The Psychiatric Bed Crisis in the US:

Understanding the Problem and Moving Toward Solutions

Section 6

Creating Models for Estimating the Number of Needed Psychiatric Beds

AMERICAN PSYCHIATRIC ASSOCIATION

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Task Force Subgroup Members Contributing to This Section

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A. Motivating Question: How Many Beds are Needed?

Within mental health systems, a continuum of care is required to meet individuals' needs in the most accessible and least restrictive environment (e.g., including outpatient services, crisis services, community support services, and inpatient psychiatric care) — as described well in other sections of this report (e.g., Sections 5 and 7). Although inpatient psychiatric care provides essential services to help stabilize individuals who are experiencing acute mental health crises, it is unclear how many beds are needed within a given community, region, or state to meet demand. To date, local and state decision-makers have typically been limited in their ability to effectively assess how many beds are needed within a given catchment region, relying on historical bed use and waitlist data for the region, rough estimates of the numbers of beds needed per 100,000 population, and/or budget and resource constraints. What is clear is that the number of beds per number of people alone is not sufficient to estimate system capacity. It is essential to also consider services that provide treatment and crisis services in advance of possible admission, as well services that could facilitate discharge once an admission does occur.

B. Why is this a Complex Question?

Determining the number of inpatient psychiatric beds needed within a given region is a complex question. In particular, there are a number of different types of inpatient beds available that vary from community to community and state to state. The demand for these beds depends not only on the distribution of these beds (e.g., the percentage of inpatient beds in state psychiatric hospitals versus general hospitals) but also the array of other outpatient services, crisis services, and community support services available within the region. Communities with more robust outpatient, crisis, and community support service systems may require fewer inpatient psychiatric beds than those regions with a less robust non-inpatient service system. The number of beds required in a given region is also dependent on the underlying population within that region and the frequency with which acute psychiatric crises are experienced by the population, for example, varying depending on the population variables noted in Section 4. In addition, services that can result in effective and accessible discharge or step down are also a necessary consideration. Because of these interdependencies, the number of beds needed within a given region cannot be estimated using a simple ratio of the number of beds required per population or similar approach.

Decision support tools are needed to help inform and refine decisions about the availability of mental health services within a given area to ensure that individuals in need of services are receiving the appropriate level of care in a timely manner. Decision-analytic models can be used to simulate the current demand for and supply of inpatient and outpatient mental health services to evaluate changes to the service system in real-time without making potentially costly and/or time-consuming changes to the actual system. For example, these models can estimate the effects of adding inpatient capacity on the number of individuals who can be served and amount of time these individuals wait for admission (for example, see La, et al., 2016). Similar scenario analyses can be conducted on other types of services as well (e.g., evaluating the effects of adding assertive community treatment (ACT) team, and/or mobile crisis capacity).

C. Approach to Bed Needs Estimation

With mental health care delivery differing by context and content, state by state, building a universal model to estimate bed need proves challenging. The system dynamics model explained here is a preliminary effort at capturing the complex dynamics at play in a given service system. Our intention was to build a "concept model" representing common service components and pathways and realistic (adjustable) parameters that can be used to illustrate nonlinear queueing dynamics and feedback loops present in real-world systems. Feedback loops document interconnections between model variables that are important in shaping how the system responds to change over time. As one example, when waits for care in the ED or crisis receiving facility become longer, individuals in acute mental health crisis might be arrested, temporarily pulling them from the acute mental health crisis system. However, some fraction of these individuals will need competency restoration, which utilizes limited inpatient resources, and may lead decision-makers to consider shifting civil inpatient capacity to meet urgent forensic needs. Doing so makes civil inpatient capacity more limited, leading to longer wait times (and the loop continues until other decisions are made).

Our concept model representing “Anytown, US” is meant to be realistic, but not real. We hope that such a model can serve as a prototype for future model iterations, adapted to capture more complex dynamics in a specific system or used to learn what balance of capacities is most appropriate under which community characteristics. We also believe that where definitions move the field toward adopting a common crisis service system vocabulary, discussion of an explicit conceptual (concept) model can promote a shared understanding of the most common but distinct patterns of system utilization and encourage revision of cross-system decision-makers’ “mental models” (internal and too-often unshared and unchecked understanding) of how the system should function.

