In [1]:
```
import numpy as np
from matplotlib import pyplot as plt
import pandas as pd
from scipy import stats as st
import itertools as it
from tqdm import notebook as tqdm
from matplotlib.animation import FuncAnimation
import random
import multiprocessing as mp
import modelutils
plt.ion()
```

In [2]:
```
npeople=300
ndays=21

locations = ['Bechtel','Lloyd','Page','Ruddock','Chandler']
ntrials = 5 #number of trials used to construct confidence intervals
```

Main Simulation

In [3]:
```
agent_states_trials = np.zeros(shape=[ntrials,ndays,11,npeople])
agent_states_nolunch_trials = np.zeros(shape=[ntrials,ndays,11,npeople])

# for trial_idx in tqdm.tqdm(range(ntrials),desc='Running Simulations'):
#     agent_locations,agent_states = modelutils.dorm_simulation(ndays,lu
nchloc='Home',lambda_=2.5e-3)
#     agent_locations_nolunch,agent_states_nolunch = modelutils.dorm_sim
ulation(ndays,lunchloc='Chandler',lambda_=2.5e-3)

#     agent_states_trials[trial_idx,...] = agent_states
#     agent_states_nolunch_trials[trial_idx,...] = agent_states_nolunch

def simulation_homelunch(x):
    agent_locations,agent_states = modelutils.dorm_simulation(ndays,lunc
hloc='Home',lambda_=1e-4)
    print('finished!')
    return agent_states

def simulation_chandler(x):
    agent_locations,agent_states = modelutils.dorm_simulation(ndays,lunc
hloc='Chandler',lambda_=1e-4)
    print('finished!')
    return agent_states

with mp.Pool(processes=8) as pool:
    agent_states_trials= pool.map(simulation_homelunch,np.arange(ntrials
))
    agent_states_nolunch_trials = pool.map(simulation_chandler,np.arange
(ntrials))

agent_states_trials = np.concatenate([np.expand_dims(x,axis=0) for x in
agent_states_trials],axis=0)
agent_states_nolunch_trials = np.concatenate([np.expand_dims(x,axis=0) f
or x in agent_states_nolunch_trials],axis=0)
```

```
Day:  20 / 21
finished!
Day:  20 / 21
finished!
Day:  20 / 21
finished!
Day:  20 / 21
finished!
Day:  20 / 21
finished!
```

```
Day:  20 / 21
finished!
Day:  20 / 21
finished!
Day:  20 / 21
finished!
Day:  20 / 21
finished!
Day:  20 / 21
finished!
```

In [5]:
```
agent_states_trials_sum = np.sum(agent_states_trials,axis=-1)/npeople
agent_states_nolunch_trials_sum = np.sum(agent_states_nolunch_trials,axi
s=-1)/npeople



agent_states_trials_reduced = np.zeros([ntrials,ndays,5])
agent_states_nolunch_trials_reduced = np.zeros([ntrials,ndays,5])
for seir_idx in range(5):
    agent_states_trials_reduced[:,:,0] =np.sum(agent_states_trials_sum
[:,:,0:3],axis=-1)
    agent_states_trials_reduced[:,:,1] = np.sum(agent_states_trials_sum
[:,:,3:6],axis=-1)
    agent_states_trials_reduced[:,:,2] = np.sum(agent_states_trials_sum
[:,:,6:9],axis=-1)
    agent_states_trials_reduced[:,:,3] = agent_states_trials_sum[:,:,9]
    agent_states_trials_reduced[:,:,4] = agent_states_trials_sum[:,:,10]

    agent_states_nolunch_trials_reduced[:,:,0] =np.sum(agent_states_nolu
nch_trials_sum[:,:,0:3],axis=-1)
    agent_states_nolunch_trials_reduced[:,:,1] = np.sum(agent_states_nol
unch_trials_sum[:,:,3:6],axis=-1)
    agent_states_nolunch_trials_reduced[:,:,2] = np.sum(agent_states_nol
unch_trials_sum[:,:,6:9],axis=-1)
    agent_states_nolunch_trials_reduced[:,:,3] = agent_states_nolunch_tr
ials_sum[:,:,9]
    agent_states_nolunch_trials_reduced[:,:,4] = agent_states_nolunch_tr
ials_sum[:,:,10]


percentiles = [10,30,90,70]
agent_states_percentiles = np.zeros([len(percentiles),ndays,5])
agent_states_nolunch_percentiles = np.zeros([len(percentiles),ndays,5])

for p_idx in range(len(percentiles)):
    agent_states_percentiles[p_idx,...]=np.percentile(agent_states_trial
s_reduced,percentiles[p_idx],axis=0)
    agent_states_nolunch_percentiles[p_idx,...]=np.percentile(agent_stat
es_nolunch_trials_reduced,percentiles[p_idx],axis=0)
```

