Supplementary Online Content


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This supplementary material has been provided by the authors to give readers additional information about their work.
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**eTable 1. Strata Classification and PTSD Prevalence and Symptoms**

<table>
<thead>
<tr>
<th>Strata</th>
<th>Race</th>
<th>Gender</th>
<th>Age</th>
<th>PTSD prevalence</th>
<th>PTSD symptoms (cases)</th>
<th>PTSD symptoms (non-cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>White non-Hispanic</td>
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<td>18-34</td>
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<td>0</td>
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<tr>
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<td>0</td>
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<td>0</td>
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<tr>
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<td>0.0338</td>
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<td>0</td>
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<td>65+</td>
<td>0.05894</td>
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<td>0-2</td>
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<td>8</td>
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<td>13</td>
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**eTable 2. Treatment Reach Among PTSD Cases**

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity = 0.8, Specificity = 0.8</th>
<th>Sensitivity = 0.8, Specificity = 1.0</th>
<th>Sensitivity = 1.0, Specificity = 0.8</th>
<th>Sensitivity = 0.8, Specificity = 0.8, SPR enrollment &gt; CBT enrollment</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Reach per 10,000</td>
<td>Reach per 10,000</td>
<td>Reach per 10,000</td>
<td>Reach per 10,000</td>
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<tr>
<td>Usual Care</td>
<td>2118.60</td>
<td>2121.66</td>
<td>2120.69</td>
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<td>Stepped Care</td>
<td>3137.25</td>
<td>3135.62</td>
<td>3388.84</td>
<td>4595.73</td>
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## eTable 3. Cost Effectiveness - Screening Performance

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Cost Per Person</th>
<th>Total Cost</th>
<th>Total Effectiveness</th>
<th>Incremental Cost Effectiveness</th>
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<tbody>
<tr>
<td></td>
<td>(Dollars)</td>
<td>(Millions)</td>
<td>(DALYs avoided)</td>
<td>($ per DALY averted)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(PTSD-free)</td>
<td></td>
</tr>
<tr>
<td>Sensitivity = 0.8, Specificity = 1.0</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario 1: CBT Cost = $60/session, SPR Cost = $15/session</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usual Care</td>
<td>72.80</td>
<td>8.37</td>
<td>23918.8</td>
<td>246832345</td>
</tr>
<tr>
<td>Stepped Care</td>
<td>425.41</td>
<td>48.71</td>
<td>36322.1</td>
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<td>Sensitivity = 1.0, Specificity = 0.8</td>
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<td>Scenario 2: CBT Cost = $60/session, SPR Cost = $30/session</td>
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<tr>
<td>Usual Care</td>
<td>145.59</td>
<td>16.74</td>
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<td>Stepped Care</td>
<td>491.98</td>
<td>56.36</td>
<td>36317</td>
<td>299786910</td>
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<tr>
<td>Sensitivity = 1.0, Specificity = 0.8</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Scenario 3: CBT Cost = $120/session, SPR Cost = $15/session</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Usual Care</td>
<td>72.80</td>
<td>8.37</td>
<td>23911.4</td>
<td>246889285</td>
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<tr>
<td>Stepped Care</td>
<td>784.55</td>
<td>89.81</td>
<td>36320.9</td>
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<tr>
<td>Sensitivity = 1.0, Specificity = 0.8</td>
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</tr>
<tr>
<td>Scenario 4: CBT Cost = $120/session, SPR Cost = $30/session</td>
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</tr>
<tr>
<td>Usual Care</td>
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<td>16.72</td>
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<td>Stepped Care</td>
<td>850.98</td>
<td>97.32</td>
<td>36291.5</td>
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**eTable 4. Cost Effectiveness - Treatment strength, Enrollment Probabilities, Disability Weights**

<table>
<thead>
<tr>
<th></th>
<th>Mean Cost Per Person (Dollars)</th>
<th>Total Cost (Millions of Dollars)</th>
<th>Total Effectiveness (DALYs avoided*)</th>
<th>Total Effectiveness (PTSD-free days)</th>
<th>Incremental Cost Effectiveness ($ per DALY averted)</th>
<th>Incremental Cost Effectiveness ($ per PTSD-free day)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity = 0.8, Specificity = 0.8, equal CBT and SPR strength</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Cost = $80/session, SPR Cost = $15/session</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usual Care</td>
<td>72.79</td>
<td>8.37</td>
<td>23913.9</td>
<td>246649845</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Stepped Care</td>
<td>279.98</td>
<td>56.43</td>
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<td>6707.95</td>
<td>1.54</td>
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<td><strong>Sensitivity = 0.8, Specificity = 0.8, SPR enrollment &gt; CBT enrollment</strong></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CBT Cost = $80/session, SPR Cost = $15/session</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usual Care</td>
<td>74.15</td>
<td>8.54</td>
<td>27017.4</td>
<td>247649215</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Stepped Care</td>
<td>196.30</td>
<td>39.50</td>
<td>34951.7</td>
<td>285347510</td>
<td>3901.45</td>
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<td><strong>Sensitivity = 0.8, Specificity = 0.8, decreased DW for severe symptoms</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CBT Cost = $80/session, SPR Cost = $15/session</td>
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<td></td>
<td></td>
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<tr>
<td>Usual Care</td>
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<td>8.37</td>
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<td>-</td>
<td>-</td>
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<td>3800.45</td>
<td>0.80</td>
</tr>
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</table>