While there are many approaches to building a simulation model, a system dynamics model was chosen because: (1) it focuses attention on the interconnected stocks (accumulations, e.g., people currently served or waiting in various model components or discrete services) within the system as shaped by the balance between in-flow (demand) and out-flow (e.g., stabilization, transfer, discharge) over time – and the factors that affect those flows; (2) it allows for studying a system more broadly by mapping and then modeling its behavior at a higher level of aggregation than other approaches like individual-based microsimulation or discrete event simulation modeling; and, (3) it encourages consideration of system feedbacks – ways in which the system responds to changes in outcomes over time that can either create balance ("balancing" or control loops) or encourage further change ("reinforcing" vicious/virtuous cycles) (Lich et al., 2013; Morrissey, et al., 2012; Hassmiller Lich and Kuhlberg, 2020; Sterman, 2000).

Related to the second point, system dynamics allows the creation of a model dashboard that decision-makers could interact with in real time to learn how changes in the capacity of different model components affect system outcomes. This is useful to communities striving to learn how to improve community-level outcomes (e.g., collaborations seeking to find the right balance of system resources that reduce wait times with fixed resources/budgets). They can be used to make the business case for growing resources within a given system component (e.g., hospital unit, community crisis resource, jail diversion program) or for shifting resources across organizational/sector lines (e.g., increasing the budget for mobile crisis or civil inpatient care through re-allocating forensic or criminal justice resources that can be used to prevent and reduce criminal involvement of individuals in acute mental health crisis). Decisions about how resources are allocated are made at the community, regional, and state levels – and decision support models such as this can inform piece-wise decisions as well as grow coordination across the system. Whether decision-makers represent community organizations, local or state government, health system leadership, payers, patients, patient advocates, legislators, or other perspectives, decision support models can be used to check their understanding of cause-and-effect relationships (e.g., how changes in model parameters they or others might affect will alter outcomes they care about). System improvement starts from having a better and shared understanding of complex system dynamics. Despite these benefits, a recent review of simulation applied to mental health (Long and Meadows, 2018) found that interactive dashboards such as this were incredibly rare, having been built for only eight studies (of 160 identified), largely with a much narrower modeling focus than proposed here. The model's dashboard was designed for direct decision-maker use in only one of these eight studies, and that with a very narrow purpose (menu planning). Clearly a concept model with an interactive dashboard is needed to advance the use of simulation in mental health system strengthening initiatives.

A system dynamics model was developed using Vensim software (https://vensim.com/) to simulate the stocks (numbers of) individuals in each of nine clinical service components of the system serving adults in acute mental health crisis over time: number in community, in the emergency department waiting, in the emergency department (receiving care and/or boarding), in a hospital bed, in a crisis receiving center, in a community-based crisis bed, engaged with intensive team-based care, in jail awaiting competency restoration, or in competency restoration. Flows into and out of each stock are depicted in the model structure diagram presented in Figure 1 (Panels A-F), along with key variables affecting rates of flow and important outcomes to track. The model structure diagram was developed by coauthors of this section, with input from Task Force members, with the goal of providing an overview of system structure common across many U.S. communities.

The current version of the Anytown, US concept model includes structure in the diagram, except for that indicated with dashed lines, and simulates outcomes over time that are described in bold plum-colored font. Clouds are used to denote model boundaries; flows from a cloud indicate data or equations are used to calculate inflow, but specific model structure producing those numbers are not included in the model (e.g., the community-based outpatient care system and how it affects the incidence rate of acute mental health crises). Flows out to a cloud indicate explicit tracking of subpopulations ceases. The concept model simulates outcomes for a generic region of the US over a 1-year period. Definitions of key model components are provided in Table 2. For the Anytown, US concept model, we sought to include common acute mental health crisis system components present in diverse communities, though this required aggregating different types of inpatient psychiatric hospital beds delineated in Section 2 (e.g., state psychiatric hospital beds, general medical hospital psychiatric beds, private psychiatric hospital beds, VA health care facility psychiatric inpatient beds, medical/psychiatric unit beds, and scatter hospital beds).

