A scenario modeling pipeline for COVID-19 emergency planning - Supplementary Material

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Non-pharmaceutical interventions

Table S1. A suite of commonly modeled interventions, listed in order of increasing impact on transmission

Intervention	Summary	R0 reduction (%)	Reference
School Closures	Only schools are closed in this mild form of social distancing. Reduction in transmission is based on studies that estimated how influenza transmission was impacted when schools were closed due to holidays or inclement weather.	16 - 30	[1,2]
Mild Social Distancing	Similar to the Washington, D.C. response to the 1918 influenza pandemic when schools, places of worship, and places of entertainment were closed, public meetings banned, and business opening hours staggered.	21 - 33	[3]
Self Isolation and Household Quarantine	Based on the BBC Pandemic data, cases are assumed to self isolate away from the home and household members of the case self-quarantine within 2.6 - 3.6 days of case being confirmed.	26 - 37	[4]
Moderate Social Distancing	Similar to the Milwaukee, Wisconsin response to the 1918 Influenza Pandemic when all public institutions were closed - schools, places of worship, places of entertainment, and non-essential businesses.	44 - 65	[3]
Test and Isolate	Based on the rapid testing and isolation efforts put in place in South Korea in response to COVID-19.	48 - 76	[5]
Self Isolation, Household Quarantine, and Contact Tracing of acquaintances	Based on the BBC Pandemic data, cases are assumed to self isolate away from the home and household members of the case self-quarantine within 2.6 - 3.6 days of case being confirmed. It's assumed that 90% of school, 79%	53 - 57	[4]

	of work, and 52% of other contacts are traceable.		
Self Isolation, Household Quarantine, Contact Tracing of acquaintances, and Social Distancing	Based on the BBC Pandemic data, cases are assumed to self isolate away from the home and household members of the case self-quarantine within 2.6 - 3.6 days of case being confirmed. It's assumed that 90% of school, 79% of work, and 52% of other contacts are traceable. Furthermore, mild social distancing is in place that limits contacts outside of home/school/work to at most 4 per day.	61 - 64	[4]
United Kingdom-like Lockdown	Based on the United Kingdom stay-at-home order in response to COVID-19.	71 - 83	[6]
Wuhan-like Lockdown	Based on the Wuhan stay-at-home order in response to COVID-19, where residents were not allowed to leave the city.	81 - 89	[7,8]

Health outcomes

For our work, we have been using this functionality to include age-standardized probabilities of hospitalization, ICU admission, and death; there is currently limited data on the age-specific risk of ventilation among ICU patients, and we used a single, average risk of ventilation across all locations. We reviewed the literature for relevant age-specific estimates of risk of each health outcome, and used a logistic generalized additive model (GAM) with penalized cubic spline for age and random effect for study to estimate the risk for 10-year aggregated age categories. We then apply these age-specific estimates to the population age distribution in each location to get location-specific, age-adjusted estimates. We assume that individuals of all ages are at equal risk of infection.

Table S2. Selected estimates of health outcomes risk and timings.

Event	Summary	Risk	Reference
Hospitalization	Probability of hospitalization given infection	2.5%, 5%, 10%	User defined; often taken to be 10x risk of death among all infected individuals
Death	Probability of death given infection	0.25%, 0.5%, 1%	User defined
ICU admission	Probability of ICU admission among those hospitalized	26.4%	[9]
		14.2%	[10]
		9.0%	[11]
Ventilation	Probability of invasive ventilation among those admitted to the ICU	15%	[12]
		85.8%	[10]
		88.5%	[11]
*Note that age-specific estimates of these risks and code to summarize these values can be found at https://github.com/HopkinsIDD/covidSeverity			

Event	Summary	Parameters	Timing	Reference
Hospitalization	**Time from symptom onset to first hospitalization**	Log-mean, log-sd	1.23, 0.79	[13]
		Gamma shape, rate	0.8, 0.18	[14]
		Gamma shape, rate	0.71, 0.27	[14]
		Median, IQR	11, 8-14	[15]
		Median	5.5	[16]
Hospital Discharge	**Length of hospital stay** Time from hospital admission to discharge	Log-mean, log-sd	log(11.5), log(1.22)	[16]
		Median, IQR	10. 7-14	[17]
		Median, IQR	12, 10-14	[18]