*Relative to receiving no treatment*
eAppendix. ABM Description Using ODD protocol

The “Hurricane Sandy” ABM is described in detail in accordance to ODD (Overview, Design concept and Details) protocol [1] as below:

1 Purpose

The purpose of this ABM is to simulate the effectiveness of a stepped care case finding intervention compared to usual care for the resolution of PTSD related to Hurricane Sandy in the five boroughs of New York City.

2 Entities, state variables and scales

The model consists of two entities: agents and boroughs. Each agent has its own unique set of static and time-varying state variables. Agent attributes are defined by the variables age, race, gender and physical location. Other variables such as number of PTSD symptoms, use of CBT and SPR treatment are related to PTSD status of an agent and type of treatment it receives for resolution of PTSD. Agent behavior includes use of CBT/SPR based on PTSD case status, resolution of PTSD as a function of CBT/SPR treatment and relapse of PTSD symptoms.

The model environment represents the physical space where agents reside during the simulation run. It consists of rectangular grid of size 760 X 400 which is further divided into smaller rectangular spaces with sizes scaled to the physical area of five boroughs (Bronx, Brooklyn, Manhattan, Queens and Staten Island) of New York City. Demographic variables were assigned to agents based on the proportions of each strata (24 strata cross-classification by race, gender and age) obtained from the American Community Survey (ACS); PTSD status was estimated for the same 24 strata and also the five boroughs using population based data from Hurricane Sandy, and combined with the ACS data through a process called raking or iterative proportional fitting in STATA [2]. In particular, we raked our pseudopopulation to reflect the following distributions (a) ACS population estimates for each of the 24 sociodemographic strata, (b) Sandy Study estimates of PTSD prevalence within each of the 24 sociodemographic strata, and (c) Sandy study estimates of PTSD prevalence within each of the 5 boroughs.

3 Process overview and scheduling

The simulation proceeds in discrete time-steps with each time-step being equivalent to one week. The sub-models where agents execute their behavior rules are processed in the following order:

(a) Prior CBT/SPR enrollment.
(b) Use of Stepped Care/SPR treatment.
(c) Decline in PTSD symptoms following Stepped Care/SPR treatment.
(d) Relapse of PTSD symptoms.
4 Design concepts

This model includes several design concepts of agent-based models such as adaptive behavior, observation, stochasticity and collectives. The design concepts included in the model are described in detail below:

4.1 Adaptive behavior

It can be defined as decisions that agents make to change their state, to pursue some objectives, in response to current state of themselves and their environment [1]. In this model, adaptive behavior was modeled as an ability of an agent to choose the type of treatment based on its PTSD case status. For example, an agent who screens positive for PTSD (PTSD>6) will either use CBT or SPR treatment for resolution of PTSD symptoms. The use of CBT (or SPR) treatment can be identified as a decision an agent made (agent behavior) to relieve PTSD symptoms and eventually become free of PTSD (objective). However, the probability of using CBT (or SPR) treatment as a medium for PTSD resolution depends upon agent’s demographic characteristics and its history of CBT (or SPR) enrollment before Hurricane Sandy.

4.2 Stochasticity

In this model, stochasticity was used to initialize agents’ demographic variables such as age, gender, race, PTSD case status and borough in which they reside, based on the proportions obtained from raking. Besides that, agent behaviors, such as enrollment in CBT treatment, were also stochastically carried out. Since demographic and behavioral parameters (see section 7.1 and 7.2) of agents were interpreted in terms of proportions and probabilities, a number drawn randomly between 0 and 1 was compared with calculated probability to assign attributes and execute their behavioral rules.

4.3 Collectives

Borough populations represent collectives in the model. The main purpose of defining collectives in the model was to derive average PTSD prevalence in different boroughs after agents receive Stepped Care/SPR treatment.