Table 2. Psychiatric Bed Need Model Definitions

Model Component	Definition
Acute mental health crisis	Mental health crisis that "requires something more than a typical outpatient or phone intervention" (National Association of State Mental Health Program Directors, 2018)
Community-based crisis bed	Mental health beds located in community-based facilities that are less secure than mental health hospital beds
Intensive team-based care	Programs such as Assertive Community Treatment (ACT) teams that provide care to the most severely ill individuals in a given community, responding to their clients' acute MH crises.
Mental health crisis receiving center	Community-based facility where individuals experiencing acute mental health crises can receive up to 23 hours of psychiatric treatment and observation, resolving the crises or triaging patients to next levels of care (e.g., emergency departments, community-based crisis beds, inpatient care)
Mental health hospital bed	Inpatient psychiatric beds in secure facilities (e.g., state psychiatric hospitals, private psychiatric hospitals, general hospital psychiatric units, general hospital scatter beds, medical units with psych support)
Mobile crisis	Mobile teams that can be dispatched to respond to acute crises, resolving the crises on site or triaging patients to next levels of care (e.g., emergency departments, mental health crisis receiving centers)
Step-down program*	Treatment programs such as intensive outpatient programs and partial hospitalization programs that allow individuals to return to the community while receiving more intensive services that might otherwise be received in an inpatient setting

*Included in qualitative model structure diagram but not in the quantified concept model

Note: these are simplified definitions for use in the concept model.

D. Model Structure

For the concept model representing Anytown, US, we considered multiple factors influencing the magnitude of bed need in many service areas including the population size, estimates of the rate of acute mental health crises per 100,000 population, adequacy of the community mental health system, intersection between the mental health and criminal justice systems, and outpatient and inpatient capacities. While model community outpatient service system adequacy or capacity is not explicitly modeled, it enters the model through a parameter adjusting the rate of acute mental health crises per year, assuming a stronger and more accessible outpatient system will reduce but not eliminate acute crises. Relationships between each of these factors and bed need are illustrated schematically in the model structure diagram presented in this section (built up through Figure 2 Panels A-F). Empirical studies and expert opinion were used to inform the directionality and magnitude of these relationships, with placeholder data used to populate concept model input parameters. When adapted to a given community, these parameter values represent a starting point, but will need to be re-estimated/updated given local data, expert opinion, and current evidence.

As shown in the model structure diagram (Figure 2A), individuals in the community experience a given number of acute mental health crises annually. This number of crises is affected by several factors, including the average annual rate of crises per 100,000 population, the number of adults in the modeled community, and other relevant characteristics of the community (i.e., the adequacy of the community mental health system represented through a multiplier that could scale up or down the acute crisis rate), and the number of individuals engaged with intensive team-based care). Future iterations of the model may further take into account other factors affecting rates of acute mental health crises (e.g., adequacy of basic necessities of living), as denoted in the diagram using dashed lines.

Patients in acute crisis enter the acute mental health crisis system through three pathways — the emergency department, community-based crisis care, and the carceral system – and then stabilize after receiving this or other downstream care. These three pathways correspond to three overlapping service strata whose capacity to deliver mental health care depends on several factors whose relationships to each other and outcome variables are delineated in model structure diagrams and text below. The model attempts to measure key outcome variables important to different decision-makers and other stakeholders within a given community. These include the number of acute mental health crises, mobile crisis encounters (if such services exist in the area), time spent in the emergency department, jail, or other patient pre-admission holding area, the volume of mental health crisis arrests, utilization of beds (e.g., average and variation in census), as well as length of stay in service components. For some, discharge from the acute mental health crisis system will eventually precede re-admission, making it important to capture key “feedback loops” shaping the special circumstances like arrest during acute crisis and release with/without linkage to community supports or discharge support from emergency departments, inpatient stay, crisis beds, or other service components have on the expected time to a next acute crisis.