		Median, IQR	12, 9-15	[15]
Death	**Time from symptom onset to death**	Log-mean, log-sd	2.84, 0.52	[19]
		mean, sd	22.3, 0.42	[20]
		Mean, sd	18.8, 0.45	[21]
		Median, IQR	18.5, 15 - 22	[15]
ICU admission	**Time from hospital admission to ICU admission** There are few direct estimates of the rate of ICU admission following hospitalization. Two small case series reported medians of 1 - 3d. Other studies estimated the time from symptom onset to ICU admission to be 10 - 12 days	Log-mean, log-sd	log(3), 0.3	[12,15,17]
ICU discharge	**Length of ICU stay** Time from ICU admission to ICU discharge	Log-mean, log-sd	log(8), 0.2	[15]
Ventilation	**Time from ICU admission to ventilation** There are few direct estimates of the rate of ventilation following ICU admission. Two studies estimated the time from symptom onset to ventilation to be 10.5 - 14.5 days, or 0 - 2 days longer than the time from symptom onset to ICU admission in each study.	Log-mean, log-sd	log(1), 0.4	[12,15]
Extubation	**Length of ventilation**	Log-mean, log-sd	log(7), 0.2	1 day shorter than ICU duration; one estimate of 4 patients had mean 17 days so this may be an underestimate [22]

