Coronavirus RF Epidemiological Modeling

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Past modeling work

- Simulation of virion in Abaqus to observe mechanical resonance and the distribution of stresses along the particle

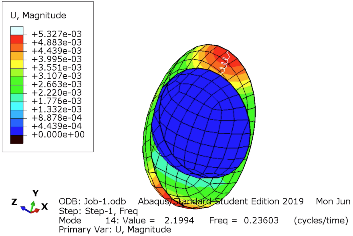

Figure: von Mises stresses are colored

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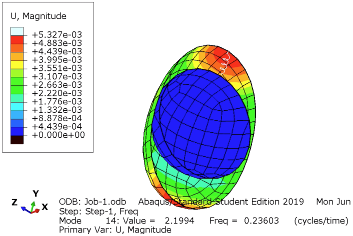


Figure: von Mises stresses are colored

Simulated HIFU heating of virion in water using k-wave toolbox.

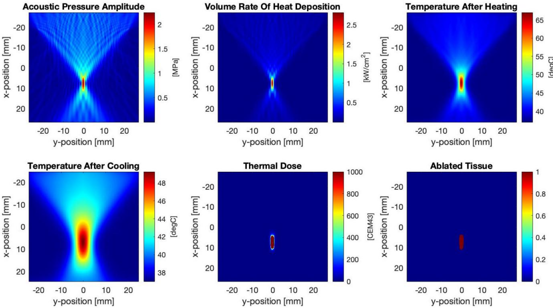
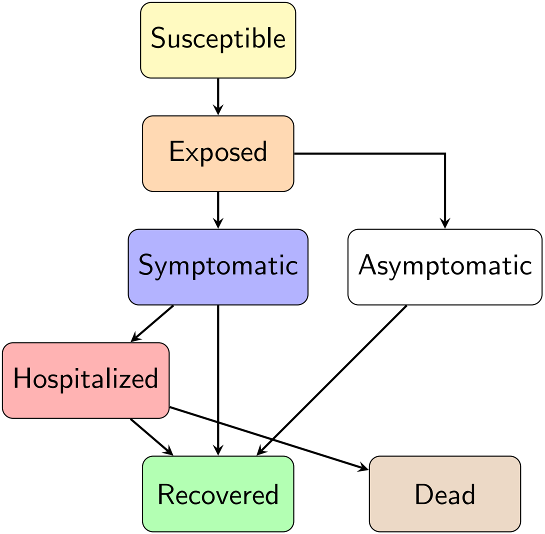


Figure: 10 seconds of HIFU heating of virion with 20 seconds cooling

Modeling COVID-19 infection with RF inactivation

- Provide a greater understanding of the impacts of RF on COVID spread
- Assess role in reducing hospitalizations and deaths
- Set targets for inactivation and RF coverage

Infection can be described with compartmental modeling



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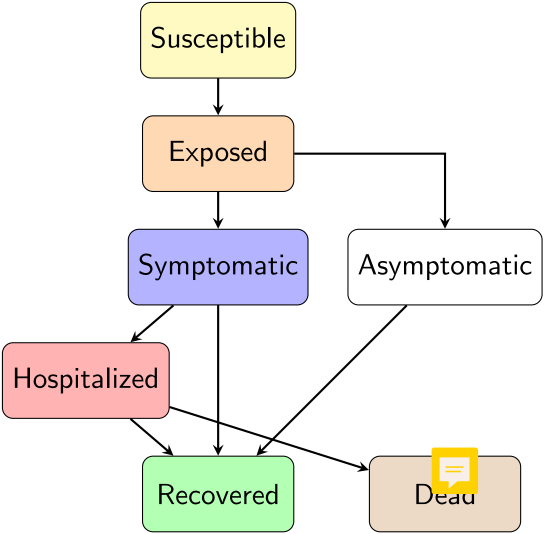


$$\frac{dS}{dt} = -\beta(t)(I + \eta A)\frac{S}{N}$$

$$\frac{dE}{dt} = \beta(t)(I + \eta A)\frac{S}{N} - \sigma E$$

$$\frac{dI}{dt} = \alpha\sigma E - \phi I - \gamma_I I$$

$$\frac{dA}{dt} = (1 - \alpha)\sigma E - \gamma_A A$$

$$\frac{dH}{dt} = \phi I - \delta H - \gamma_H H$$

$$\frac{dR}{dt} = \gamma_I I + \gamma_A A + \gamma_H H$$

$$\frac{dD}{dt} = \delta H$$

The base model is adapted to account for inactivation

- Partition the population into a group that interacts in areas with inactivation and areas without inactivation (model based on work from Eikenberry et al. 2020)
- Each compartment in the base model has a corresponding class with inactivation
- Need to obtain a parameter (ϵ) that captures the efficacy of inactivation at preventing spread

Efficacy depends on rate of inactivation

Independent action hypothesis (IAH)

Each virion has an equal, nonzero probability of causing an infection.

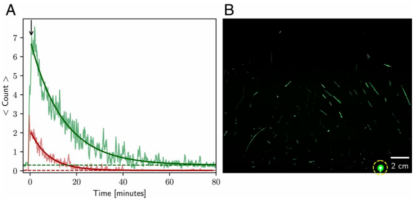
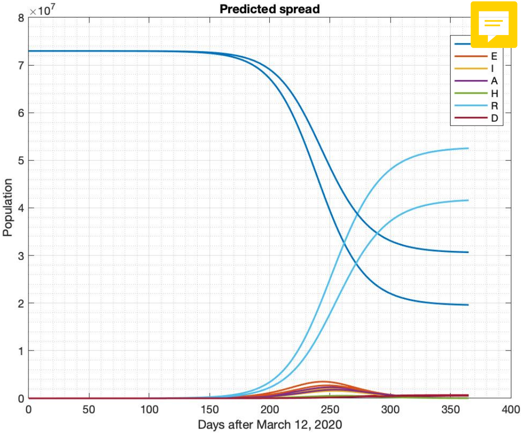


Figure: Figure from Stadnytskyi et al. 2020

- Used 100% inactivation in 25 with UVC at 3 mJ/cm^2/hour as reported in Buonanno et al. 2020. Assumed a linear rate of inactivation.
- ϵ is the ratio of the areas under the new curves.

Model of 50% population with inactivation technology



- At the end of the simulation, the number of recovered individuals is produces herd immunity effects.

Benefits are dependent upon the percentage of individuals exposed to the inactivation

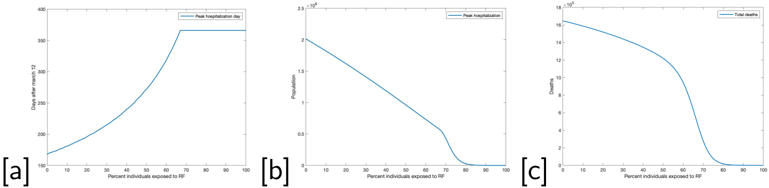


Figure: (a) Day of peak hospitalization (b) Hospitalized cases (c) Total deaths

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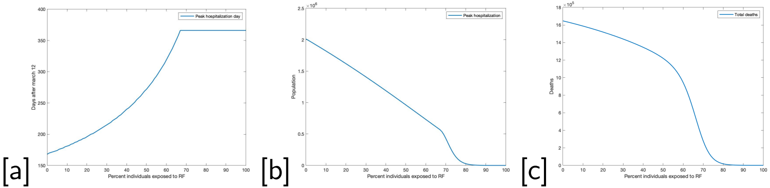

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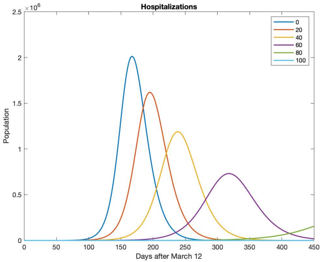
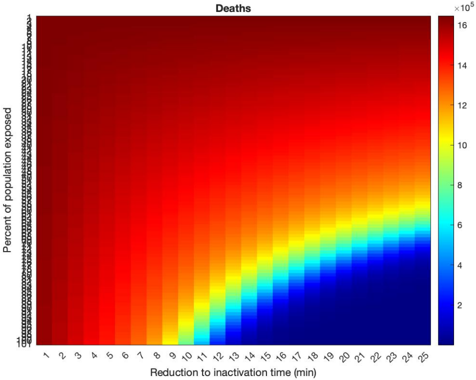


Outcomes depend on rate of inactivation



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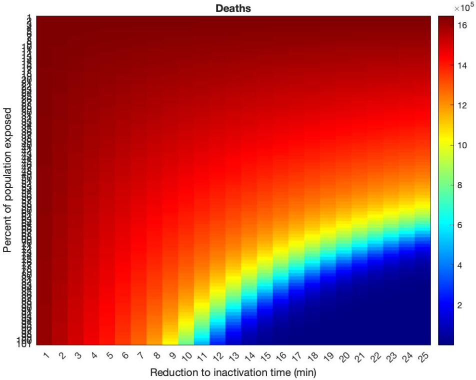

- Is the assumption of having a linear rate of inactivation valid?
- Future work will attempt to compartmentalize interactions based on location. i.e. if RF inactivation is used in public transportation