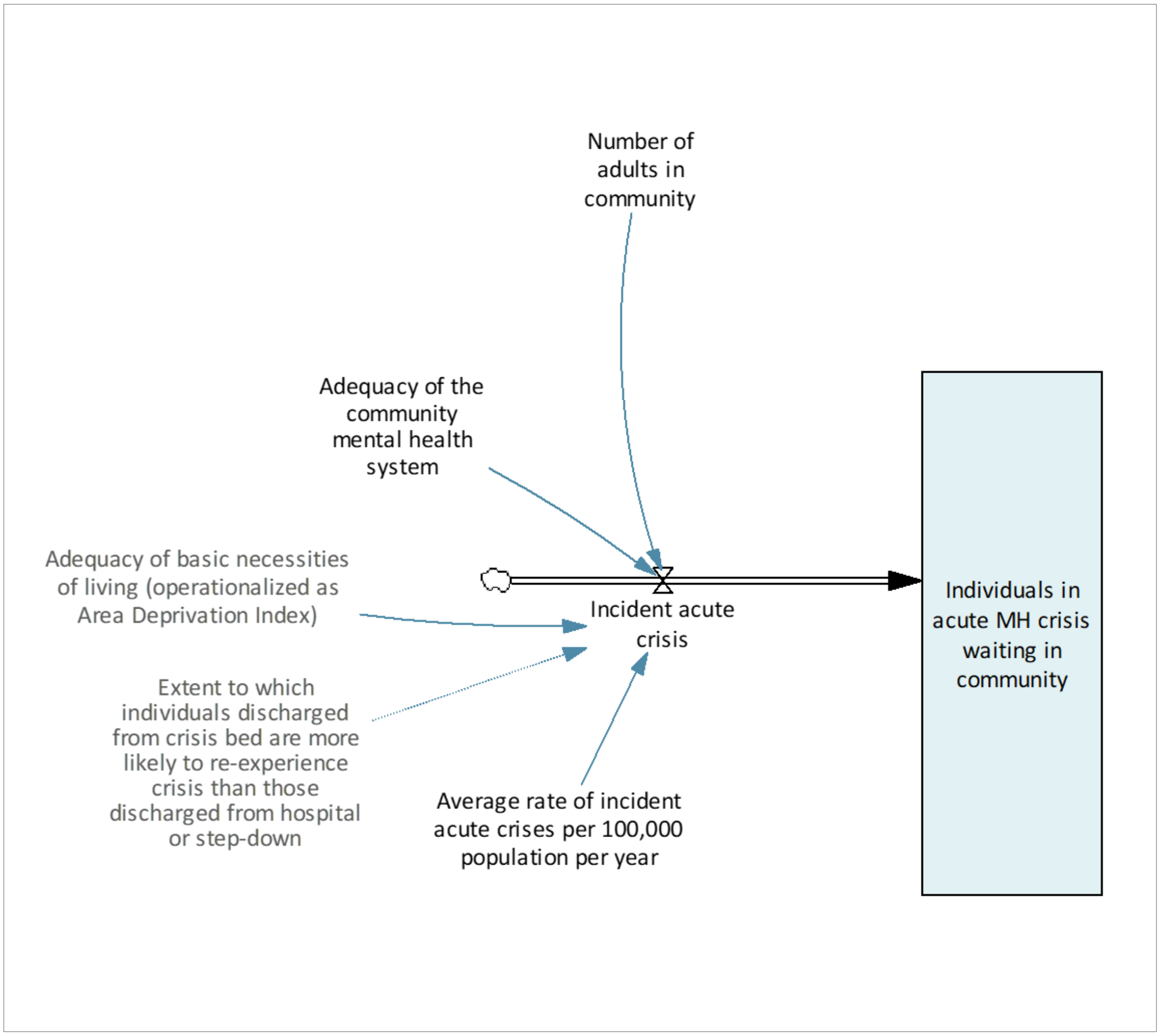

Figure 2 Panel A: Model structure diagrams are used to present an overview of the model's structure, including key variables and their effects (black text and blue arrows) and flows (pipelines) that determine the number of adults in acute mental health crisis in each stock (shaded box) over time. Here we see the modeled factors affecting the number of incident acute mental health crises among adults over time. Initially, individuals in crisis are in the community (as opposed to an acute care setting) until they transition out (not shown). A cloud indicates model boundaries – dynamics not explicitly modeled. For example, while we track incident crises, we do not model how they occur as a function of population interactions with a community outpatient care system. NOTES: MH = mental health.

The model assumes that individuals in acute mental health crisis who are waiting in the community can access mental health services or experience events that impact future service use through one of three pathways: by visiting an emergency department (ED), by visiting a mental health crisis receiving center, or by being arrested (where they may or may not receive competency restoration or other therapeutic services). Based on expert clinical opinion, a typical community might see approximately 47.5% of individuals experiencing crises seeking care in an ED or mental health crisis receiving center, each, with the remaining 5% of individuals expected to be arrested. The longer an individual has to wait in either care setting, the chances increase that they will abandon the facility, leading to a chance of arrest once back in the community before they receive additional support.

