eta * \zeta * Dx_{1,i}) + VE_S(\eta * (1-\zeta) * Dx_{1,i})$$

Parameters of the model

Parameter	Description
i	Risk group. H = high, L = low
λ	Force of infection $\lambda_H = \beta_H \frac{I_H}{N_H} + \beta_L \frac{I_L+I_H}{N_L}$ $\lambda_L = \beta_L \frac{I_L+I_H}{N_L}$
β_i	$\beta_i = R_{0,i} * 1/\rho$
θ	Daily rate of exogenous shocks
η	Number of quarantined students per newly diagnosed student
ζ	Secondary attack rate
ω	$\omega = \frac{1}{quarantine\ duration}$
γ	$\gamma = \frac{1}{\text{duration of time from infection to symptom onset}}$
ρ	Recovery rate
δ	Diagnosis rate

Additional Results

Appendix Table 1. Summary of different scenarios with varying diagnosis and isolation rates given one hMPXV introduction over 100 days, R0 in high-risk group assumed at 1.4. Likelihood of more than one additional case and mean number of additional cases given one hMPXV case introduction on day 0 onto a campus of 6,500 students over 100 days, by percent cases detected and isolated, for 1,000 model runs. R0 for the high-risk group is estimated at 1.4, and the R0 for the low-risk group is estimated at 0.8.

	High-risk sub-group		**Low-risk sub-group**		**Total Population**	
Detection and Isolation	***Likelihood of additional cases beyond initial case***	***Mean number of additional cases, 95% range***	***Likelihood of cases***	***Mean number of cases, 95% range***	***Mean number of isolated cases, given ongoing outbreak***	***Maximum isolation capacity needed***
None	75%	24 (3-85)	77%	17 (1-61)	-	-
20% of cases	70%	16 (3-63)	71%	11 (1-44)	4	15
50% of cases	60%	9 (3-28)	55%	5 (1-17)	4	17
80% of cases	45%	4 (3-9)	27%	2 (1-4)	3	8

Appendix Table 2. Summary of different scenarios with varying vaccination rates , R0 in high-risk group assumed at 1.4. Likelihood of more than one additional case and mean number of additional cases given one initial hMPXV case on a campus of 6,500 students, by level of vaccination with 50% detection and isolation of cases, for 1,000 model runs. R0 for the high-risk group is estimated at 1.4, and the R0 for the low-risk group is estimated at 0.8.

	High-risk sub-group		**Low-risk sub-group**		**Total Population**		
Vaccination of identified contacts	***Likelihood of additional cases beyond initial case***	***Mean number of additional cases, 95% range***	***Likelihood of cases***	***Mean number of cases, 95% range***	***Maximum isolation capacity needed***	***Mean number students vaccinated***	***Maximum number students vaccinated***
None	60%	9 (3-28)	55%	5 (1-17)	17		
2 contacts per case	61%	8 (3-27)	54%	5 (1-19)	16	6	68
6 contacts pr case	62%	8 (3-22)	53%	4 (1-14)	14	19	161
20 contacts per case	60%	7 (3-19)	53%	4 (1-13)	14	59	478