4.4 Observation

The main purpose of these design concepts is to understand model behavior through graphical displays. This ensures that agents are executing their behavioral rules as intended. In this model, population level characteristics of agents (such as percentage of agents with PTSD, percentage of agent using CBT and SPR treatment) were recorded at each time step and displayed via graphs and plots. The simulation was run for 50 trials to generate PTSD prevalence, under stepped care and usual care, in each of the five boroughs in order to account for stochasticity in simulating treatment.

5 Initialization

The agents were assigned demographic attributes (such as age, race and borough where they reside) along with their PTSD status based on derived proportions of each strata obtained from
the raked data, after the simulation space was divided into rectangular grids with areas equivalent to five boroughs. The physical location (x- and y- coordinates) of agents was randomly chosen based on boundary coordinates assigned to each boroughs.

6 Input data

The model did not require input data beyond what was provided in initializations, since the environment remained constant throughout the simulation.

7 Sub-models

The six sub-models along with specific equations to calculate behavioral probabilities are described in detail below:

7.1 Prior CBT/SPR enrollment

This sub-model determined whether an agent has used either CBT or SPR treatment before the occurrence of Hurricane Sandy. The probability with which an agent has used CBT in the past, prior to Hurricane Sandy, was calculated with a logistic regression equation estimated from the WTC population based survey, as below:

For PTSD cases:

\[
\text{Logit}(\text{priorCBT}) = 0.2887 + (-0.1323 \times \text{Male}) + (-0.4647 \times \text{Black}) + \\
(-0.4502 \times \text{Hispanic}) + (-1.2979 \times \text{OtherRace}) + \\
(0.1119 \times \text{Age}35 - 64) + (-0.1129 \times \text{Age65+})
\] (1)

For non PTSD cases:

\[
\text{Logit}(\text{priorCBT}) = -1.3360 + (-0.0881 \times \text{Male}) + (-0.7250 \times \text{Black}) + \\
(-0.3133 \times \text{Hispanic}) + (-0.7122 \times \text{OtherRace}) + \\
(0.6201 \times \text{Age}35 - 64) + (-0.6444 \times \text{Age65+})
\] (2)

\[
P(\text{priorCBT}) = \exp[\text{Logit}(\text{priorCBT})]/(1 + \exp[\text{Logit}(\text{priorCBT})])
\] (3)
where,

\[ \begin{align*}
\text{Male} &= 1 \text{ if an agent is male} \\
&= 0 \text{ if an agent is female} \\
\text{Black} &= 1 \text{ if an agent is black} \\
&= 0 \text{ otherwise} \\
\text{Hispanic} &= 1 \text{ if an agent is Hispanic} \\
&= 0 \text{ otherwise} \\
\text{OtherRace} &= 1 \text{ if an agent belongs to other race} \\
&= 0 \text{ otherwise} \\
\text{Age35-64} &= 1 \text{ if an agent is between ages of 35-64} \\
&= 0 \text{ otherwise} \\
\text{Age65+} &= 1 \text{ if an agent is 65 or older} \\
&= 0 \text{ otherwise}
\end{align*} \]

If a given agent’s probability, indicating the use of CBT in the past \( P(\text{priorCBT}) \), is less than a random number generated between 0 and 1, the variable “priorCBT” is assigned value equal to one at time-step zero, otherwise, it is assigned zero.

Similarly, the probability with which has used SPR treatment, prior to Hurricane Sandy, was calculated with following logistic regression equation estimated from WTC population based survey:

For PTSD cases:

\[ \text{Logit}(\text{priorSPR}) = 0.6048 + (-0.3331 \times \text{Male}) + (-0.5914 \times \text{Black}) + (-0.4878 \times \text{Hispanic}) + (-0.8119 \times \text{OtherRace}) + (0.2076 \times \text{Age}35 - 64) + (-0.0720 \times \text{Age}65+) \]  

(4)

For non-PTSD cases:

\[ \text{Logit}(\text{priorSPR}) = -1.095 + (-0.2119 \times \text{Male}) + (-0.5343 \times \text{Black}) + (-0.2377 \times \text{Hispanic}) + (-0.7551 \times \text{OtherRace}) + (0.5693 \times \text{Age}35 - 64) + (-0.5413 \times \text{Age}65+) \]  

(5)

\[ P(\text{priorSPR}) = \exp[\text{Logit}(\text{priorSPR})]/(1 + \exp[\text{Logit}(\text{priorSPR})]) \]  

(6)

Again, if a given agent’s probability, indicating the use of SPR in the past \( P(\text{priorSPR}) \), is less than a random number generated between 0 and 1, the variable “priorSPR” is assigned value equal to one at time-step zero, otherwise, it is assigned zero.