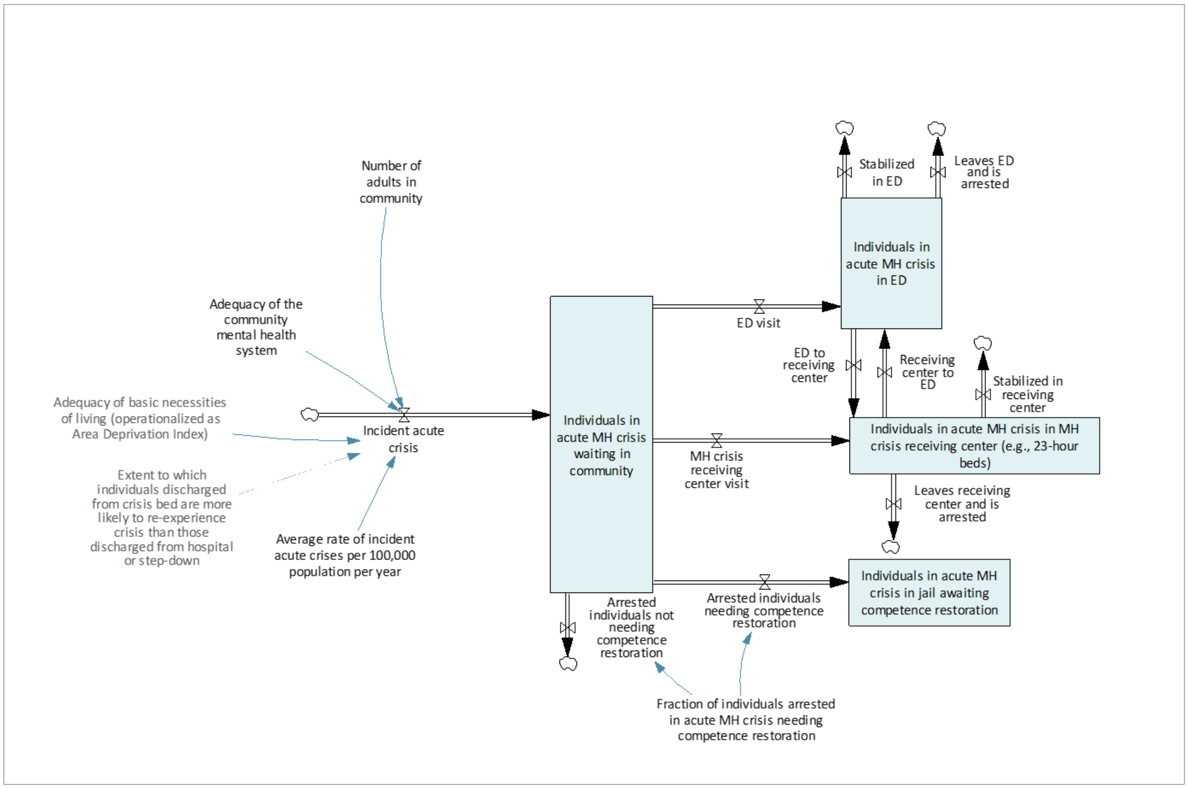

Figure 2 Panel B: Model structure diagram depicting three pathways through which adults in crisis enter the acute mental health crisis system – through an ED, crisis receiving center, or jail. Not illustrated, if wait times exceed a specified threshold in the ED or the crisis receiving facility, we assume individuals cycle back to the community where they are again at risk of arrest. As described in Figure 2-A, clouds indicate model boundaries. In Figure 2-B you can see that we do not model community services received after individuals leave the acute crisis system (e.g., after they are stabilized or arrested without need of competency restoration). NOTES: ACT = Assertive Community Treatment; ED = emergency department; MH = mental health.

Beyond these three pathways, the model includes the provision of mobile crisis and intensive team-based care (added in figure 2-C). Mobile crisis teams go onsite to help an individual in acute crisis with the goal of stabilizing the situation, which this model estimates to be 50% of the time or directing the individual to a crisis receiving center or ED where they can receive the most appropriate care, which 50% of the time results in hospitalization. Each mobile crisis team may engage up to four individuals per day in acute crisis.

Intensive team-based services work with an identified group of individuals with chronic need who experience an estimated 12 crises per year ("frequent users" of the acute care system). Intensive wrap-around services are estimated to reduce the number of acute crises entering the system by 90%. When inpatient care is needed, patients are routed to the ED (avoiding risk of arrest). Each team services a group size consisting of 50 individuals.