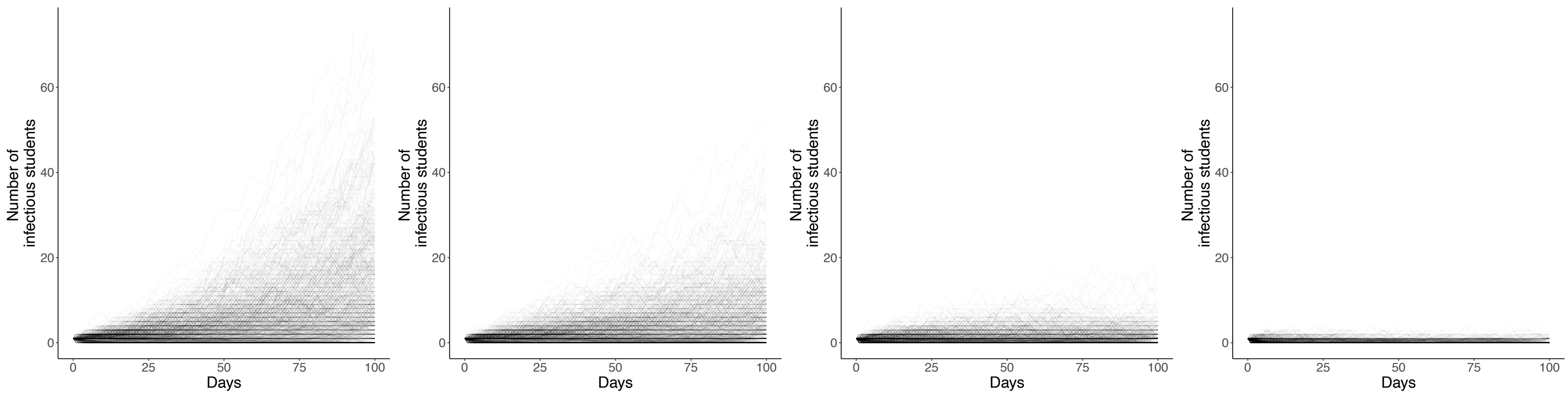
Appendix Table 3. Summary of different scenarios with varying quarantine rates. Likelihood of more than one additional case and mean number of additional cases given one initial hMPXV case on a campus of 6,500 students, by level of quarantine with 50% detection and isolation of cases, for 1,000 model runs. R0 for the high-risk group is estimated at 2.4, and the R0 for the low-risk group is estimated at 0.8.

	High-risk sub-group		**Low-risk sub-group**		**Total Population**		
Vaccination of identified contacts	***Likelihood of additional cases beyond initial case***	***Mean number of additional cases, 95% range***	***Likelihood of cases***	***Mean number of cases, 95% range***	***Maximum isolation capacity needed***	***Mean number students quarantined***	***Maximum number students quarantined***
None	75%	26 (3-109)	66%	11 (1-43)	57		
2 contacts per case	72%	22 (3-83)	65%	9 (1-34)	40	7	47
6 contacts pr case	73%	19 (3-79)	65%	8 (1-31)	54	18	136
20 contacts per case	72%	17 (3-57)	65%	7 (1-25)	48	55	343

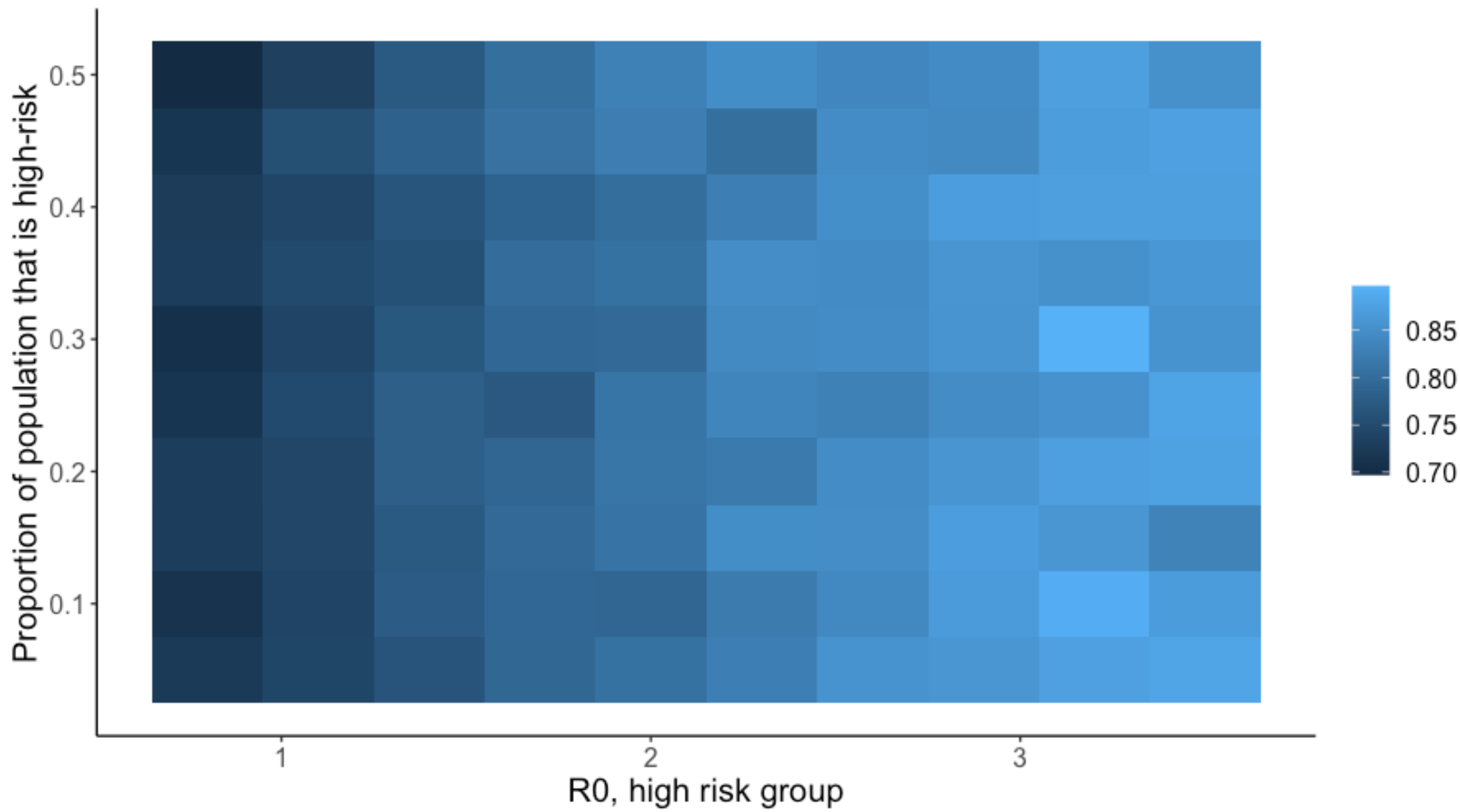
Appendix Table 4. Summary of different scenarios with varying quarantine rates , R0 in high-risk group assumed at 1.4. Likelihood of more than one additional case and mean number of additional cases given one initial hMPXV case on a campus of 6,500 students, by level of quarantine with 50% detection and isolation of cases, for 1,000 model runs. R0 for the high-risk group is estimated at 1.4, and the R0 for the low-risk group is estimated at 0.8.