### 7.2 Use of Stepped Care/Usual Care

In this ABM, two treatment interventions (Stepped Care and Usual Care) were run simultaneously as a post-disaster treatment of Hurricane related PTSD. Intervention 1 simulated Stepped Care treatment whereas intervention 2 simulated usual post-disaster care, and specified that all agents seeking care were referred to SPR.
Stepped care treatment involved triage screening at initial entry to services. Agents were assessed for their current PTSD case status, and if they were tested positive for PTSD, they were referred to CBT treatment, otherwise, they were referred to SPR.

The probability with which an agent used CBT treatment was calculated by following logistic regression equation, estimated from WTC population based survey.

For PTSD cases:

\[
\text{Logit}(CBT) = -2.11 + (-0.1941 \times \text{Male}) + (-0.5237 \times \text{Black}) + (-1.0845 \times \text{Hispanic}) + (-0.2653 \times \text{OtherRace}) + (-0.1139 \times \text{Age35-64}) + (0.2455 \times \text{Age65+}) + (1.8377 \times \text{priorCBT})
\]  

(7)

For non PTSD cases:

\[
\text{Logit}(CBT) = -4.1636 + (-0.6422 \times \text{Male}) + (-0.8040 \times \text{Black}) + (-0.6795 \times \text{Hispanic}) + (0.1976 \times \text{OtherRace}) + (0.1453 \times \text{Age35-64}) + (-0.4203 \times \text{Age65+}) + (2.4109 \times \text{priorCBT})
\]  

(8)

\[
P(CBT) = \frac{\exp[\text{Logit}(CBT)]}{1 + \exp[\text{Logit}(CBT)]}
\]  

(9)

where,

\[
\text{Male} = 1 \text{ if an agent is male} \\
\text{Male} = 0 \text{ if an agent is female} \\
\text{Black} = 1 \text{ if an agent is black} \\
\text{Black} = 0 \text{ otherwise} \\
\text{Hispanic} = 1 \text{ if an agent is Hispanic} \\
\text{Hispanic} = 0 \text{ otherwise} \\
\text{OtherRace} = 1 \text{ if an agent belongs to other race} \\
\text{OtherRace} = 0 \text{ otherwise} \\
\text{Age35-64} = 1 \text{ if an agent is between ages of 35-64} \\
\text{Age35-64} = 0 \text{ otherwise} \\
\text{Age65+} = 1 \text{ if an agent is 65 or older} \\
\text{Age65+} = 0 \text{ otherwise} \\
\text{priorCBT} = 1 \text{ if an agent had ever used CBT prior to Sandy} \\
\text{priorCBT} = 0 \text{ otherwise}
\]

If the probability of using CBT is greater than the random number generated between 0 and 1, agents used CBT treatment at current time-step. The maximum number of sessions of CBT, an agent can have, ranged from 8 to 12 sessions. If agents continue to have PTSD, even after completion of initially assigned CBT treatment sessions, the treatment was extended from 16 to 24 sessions.

However, agents who tested positive for PTSD, but did not receive CBT treatment, were either enrolled into SPR treatment or did not receive treatment at all. They used SPR treatment
based on the computed probability for SPR uptake. Furthermore, agents who tested negative for PTSD, were also referred to SPR treatment. The maximum number of sessions for SPR was limited to 5. Among those agents who did not receive either SPR or CBT treatment, we assumed that 30% [3] will enter a course of spontaneous remission.

The probability with which an agent used SPR treatment was predicted by following logistic regression equation estimated from WTC data collected among NYC residents in following the terrorist attacks of September 11th:

For PTSD cases:

\[
\text{Logit}(SPR) = -1.7778 + (0.00136 \times \text{Male}) + (-0.6774 \times \text{Black}) + \\
(-0.8136 \times \text{Hispanic}) + (-0.3118 \times \text{Other Race}) + \\
(-0.0549 \times \text{Age35} - 64) + (0.3746 \times \text{Age65+}) + \\
(1.4076 \times \text{priorSPR})
\]

For non PTSD cases:

\[
\text{Logit}(SPR) = -3.7355 + (-0.5319 \times \text{Male}) + (-1.2562 \times \text{Black}) + \\
(-0.4632 \times \text{Hispanic}) + (0.1427 \times \text{Other Race}) + \\
(0.1703 \times \text{Age35} - 64) + (-0.5289 \times \text{Age65+}) + \\
(2.0696 \times \text{priorSPR})
\]

\[
P(SPR) = \frac{\exp[\text{Logit}(SPR)]}{1 + \exp[\text{Logit}(SPR)]}
\]

where,

\[\text{priorSPR} = 1 \text{ if an agent had ever used SPR prior to Sandy} \]
\[= 0 \text{ otherwise}\]