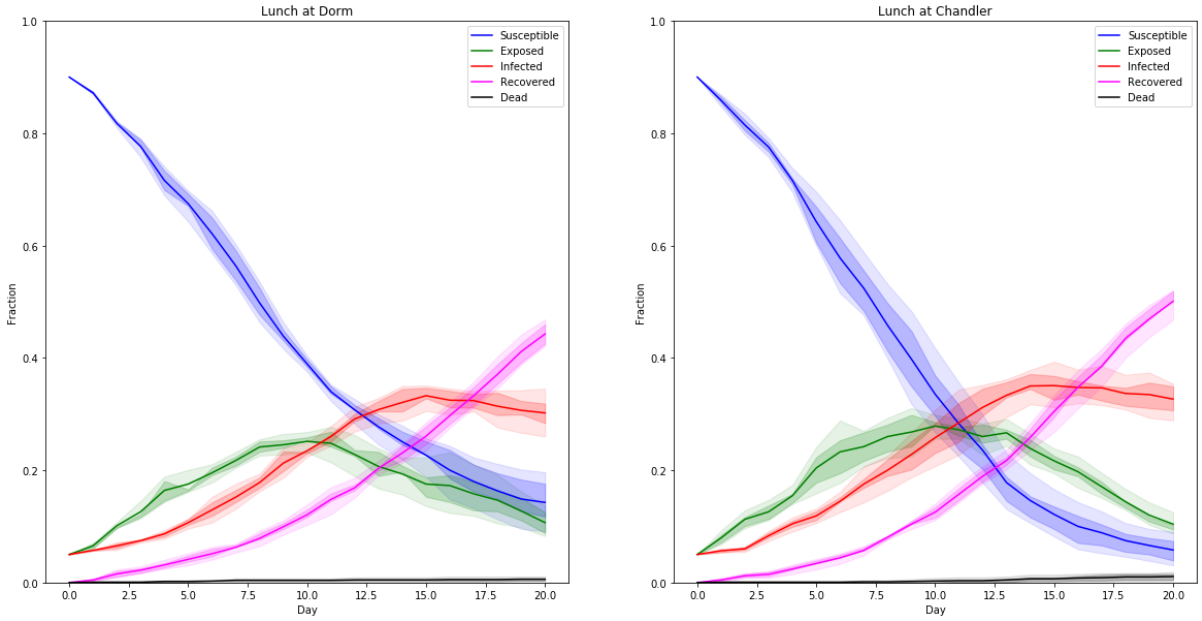
Visualization and animation code below.

In [6]:
```
alphalist = np.linspace(0.1,.3,3)
colorlist = ['blue','green','red','magenta','black']
time = np.arange(ndays)

fig,ax = plt.subplots(ncols=2,figsize=[20,10])

for plot_idx in range(len(percentiles)//2):
    for seir_idx in range(5):
        ax[0].fill_between(time,agent_states_percentiles[plot_idx,:,seir
_idx],agent_states_percentiles[plot_idx+2,:,seir_idx],color=colorlist[se
ir_idx],alpha=alphalist[plot_idx])
        ax[1].fill_between(time,agent_states_nolunch_percentiles[plot_id
x,:,seir_idx],agent_states_nolunch_percentiles[plot_idx+2,:,seir_idx],co
lor=colorlist[seir_idx],alpha=alphalist[plot_idx])

        if plot_idx==1:
            ax[0].plot(time,np.mean(agent_states_trials_reduced[:,:,seir
_idx],axis=0),color=colorlist[seir_idx])
            ax[1].plot(time,np.mean(agent_states_nolunch_trials_reduced
[:,:,seir_idx],axis=0),color=colorlist[seir_idx])
ax[0].legend(['Susceptible','Exposed','Infected','Recovered','Dead'])
ax[1].legend(['Susceptible','Exposed','Infected','Recovered','Dead'])
ax[0].set_title('Lunch at Dorm')
ax[1].set_title('Lunch at Chandler')
ax[0].set_xlabel('Day')
ax[1].set_xlabel('Day')
ax[0].set_ylim([0,1])
ax[1].set_ylim([0,1])
ax[0].set_ylabel('Fraction')
ax[1].set_ylabel('Fraction')
plt.savefig('chandler_simulation_FINAL.png')
```