Example YAML configuration file

Please see additional details for each of these configuration file options in the wiki page of the GitHub template repository “HopkinsIDD/COVID19_Minimal.”

```
name: location-x
start_date: 2020-01-31
end_date: 2020-12-31
nsimulations: 1000
dt: 0.25
report_location_name: Location X

spatial_setup:
  base_path: data/location-x
  setup_name: location-x
  geodata: geodata.csv
  shapefile_name: shp_location_x/counties_2018.shp
  shapefile: shp_location_x/counties_2018.shp
  mobility: mobility.csv
  popnodes: pop2010
  nodenames: geoid
  census_year: 2010
  modeled_states:
    - AA
    - BB
    - CC
  include_in_report: targeted

importation:
  census_api_key: "insert_key_here"
  travel_dispersion: 3
  maximum_destinations: Inf
  dest_type : state
  dest_country : USA
  aggregate_to: airport
  cache_work: TRUE
  update_case_data: TRUE
  draw_travel_from_distribution: FALSE
  print_progress: FALSE
  travelers_threshold: 10000
  airport_cluster_distance: 80
  param_list:
```

```
    incub_mean_log: log(5.89)
    incub_sd_log: log(1.74)
    inf_period_nohosp_mean: 15
    inf_period_nohosp_sd: 5
    inf_period_hosp_mean_log: 1.23
    inf_period_hosp_sd_log: 0.79
    inf_period_hosp_shape: 0.75
    inf_period_hosp_scale: 5.367
    p_report_source: [0.05, 0.25]
    shift_incid_days: -10
    delta: 1

seeding:
 method: FolderDraw
 folder_path: importation/location-x/

interventions:
  scenarios:
    - Uncontrolled
    - SocialDistancing_fixed
    - SocialDistancing_fatigued
    - SocialDistancing_pulsed
    - SocialDistancing_checker
  settings:
    Uncontrolled:
      template: ReduceR0
      period_start_date: 2020-03-19
      period_end_date: 2020-05-14
      value:
        distribution: fixed
        value: 0
    SocialDistancing_fixed:
      template: ReduceR0
      period_start_date: 2020-03-19
      period_end_date: 2020-12-31
      value:
        distribution: uniform
        low: .71
        high: .83
    SocialDistancing_checker:
      template: ReduceR0
      affected_geoids: ["County B", "County E", "County F"]
      period_start_date: 2020-03-19
```

```
  period_end_date: 2020-12-31
  value:
    distribution: uniform
    low: .71
    high: .83
SD_Deg1:
  template: ReduceR0
  period_start_date: 2020-03-19
  period_end_date: 2020-04-12
  value:
    distribution: uniform
    low: .71
    high: .83
SD_Deg2:
  template: ReduceR0
  period_start_date: 2020-04-13
  period_end_date: 2020-04-26
  value:
    distribution: uniform
    low: .71*.90
    high: .83*.90
SD_Deg3:
  template: ReduceR0
  period_start_date: 2020-04-27
  period_end_date: 2020-05-10
  value:
    distribution: uniform
    low: .71*.80
    high: .83*.80
SD_Deg3_Road2Recovery:
  template: ReduceR0
  period_start_date: 2020-04-27
  period_end_date: 2020-05-14
  value:
    distribution: uniform
    low: .71*.80
    high: .83*.80
SD_Deg4:
  template: ReduceR0
  period_start_date: 2020-05-11
  period_end_date: 2020-05-24
  value:
    distribution: uniform
```

```
    low: .71*.70
    high: .83*.70
SD_Deg5:
  template: ReduceR0
  period_start_date: 2020-05-25
  period_end_date: 2020-06-14
  value:
    distribution: uniform
    low: .71*.60
    high: .83*.60
SD_Deg6:
  template: ReduceR0
  period_start_date: 2020-06-15
  period_end_date: 2020-06-28
  value:
    distribution: uniform
    low: .71*.50
    high: .83*.50
SD_Deg7:
  template: ReduceR0
  period_start_date: 2020-06-29
  period_end_date: 2020-07-12
  value:
    distribution: uniform
    low: .71*.40
    high: .83*.40
SD_Deg8:
  template: ReduceR0
  period_start_date: 2020-07-13
  period_end_date: 2020-08-31
  value:
    distribution: uniform
    low: .71*.30
    high: .83*.30
SD_Deg9:
  template: ReduceR0
  period_start_date: 2020-09-01
  period_end_date: 2020-12-31
  value:
    distribution: uniform
    low: .71*.20
    high: .83*.20
SD_Pulse1:
```

```
  template: ReduceR0
  period_start_date: 2020-03-19
  period_end_date: 2020-04-08
  value:
    distribution: uniform
    low: .71
    high: .83
SD_Pulse2:
  template: ReduceR0
  period_start_date: 2020-04-30
  period_end_date: 2020-05-20
  value:
    distribution: uniform
    low: .71
    high: .83
SD_Pulse3:
  template: ReduceR0
  period_start_date: 2020-06-11
  period_end_date: 2020-07-01
  value:
    distribution: uniform
    low: .71
    high: .83
SD_Pulse4:
  template: ReduceR0
  period_start_date: 2020-07-23
  period_end_date: 2020-08-12
  value:
    distribution: uniform
    low: .71
    high: .83
SocialDistancing_fatigued:
  template: Stacked
  scenarios:
    - SD_Deg1
    - SD_Deg2
    - SD_Deg3
    - SD_Deg4
    - SD_Deg5
    - SD_Deg6
    - SD_Deg7
    - SD_Deg8
    - SD_Deg9
```

```
    SocialDistancing_pulsed:
      template: Stacked
      scenarios:
        - SD_Pulse1
        - SD_Pulse2
        - SD_Pulse3
        - SD_Pulse4

seir:
  parameters:
    sigma: 1 / 5.2
    gamma:
      distribution: uniform
      low: 1 / 6
      high: 1 / 2.6
    R0s:
      distribution: uniform
      low: 2
      high: 3

hospitalization:
  paths:
    output_path: hospitalization
    run_age_adjust: TRUE
  parameters:
    time_hosp: [log(7), 0.3]
    time_disch: [log(11.5), 0.20]
    time_ICU: [log(3), 0.3]
    time_ICUdur: [log(8), 0.2]
    time_ventdur: [log(7), 0.2]
    time_vent: [log(1), 0.4]
    time_onset_death: [log(17.1), 0.52]
    p_death: [.01]
    p_death_names: ["high"]
    p_hosp_inf: [0.1]

report:
  data_settings:
    pop_year: 2018
  plot_settings:
    plot_intervention: TRUE
  formatting:
    scenario_labels_short: ["UC", "SDfix", "SDfat", "SDpul", "SDchx"]
```

```
    scenario_labels:
    - "Uncontrolled"
    - "Social Distancing Fixed"
    - "Social Distancing Fatigued"
    - "Social Distancing Pulsed"
    - "Social Distancing Checker"
    scenario_colors: ["#993404", "#D95F02", "#1B9E77", "#7570B3",
"#4278cf"]
    pdeath_labels: ["1% IFR"]
    display_dates: ["2020-04-01", "2020-05-01", "2020-06-01",
"2020-07-01", "2020-08-01", "2020-09-01"]
    display_dates2: ["2020-05-01", "2020-07-01", "2020-09-01"]
```

Supplementary References:

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