	High-risk sub-group		Low-risk sub-group		Total Population		
Quarantine	***Likelihood of additional cases beyond initial case***	***Mean number of additional cases, 95% range***	***Likelihood of cases***	***Mean number of cases, 95% range***	***Maximum isolation capacity needed***	***Mean number students quarantined***	***Maximum number students quarantined***
None	60%	9 (3-28)	55%	5 (1-17)	17		
2 contacts per case	62%	8 (3-28)	55%	4 (1-16)	16	4	26
6 contacts pr case	66%	8 (3-26)	57%	4 (1-15)	18	11	57
20 contacts per case	60%	8 (3-25)	55%	4 (1-15)	19	35	172

Appendix Figure 1. Number of infectious monkeypox cases over time for different isolation rates. Each line represents one of 1000 stochastic model runs, representing possible outbreak pathways for a population of 6,500 students with 1 infectious student at the start of semester over 100 days and an average of 1 additional outside infection in that time period. R0 for the high-risk group is estimated at 1.4, and the R0 for the low-risk group is estimated at 0.8. This scenario assumes no vaccination or quarantine. The proportion of cases that are detected and isolated (=$\delta/(\delta+\rho)$) varies by panel, from left to right: a. No diagnosis/isolation, b. 20% of students isolated, c. 50% of students isolated, d. 80% of students isolated.



Appendix Figure 2. Two-way sensitivity analysis of proportion of scenarios with more than initial cases given proportion of high-risk population and R0 in the high-risk population. The horizontal axis varies the R0 for the high-risk population from 0.8 to 5. The vertical axis varies the proportion of the population that is high-risk for hMPXV from 0.01 to 0.5. Shading represents the proportion of scenarios which had cases beyond the initial cases introduced in the population, ranging from 0.55 (dark blue) to 0.8 (lighter blue). Based on 1,000 model runs, and this assumes 20% detection and isolation and no vaccination or quarantine.



Appendix Figure 3. Two-way sensitivity analysis of proportion of mean additional cases given proportion of high-risk population and R0 in the high-risk population. The horizontal axis varies the R0 for the high-risk population from 0.8 to 5. The vertical axis varies the proportion of the population that is high-risk for hMPXV from 0.01 to 0.5. Shading represents the mean additional hMPXV cases, ranging from <10 (light blue) to 75+ (dark blue). Based on 1,000 model runs, and this assumes 20% detection and isolation and no vaccination or quarantine.