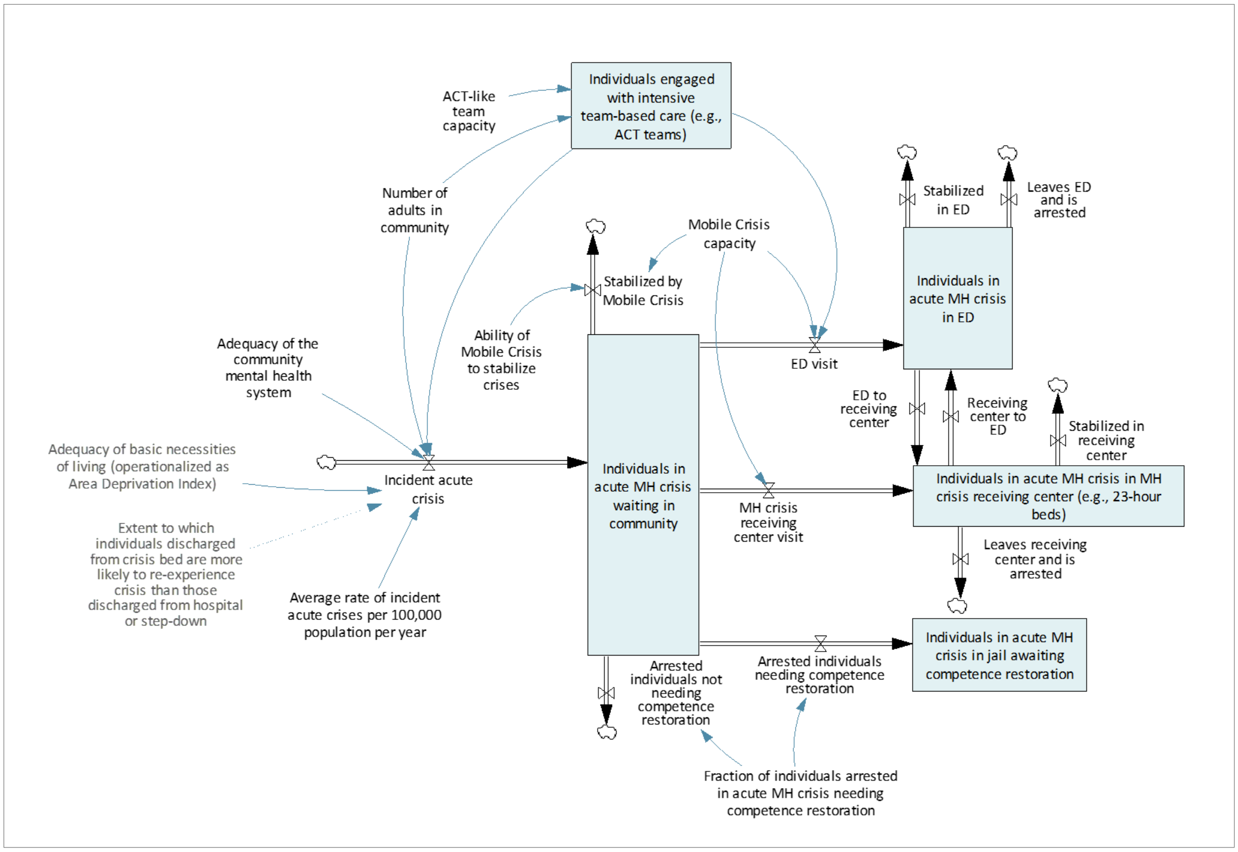

Figure 2 Panel C: Model structure diagram adding intensive team-based care stocks and mobile crisis capacity (which supports stabilization pre-receiving facility in some cases and guides patients to the most appropriate receiving facility, avoiding arrest). NOTES: ACT = Assertive Community Treatment; ED = emergency department; MH = mental health.

As illustrated in Figure 2-D, individuals in acute mental health crisis in an ED can stabilize and return to the community, leave the ED before being stabilized (some will return to the ED or seek care at the crisis receiving center, while others may be arrested with the same probabilities as used for initial routing) or they may be admitted to a mental health hospital bed. As described in Section 5, because the length of stay for individuals admitted to a mental health hospital bed or crisis bed can either be short (e.g., “acute” -- under 30 days) or, less frequently, longer, we assume that length of stay follows an exponential distribution to capture both. To ensure a minimum length of stay once admitted, we implement a third-order exponential time delay (i.e., pass individuals through a series of three exponentially distributed delays before being discharged). Individuals admitted to mental health hospital beds are assumed to have an average length of stay of seven days and then are discharged from the hospital. While not currently included in the concept model, Figure 2-E documents the potential role step-down programs could play in offering an alternative treatment option from inpatient care (hospital or crisis beds).