In [7]:
```
#UNCOMMENT FOR MOVEMENT DEMO

# def draw_dorm(agent_locations,disease_states,ax,background_map = plt.i
mread('dorms.png')):
#     """
#     agent locations is a list containing the location of each agent in
the simulation
#     disease states is a list of booleans describing whether or not an
 individual is infected (0=healthy,1=infected)
#     ax is the matplotlib axes object you want to draw on

#     returns nothing, operates in-place
#     """

#     #group together states so they're not randomly shuffled
#     agent_locations = [x for _,x in sorted(zip(disease_states,agent_lo
cations))]
#     disease_states = sorted(disease_states)
#     locations = ['Bechtel','Lloyd','Page','Ruddock','Chandler','Quaran
tine']

#     alphaarray = np.linspace(0.25,1,num=3)
#     colors=['blue','green','red']

#     ax.imshow(background_map)


#     #add labels
#     ax.text(30,75,'Bechtel',size=14)
#     ax.text(215,450,'Lloyd',size=14)
#     ax.text(157,450,'Page',size=14)
#     ax.text(230,350,'Ruddock',size=14)
#     ax.text(170,340,'Chandler',size=14)
#     ax.text(230,210,'Quarantine',size=14)

#     #each value is a 2 list describing the ranges on x and y for that
 location
#     coor_ranges = {
#         'Bechtel': [[10,100],[5,60]],
#         'Lloyd': [[200,230],[377,450]],
#         'Page': [[150,200],[377,450]],
#         'Ruddock': [[230,275],[360,420]],
#         'Chandler': [[150,230],[340,385]],
#         'Quarantine':[[225,290],[5,200]]

#     }

#     people_counter = np.zeros(len(coor_ranges.keys())).astype(np.int)

#     gridlen = np.ceil(np.sqrt(len(agent_locations))).astype(np.int) #c
reate enough gridpoints such that everyone has a space if they mob a sin
gle location (chandler)

#     #iterate over people and draw each on the axis
#     for person_idx in range(len(agent_locations)):
```

```
#         color_idx = int(disease_states[person_idx]//3)
#         alpha_idx = int(disease_states[person_idx] % 3)
#         if color_idx<=2:
#             color=colors[color_idx]
#             alpha=alphaarray[alpha_idx]
#         elif disease_states[person_idx]==9:
#             color='magenta'
#             alpha=1
#         elif disease_states[person_idx]==10:
#             color='black'
#             alpha=1

#         people_counter[locations.index(agent_locations[person_idx])] +
= 1

#         #draw a grid over the current location and place agent at spec
ified spot
#         current_ranges = coor_ranges[agent_locations[person_idx]]
#         xx,yy = np.meshgrid(np.linspace(current_ranges[0][0],current_r
anges[0][1],num=gridlen),np.linspace(current_ranges[1][0],current_ranges
[1][1],num=gridlen))

#         #we need to convert the raw counts into row,col indices to get
the coordinates of interest
#         pal = people_counter[locations.index(agent_locations[person_id
x])]-1 #again, -1 is for indexing. pal stands for people at location

#         ax.plot(xx[pal//gridlen,pal%gridlen],yy[pal//gridlen,pal%gridl
en],color=color,alpha=alpha,marker='*',markersize=10,markeredgecolor='bl
ack')









# ##########################################################################
######


# def num2titlestr(n):
#     day = n//96
#     day_rem = n % 96
#     hours = day_rem // 12

#     fmt_hours = 9 + hours
#     if fmt_hours>12:
#         fmt_hours+=-12
#     fmt_hours= str(fmt_hours)
#     if len(fmt_hours)!=2:
#         fmt_hours = '0'+fmt_hours

#     hour_rem = day_rem % 12
#     minutes = hour_rem * 5
#     fmt_minutes = str(minutes)
```

```
#     if len(fmt_minutes) != 2:
#         fmt_minutes = '0'+fmt_minutes
#     return 'Day: '+str(day)+' / '+ fmt_hours+':'+fmt_minutes


# fig,ax = plt.subplots(ncols=2,figsize=[20,10])
# skip=3


# ax[0].set_xlabel('Timestep')
# ax[0].set_ylabel('Fraction')
# ax[1].set_xlabel('Timestep')
# ax[1].set_ylabel('Fraction')




# def update(i,skip=skip):
#     print('Step: ',i,' / ',agent_locations.shape[0],end='\r')


#     plot_indices = np.arange(0,i,step=skip)

#     ax[0].clear()
#     ax[1].clear()
#     ax[0].set_title('Lunch in Dorm /'+num2titlestr(i))
#     ax[1].set_title('Lunch in Chandler /'+num2titlestr(i))




#     disease_states = np.squeeze(agent_states[i//96,:,:])  #we need to
 "compress this one hot matrix (one hot along columns)"
#     disease_states = np.array([np.where(disease_states[:,x]==1)[0] for
x in range(disease_states.shape[1])])

#     disease_states_nolunch = np.squeeze(agent_states_nolunch[i//9
6,:,:])  #we need to "compress this one hot matrix (one hot along column
s)"
#     disease_states_nolunch = np.array([np.where(disease_states_nolunch
[:,x]==1)[0] for x in range(disease_states_nolunch.shape[1])])


#     draw_dorm(agent_locations[i,:],disease_states,ax[0])
#     draw_dorm(agent_locations_nolunch[i,:],disease_states_nolunch,ax
[1])
#     #ax[0].axis('off')
#     #ax[1].axis('off')






# anim = FuncAnimation(fig, update, frames=np.arange(0,250,skip), interv
al=200,repeat_delay=1000)
```

```
# anim.save('200701_movement.gif', dpi=80, writer='imagemagick')
# print('GIF Finished!')
```

In [ ]: