DEVELOPMENT AND DEPLOYMENT OF A FARMWORKER HOUSING SIMULATOR FOR COVID-19 RISK MITIGATION

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How does a ship dynamics person get involved in COVID-19 modeling efforts?

University suspends all international university-sponsored student travel	March 5
Depart Dulles for Panama	March 8
University suspends all travel effective March 16; depart Panama for Cartagena, Colombia	March 10
WHO declares COVID-19 a global pandemic; hop an earlier flight to Dulles from Cartagena via Panama	March 11
Governor prohibits out of state travel for Commonwealth employees; scheduled to depart Cartagena for Barranquilla	March 12
Scheduled to depart Barranquilla for Dulles	March 14
Colombia closes borders, Panama restricts entry to citizens/residents	March 16
Panama suspends all international flights	March 22

So I'm boarding my first flight, at the start of a pandemic, and notice cash under the arm rest in the row in front of me. Thoughts:

- So much for increased cleaning.
- I hope I packed enough Clorox wipes and hand sanitizer.
- People are touching *everything.*
- I wonder how quickly something could spread through this airplane by contact?
- Can I model that drawing off the kernel function idea utilized in *smoothed particle hydrodynamics (SPH)*? Result:
  - Very simplified model – no aerosolized flow
  - Purely tracking contact/proximity, with no movement through cabin
  - No consideration for flight length
  - **Very computationally efficient**

CAN WE USE A SIMILAR APPROACH FOR FARM WORKERS?

- 10% of crop workers in the U.S. enter on H-2A visas, and employers must provide housing for those workers.
- For the safety of those workers and security of the food pipeline, need ways to help educate farm owners and workers on ways to stay safe with dormitory-style workforce housing.

Model divided into two sub-domains:

- Evening: proximity based, like airplane model
  - Each individual has random baseline health
  - Assignments of individuals to specific beds is random
  - One sick resident introduced into room
  - If individual becomes infected, asymptomatic number of days randomly assigned within pre-defined guidelines
- Daytime: S-I-R-type model
  - Presumes sick individual identified upon arriving at work, removed to quarantine
  - Bed location of any infected individual(s) randomly assigned
  - Asymptomatic number of days randomly assigned for infected individual(s) within pre-defined guidelines

S-I-R-TYPE MODEL

- S: susceptible
- I: infected
- R: removed
- N: total number of individuals
- β: infection rate
- γ: recovery rate (1/average duration of infection)
- Many variations exist to model greater complexity, including births, deaths, reinfection, etc…
- Small sample sizes and stochastic asymptomatic periods complicate this:

Typical	Modified
$S(m+1) = S(m) - \left(\frac{\beta S(m) * I(m)}{N}\right)$	$S(m+1) = S(m) - \text{round}\left(\frac{\beta S(m) * I(m)}{N}\right)$
$I(m+1) = I(m) + \left(\frac{\beta S(m) * I(m)}{N}\right) - \gamma I(m)$	$I(m+1) = I(m) + \text{round}\left(\frac{\beta S(m) * I(m)}{N}\right) - \Delta R(m)$
$R(m+1) = R(m) + \gamma I(m)$	$R(m+1) = R(m) + \Delta R(m)$

DELIVERY METHOD

- For this farm housing work, the goal was to provide an educational tool for farm owners/workers.
- Collaboration with NEC personnel critical to this effort.
  - Choice of phrasing
  - Multi-lingual
  - Graphic user interface
  - Graphic design
  - Coding language selection

WHEN AN ENGINEER DESIGNS AN INTERVENTION TOOL

housesims.m | H2A.m

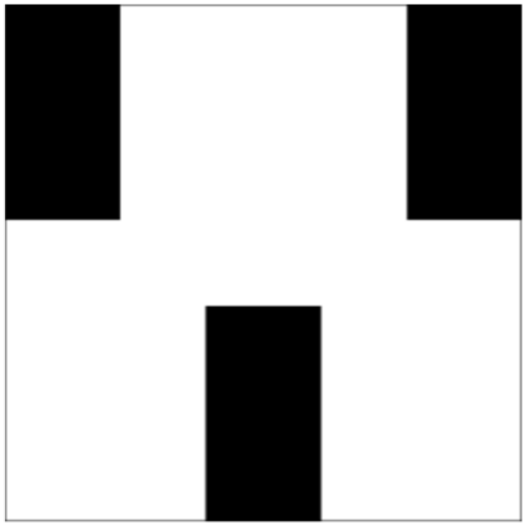
```
clear all
close all
tic

iterations=10000; % number of Monte Carlo Simulations per case
roomwidth=15; % feet
roomlength=15; % feet
bunkbeds=2; % 2 for bunkbeds, 1 for single beds
headtotoe=0; % relevant for bunkbeds: 1 for head to toe, 0 for heads at walls
Ndays=7; % number of days to simulate
b=0.2; % infection rate
allinfectedlocations=[];

for j=1:1
    healththreshold=0.3;
    for i=1:iterations
        [Nresidents(i,j),Ninfected(i,j),sirS,sirI,sirR,infectedlocation]=H2A(healththreshold,roomlength,roomwidth,bunkbeds,headtotoe,Ndays,b);
        allinfectedlocations=[allinfectedlocations;infectedlocation];
    end
end
```

Command Window

```
>> housesims

ans =

        8000


ans =

    16


ans =

    80
```

The room area you provided is 225 sq ft.

Per the Code of Federal Regulations, the maximum permissible number of residents for this sleeping area is 5. You specified that the actual number of residents is 5. With this number of residents and the room dimensions you provided, the floorplan may look something like this (black rectangles are beds or bunks):

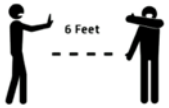


We re-ran this simulation where there are always 5 residents in this room, and one of them is sick the first night. That person is identified as sick the next morning, sent away from work, and removed from the housing. Again running this simulated configuration 10000 times where in each simulation we randomly generated each residents' baseline health and which bunk they slept in resulted in at least one person becoming infected 80 percent of the time. 16 percent of the residents became infected.

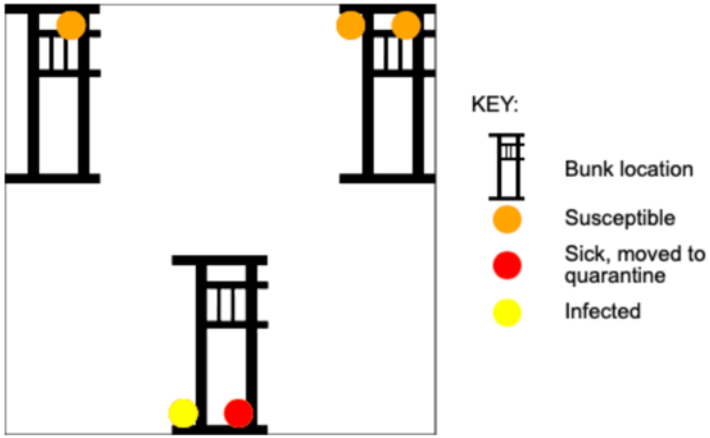
WHEN AN ENGINEER AND OCCUPATIONAL SAFETY EXPERTS ITERATE

Step 2: Preventative Practices

To prevent the spread of coronavirus, it is important to wash your hands, stay 6 ft (2 meters) away from others and wear face coverings. Please select the coronavirus safety measures in place at the farm workplace.

Face Coverings Provided	Face Coverings Required	Hand Washing Stations Provided	Contact Kept to a Minimum	Social Distancing Practiced	None of Those Listed
					
☑	☐	☐	☐	☐	☐

Submit



Based on the information you gave, if one worker in the bedroom had coronavirus at the beginning of the week, then the most likely outcome is that 1 of the 4 workers sharing the bedroom would have coronavirus by the end of the week. The worst case scenario found in this simulation (shown in the figure) is that 1 of the 4 workers sharing the bedroom would have coronavirus by the end of the week.

ITERATION ON GUI ENHANCED RESEARCHER UNDERSTANDING AS WELL

Began to probe questions such as:

- Is there a worst bed/bunk?
- How does one manage risk?
  - Most likely scenario?
  - Worst case scenario?

FUTURE WORK

This is, essentially, a simple agent-based model. Logical next steps would include:

- Finetuning parameters in S-I-R-type model
- Reducing dependency on S-I-R-type model and building out modeling for typical day-to-day interactions: movements within housing, airflow in housing, meal time, transit to workplace, transit between farms, interactions between neighboring farmworker communities, etc…
- Generating validation data set(s)

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CLICK BELOW TO ACCESS SIMULATOR:

HTTPS://VESSELDYNAMICS.COM/RESEARCH/FARMWORKER-HOUSING-SIMULATOR/