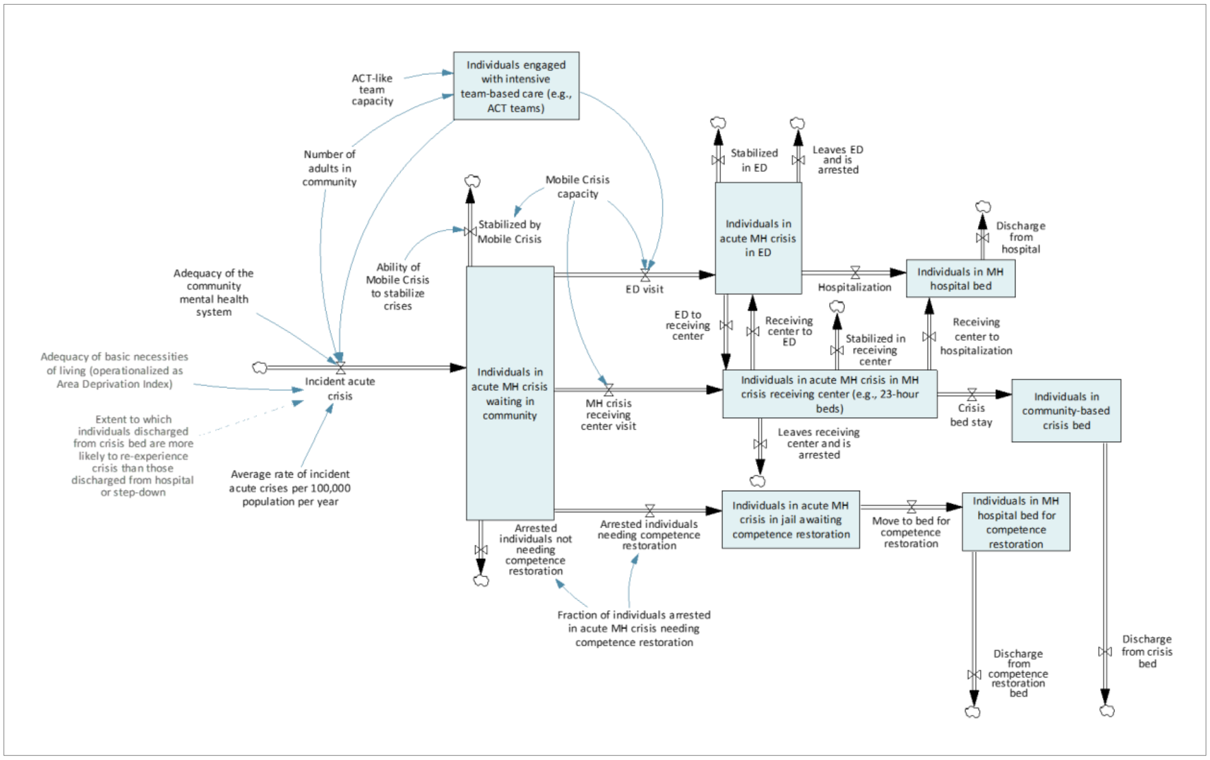

Figure 2 Panel D: Model structure diagram adding flows between receiving centers, and from receiving centers to inpatient services and the community. NOTES: ACT = Assertive Community Treatment; ED = emergency department; MH = mental health.