7.3 Decline in PTSD symptoms following CBT and SPR treatment

This sub-model computes the decline in PTSD symptoms after agents undergo CBT or SPR treatment. For agents enrolled into CBT treatment, the proportion for reduction in PTSD symptom over the course of CBT treatment was estimated from [4]. The reduction in PTSD symptom count after receiving CBT treatment was calculated as:

\[
\text{PTSD}_x = \text{PTSD}_x - \left(\text{prop(PTSD}_x \text{ CBT)} / \text{CBT SESSIONS}) \times \text{PTSD}_x
\]

In Eq. 13, PTSD\_x is number of symptoms of PTSD, range of (6-17) for PTSD cases, prop(PTSD\_x \text{ CBT}) is the proportion of PTSD\_x reduction after CBT treatment which was set to 0.36 and CBT SESSIONS is the duration of CBT treatment, ranging from 8-12 sessions.

Similarly, the proportion of reduction in PTSD symptoms for agents using SPR treatment was also estimated from [4]. The reduction in PTSD symptoms after using SPR treatment can be calculated as:

\[
\text{PTSD}_x = \text{PTSD}_x - \left(\text{prop(PTSD}_x \text{ SPR)} / \text{SPR SESSIONS}) \times \text{PTSD}_x
\]

where, prop(PTSD\_x \text{ SPR}) is the proportion of PTSD\_x reduction after SPR treatment which was set to 0.20 and SPR SESSIONS is the duration of SPR treatment (5 sessions).
Besides that, there was a slight reduction in symptoms by natural decay among 30% of the agents that do not receive any treatment[3]. The proportion with which PTSD symptoms decline by natural decay, over the course of 3 months, was estimated from [4]. The reduction in PTSD symptoms by natural decay can be calculated as:

\[ PTSD_x = PTSD_x - \left( \frac{\text{prop}(PTSDx\ text{ND})}{\text{NUM \text{WEEKS}}} \right) \times PTSD_x \]  
(15)

where, \( \text{prop}(PTSDx\ text{ND}) \) is equal to 0.14 which represents proportion of reduction in PTSD symptom by natural decay and \( \text{NUM \text{WEEKS}} \) is set to 12 weeks (3 months) which represent the duration at which \( \text{prop}(PTSDx\ text{ND}) \) is estimated.

### 7.4 Relapse of PTSD symptoms

This sub-model determines whether an agent will undergo a relapse phase after recovering from PTSD. It was modeled based on initial severity of PTSD, such that agents with symptoms greater than 11 at the start of the simulation, had the greatest chance of symptom relapse. Relapse of symptoms did not occur immediately, however, but happened 2-3 months (8-13 weeks) after recovery. Furthermore, the percentage of recovered agents who will underwent a relapse phase ranged from 15-20%, the number of relapses an agent can undergo was set to 1, and the proportion of initial symptoms that present under relapse was set to 0.8.

### 8 Risk Differences

Risk difference can be defined as the change in the risk of an outcome for a given treatment or exposure in comparison to another treatment/exposure. In this ABM, risk differences have been used to calculate the difference between ratio of PTSD recovery in Stepped Care and ratio of PTSD recovery in usual care. The formula to calculate the risk difference for PTSD recovery can be generalized as:

\[ \text{RiskDiff} = \frac{a}{a+b} - \frac{c}{c+d} \]

where,

- \( a \) = number of PTSD cases resolved by Stepped Care
- \( b \) = number of PTSD cases NOT resolved by Stepped Care
- \( c \) = number of PTSD cases resolved by Usual Care
- \( d \) = number of PTSD cases NOT resolved by Usual Care

### 9 Risk Ratios

Risk ratio can be defined as the ratio of the probability of occurrence of an event in an exposed group to the probability of occurrence of an event in non-exposed group. In this ABM, the risk ratios have been used to compare the resolution of PTSD cases among the agents who used Stepped Care treatment versus the agents who used only SPR treatment. The formula to calculate the risk ratio, to compare the resolution of PTSD, can be generalized as:
\[ RiskRatio = \frac{\alpha}{\frac{a+b}{c+d}} \]

where,

- \( a \) = number of PTSD cases resolved by Stepped Care
- \( b \) = number of PTSD cases NOT resolved by Stepped Care
- \( c \) = number of PTSD cases resolved by Usual Care
- \( d \) = number of PTSD cases NOT resolved by Usual Care

Risk ratios can range from 0 to infinity. If the value of risk ratio is 1, it implies that there is neither increase nor decrease in PTSD resolution among people who used SPR treatment. The risk ratio will be less than 1 if number of PTSD cases resolved by Stepped Care is less than PTSD cases resolved by SPR treatment. Conversely, when the number of PTSD cases resolved by Stepped Care is greater than the number of cases treated by SPR, the risk ratio will be greater than 1.

10 Disability Adjusted Life Years (DALYs)

Disability Adjusted Life Years (DALYs) can be defined as number of years lost due to some disease, sickness or syndromes. The DALYs has two notable components, namely, Years of Life Lost (YLL) and Years Lost due to Disability (YLD). YLL refers to the number of additional years an individual would have lived without the disease. YLD measures the number of years of productive life that is lost due to disability caused by particular health indicator.

In this ABM, number of years lost (DALYs) due to PTSD is calculated to compare the cost effectiveness of two treatments - Stepped Care and SPR alone. The Years of Life Lost (YLL) is not calculated since PTSD does not attribute to premature death of an individual. Thus, DALYs are calculated solely based on Years Lost due to Disability (YLD) in this model. YLD, for each agent, can be calculated as:

\[ YLD = DW \times L \]

where,

- \( YLD \) = Years Lost due to Disability
- \( DW \) = Disability Weight
- \( L \) = Duration of the health indicator (PTSD)

The disability weight measures the severity of the health indicator (PTSD in this case) from a scale of 0 to 1, with 0 representing a perfect health and 1 representing death. The severity of disability caused by PTSD can be classified as mild (\( DW = 0.03 \)), moderate (\( DW = 0.149 \)) and severe (\( DW = 0.523 \)) based on the PTSD symptom count of an individual.
11 Cost Effectiveness Analysis (CEA)

CEA can be defined as a method to assess the health benefits received from a particular intervention in relation to cost of that intervention. It is calculated by dividing the overall cost of the treatment by number of life years saved by that treatment. In this ABM, we present Cost-Effective Analysis (CEA) of two interventions - Stepped Care and SPR alone, based on DALYs saved and PTSD free days. Cost-Effective Analysis is carried out by evaluating cost-effectiveness ratio which calculates the cost of each intervention (both Stepped Care and usual care) relative to DALYs saved and PTSD free days from that intervention. It was also used to evaluate incremental cost-effectiveness ratio which was calculated by dividing incremental cost with incremental effectiveness. Incremental cost, in this ABM, refers to the net cost of Stepped Care (i.e. difference between total cost of Stepped Care and SPR alone) where as incremental effectiveness refers to DALYs averted (or net PTSD free days) as a result of Stepped Care treatment. The general formula to calculate cost-effectiveness ratio (or incremental cost-effectiveness ratio) is:

$$ CER = \frac{C1 - C2}{E1 - E2} $$

where,

- $CER$ = Cost Effectiveness Ratio
- $C1$ = Total cost of intervention 1 (Stepped Care)
- $C2$ = Total cost of intervention 2 (SPR alone)
- $E1$ = Total DALYs (or PTSD free days) in Stepped Care cohort
- $E2$ = Total DALYs (or PTSD free days) in SPR alone cohort

12 Discounting future costs and benefits

In health economics, discounting can be defined as a method to adjust future costs and benefits of health care interventions in present-day terms [5]. In this ABM, the discounting of costs and outcomes (DALYs) was done for both Stepped Care and Usual care (SPR alone). The standard discount rate of 3% is applied to both costs and health outcomes. The general formula to discount future cost is:

$$ PresentValue = \frac{FutureValue}{(1 + r)^n} $$

where,

- Present value = Cost of treatment in present terms
- Future value = Future cost of treatment
- $r$ = discount rate
- $n$ = number of years in the future

The discounted DALYs, in our model, was calculated by using the formula [6]:

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\[ \text{DiscountedDALY} = DW \times \frac{1}{r} \times (1 - e^{-rN}) \]

where,

- \( DW \) = Disability weight
- \( r \) = discount rate
- \( N \) = number of years in the future
# Summary of agent characteristics and initialization parameters

## 1. Agent characteristics, values and description

<table>
<thead>
<tr>
<th>Agent characteristics</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age1 (18-34) &lt;br&gt;Age2 (35-64) &lt;br&gt;Age3 (65+)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male &lt;br&gt;Female</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>White non-Hispanic &lt;br&gt;Black non-Hispanic &lt;br&gt;Other non-Hispanic Hispanic</td>
<td></td>
</tr>
<tr>
<td>Borough</td>
<td>Bronx &lt;br&gt;Brooklyn &lt;br&gt;Manhattan &lt;br&gt;Queens &lt;br&gt;Staten Island</td>
<td></td>
</tr>
<tr>
<td>Strata</td>
<td>1-24</td>
<td>Cross-classification based on gender, race and age.</td>
</tr>
<tr>
<td>PTSD symptom</td>
<td>0-17</td>
<td>Estimated from an observational survey conducted among Hurricane Sandy survivors.</td>
</tr>
<tr>
<td>Probability of CBT use</td>
<td>0-1</td>
<td>Estimated from WTC data based on age, gender, race and prior enrollment in CBT treatment</td>
</tr>
<tr>
<td>Probability of SPR use</td>
<td>0-1</td>
<td>Estimated from WTC data based on age, gender, race and prior use of SPR treatment</td>
</tr>
</tbody>
</table>
2. Initialization parameters and default values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of agents</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Number of Boroughs</td>
<td>5</td>
</tr>
<tr>
<td>Number of Strata</td>
<td>24</td>
</tr>
<tr>
<td>Number of CBT sessions</td>
<td>12</td>
</tr>
<tr>
<td>Number of SPR sessions</td>
<td>5</td>
</tr>
<tr>
<td>Symptom reduction by CBT</td>
<td>0.36</td>
</tr>
<tr>
<td>Symptom reduction by SPR</td>
<td>0.20</td>
</tr>
<tr>
<td>Symptom reduction by Natural Decay</td>
<td>0.14</td>
</tr>
<tr>
<td>Waiting time for PTSD relapse</td>
<td>13 weeks</td>
</tr>
<tr>
<td>Simulation duration</td>
<td>104 weeks</td>
</tr>
<tr>
<td>Number of trials</td>
<td>50</td>
</tr>
</tbody>
</table>
14 Model flow charts

1. Flow chart indicating steps in model initialization

   Divide 760 X 400 simulation space into rectangular grid representing 5 boroughs of NYC

   Assign demographic attributes (age, gender, race and borough) as well as PTSD status to agents

   Randomly choose agent's physical location based on boundary coordinates of boroughs
2. Flow chart for the processes occurring at each time-step of the model

- **Determination of prior CBT enrollment**
  - Calculate probability of prior CBT enrollment \( P(\text{priorCBT}) \)
  - Is \( P(\text{priorCBT}) > \text{rand}(0,1) \)?

- **Determination of prior SPR enrollment**
  - Calculate probability of prior SPR enrollment \( P(\text{priorSPR}) \)
  - Is \( P(\text{priorSPR}) > \text{rand}(0,1) \)?

- **Agent receives PTSD treatment**
  - Stepped Care
    - Calculate probability of using CBT \( P(\text{CBT}) \)
    - Is \( P(\text{CBT}) > \text{rand}(0,1) \) ?
    - Agent uses CBT
    - Agent uses SPR
  - SPR
    - Calculate probability of using SPR \( P(\text{SPR}) \)
    - Is \( P(\text{SPR}) > \text{rand}(0,1) \) ?
    - Agent uses SPR

- **Decline in PTSD symptoms**
  - Stepped Care
    - Is agent receiving CBT?
    - Calculate decline in PTSD symptom from Eq.9
  - SPR
    - Is agent receiving SPR?
      - Calculate decline in PTSD symptom from Eq.10

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Relapse of PTSD symptoms → Did agent recover from PTSD? Y → Is PTSDx >12? Y → Is time after recovery greater than time for relapse? Y → Agent undergo relapse phase Y → Is proportion for relapse greater than rand(0,1)?
15 Pseudo-code

MODEL INITIALIZATION

1. Assign demographic characteristics to agents

Algorithm 1 Assign characteristics to agents

1: procedure AgentCharacteristics()
2: for $i = 1$ to number of agents do
3:   assign ID to agent $i$
4:   random = rand(0, 1)
5:   if (random $<$ pBronx) then $\triangleright$ pBronx: proportion of agents in Bronx
6:     assign strata, age, race and PTSD status
7:     borough = Bronx
8:   end if
9:   if (random $<$ pBrook) then $\triangleright$ pBrook: proportion of agents in Brooklyn
10:  assign strata, age, income and race
11:  borough = Brooklyn
12: end if
13: if (random $<$ pManh) then $\triangleright$ pManh: proportion of agents in Manhattan
14:  assign strata, age, race and PTSD status
15:  borough = Manhattan
16: end if
17: if (random $<$ pQueens) then $\triangleright$ pQueens: proportion of agents in Queens
18:  assign strata, age, race and PTSD status
19:  borough = Queens
20: end if
21: if (random $<$ pStaten) then $\triangleright$ pStaten: proportion of agents in Staten Island
22:  assign strata, age, race and PTSD status
23:  borough = Staten Island
24: end if
25: end for
2. Assign PTSD symptoms

Algorithm 2 Assign PTSD symptoms to agents

1: procedure PTSDsymptomcount()
2: for $i = 1$ to number of agents do
3:     for $j = 1$ to number of strata do
4:         if (strata=$j$) then
5:             if (agent $i$ doesn’t have PTSD) then
6:                 Assign PTSD count is less than 6 for agent $i$
7:             end if
8:             if (agent $i$ has PTSD) then
9:                 Assign PTSD count greater than 6 for agent $i$
10:            end if
11:        end if
12:     end for
13: end for
MODEL STEPS

1. Prior CBT/SPR enrollment

Algorithm 3 Prior CBT/SPR enrollment

1: procedure priorTreatment()
2:     if (iteration = 0) then
3:         for i = 1 to number of agents do
4:             if (agent i has PTSD) then
5:                 calculate probability of prior CBT(pPriorCBT) use by agent i
6:                 random = rand(0, 1)
7:                 if (random < pPriorCBT) then
8:                     agent i has a history of CBT use
9:                 else
10:                     agent i doesn’t have a history of CBT use
11:             end if
12:         end if
13:     calculate probability of prior SPR (pPriorSPR) use by agent i
14:     random = rand(0, 1)
15:     if (random < pPriorSPR) then
16:         agent i has a history of SPR use
17:     else
18:         agent i doesn’t have a history of SPR use
19: end if
20: end for
21: end if

2. PTSD treatment through SPR alone

Algorithm 4 PTSD treatment through SPR alone

1: procedure PTSDtreatmentSPR()
2:     for i = 1 to number of agents do
3:         if (agent i has PTSD) then
4:             calculate probability of using SPR (pSPR)
5:             random = rand(0, 1)
6:             if (random < pSPR) then
7:                 agent i use SPR treatment
8:         end if
9:     end if
10: end for
3. PTSD treatment through Stepped Care

**Algorithm 5** PTSD treatment through Stepped Care

```plaintext
1: procedure PTSDtreatmentSteppedCare()
2:   for i = 1 to number of agents do
3:     if (agent i has PTSD) then
4:       calculate probability of using CBT (pCBT)
5:       random = rand(0, 1)
6:       if (random < pCBT) then
7:         agent i use CBT treatment
8:     else
9:       calculate probability of using SPR (pSPR)
10:      random = rand(0, 1)
11:     if (random < pSPR) then
12:       agent i use SPR treatment
13:     end if
14:   end if
15: end for
```

4. Resolution of PTSD symptoms in SPR

**Algorithm 6** Resolution of PTSD symptoms in SPR

```plaintext
1: procedure PTSDResolutionSPR()
2:   for i = 1 to number of agents do
3:     if (agent i has PTSD) then
4:       if (agent i used SPR) then
5:         calculate decline PTSD symptoms from SPR
6:     end if
7:     if (PTSDx > 6) then
8:       agent i still has PTSD
9:     else
10:    agent i is free from PTSD
11:   end if
12: end if
13: end for
```
5. Resolution of PTSD symptoms in Stepped Care

Algorithm 7 Resolution of PTSD symptoms in Stepped Care

1: procedure PTSDresolutionSteppedCare()
2:     for \( i = 1 \) to number of agents do
3:     if (agent \( i \) has PTSD) then
4:        if (agent \( i \) used CBT) then
5:            calculate decline PTSD symptoms from CBT
6:        end if
7:        if (agent \( i \) used SPR) then
8:            calculate decline PTSD symptoms from SPR
9:        end if
10:       if (PTSDx >6) then
11:          agent \( i \) still has PTSD
12:       else
13:          agent \( i \) is free from PTSD
14:       end if
15:     end if
16:  end for

6. Relapse of PTSD symptoms

Algorithm 8 Relapse of PTSD symptoms

1: procedure RelapsePTSDsymptoms()
2:     for \( i = 1 \) to number of agents do
3:     if (agent \( i \) recovered from PTSD) then
4:        if (PTSDx >12) then \( \triangleright \) use PTSDx initialized at the start
5:            recoveryTime += 1
6:        if (recoveryTime >relapseTime) then
7:            random = \text{rand}(0,1)
8:            if (random <pRelapse) then \( \triangleright \) pRelapse = 0.15-0.2
9:               agent \( i \) undergo PTSD relapse
10:           end if
11:        end if
12:     end if
13:  end if
14: end for

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References