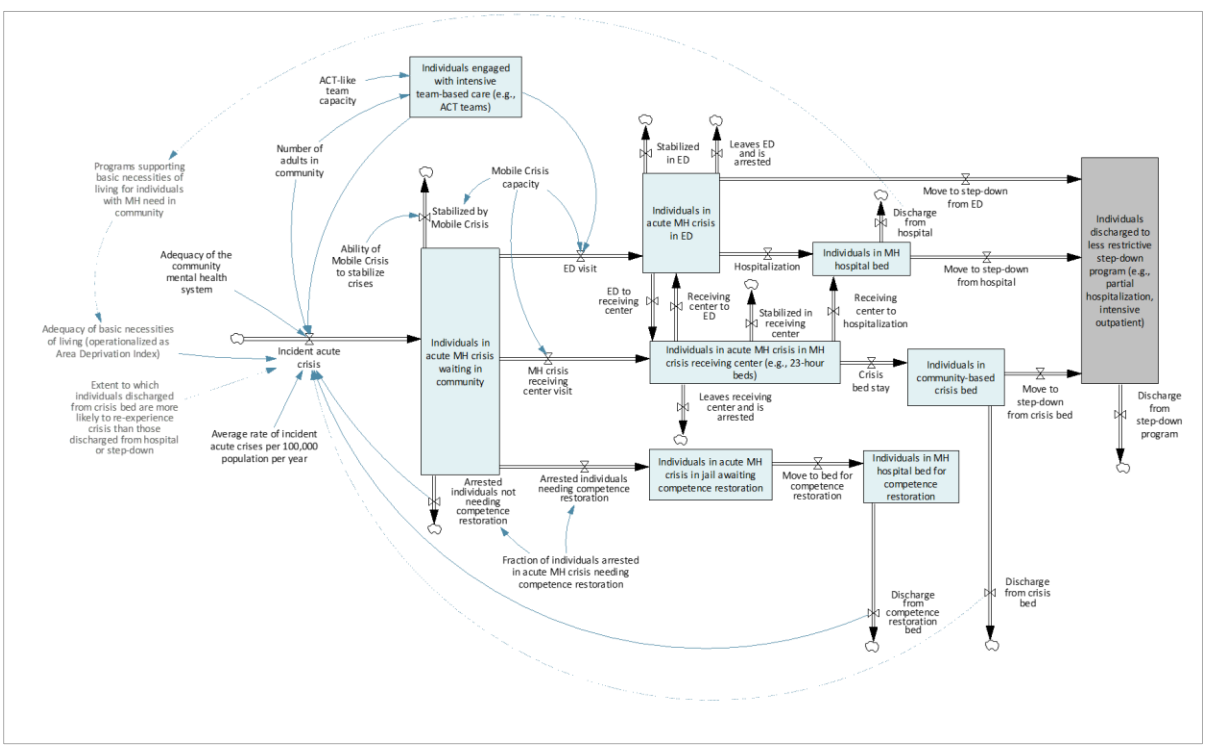

Figure 2 Panel E: Model structure diagram depicting role of step-down programs (not currently included in the concept model, thus shaded in grey). NOTES: ACT = Assertive Community Treatment; ED = emergency department; MH = mental health.

Individuals seeking care from a receiving center (e.g., 23-hour bed) can stabilize and return to the community, leave the receiving center before being stabilized (and as with EDs, seek care subsequently in either an ED or return to the crisis receiving center, or be arrested, with the same probabilities used for initial routing), or be admitted to either a mental health hospital bed or a community-based crisis bed. From the ED and mental health hospital bed, pathways are the same as described above. Individuals admitted to a community-based crisis bed are assumed to have an average 14-day length of stay before being discharged.

And last, for individuals in acute mental health crisis who are arrested, the model assumes that 80% do not require competence restoration. The current version of the model focuses on the remaining 20% of arrested individuals who do require competence restoration and does not yet include other aspects of the forensic mental health system – because there is little interaction among resources on the civil and other aspects of forensic care (though this simplifying assumption can be revised if appropriate when adapting the model to a specific location). Individuals requiring competence restoration wait in jail before moving to an inpatient mental health hospital bed for competence restoration. The competence restoration process is assumed to take an average of 90 days before individuals are discharged. While jail time is not explicitly modeled, we do model individuals having been arrested undergoing an assessment of competence restoration needs, which requires five days to complete. Individuals released directly from jail into the community, after a delay (time served), do have an increased risk of acute crisis in the following 30 days. Given that these individuals were experiencing an acute mental health crisis when arrested, and have not received therapeutic care, the incidence of being in acute crisis for these individuals upon release is assumed to be high (85%), with the onset delay of occurrence following an exponential distribution. When these acute crises occur, individuals may engage one of the three initial service pathway portals described above.

The model structure describes the flow of individuals from the onset of an acute mental health crisis through the engagement of mental health services and care pathways (or lack thereof) and the role that facility capacity and resources limitations have on the process/outcomes.

The model structure describes the flow of individuals from the onset of an acute mental health crisis through the engagement of mental health services and care pathways (or lack thereof) and the role that facility capacity and resources limitations have on the process/outcomes. The model is required to address the flow of individuals who often have discrete outcomes or choices along a pathway, thus making it necessary to incorporate some details that can only be represented through random events which are drawn from probability distributions during the simulation execution. Most of these random events are associated with a decision by the individual (e.g., randomly determine whether an individual in acute crisis goes to the ED, to the crisis receiving center, or is arrested prior to receiving care), however, there are also instances where the number of individuals in a specific population may be deemed to have an acute crisis at a time point. These random events sampled from probability distributions result in the stochastic behavior observed with the model. This is a deviation from conventional system dynamics modeling, making this a hybrid system dynamics/discrete event simulation model. It is a critical complexity to add, as most acute mental health crisis systems are operating right at the edge of their tipping points, where day-to-day variation drives undesirable outcomes such as excessive wait times.

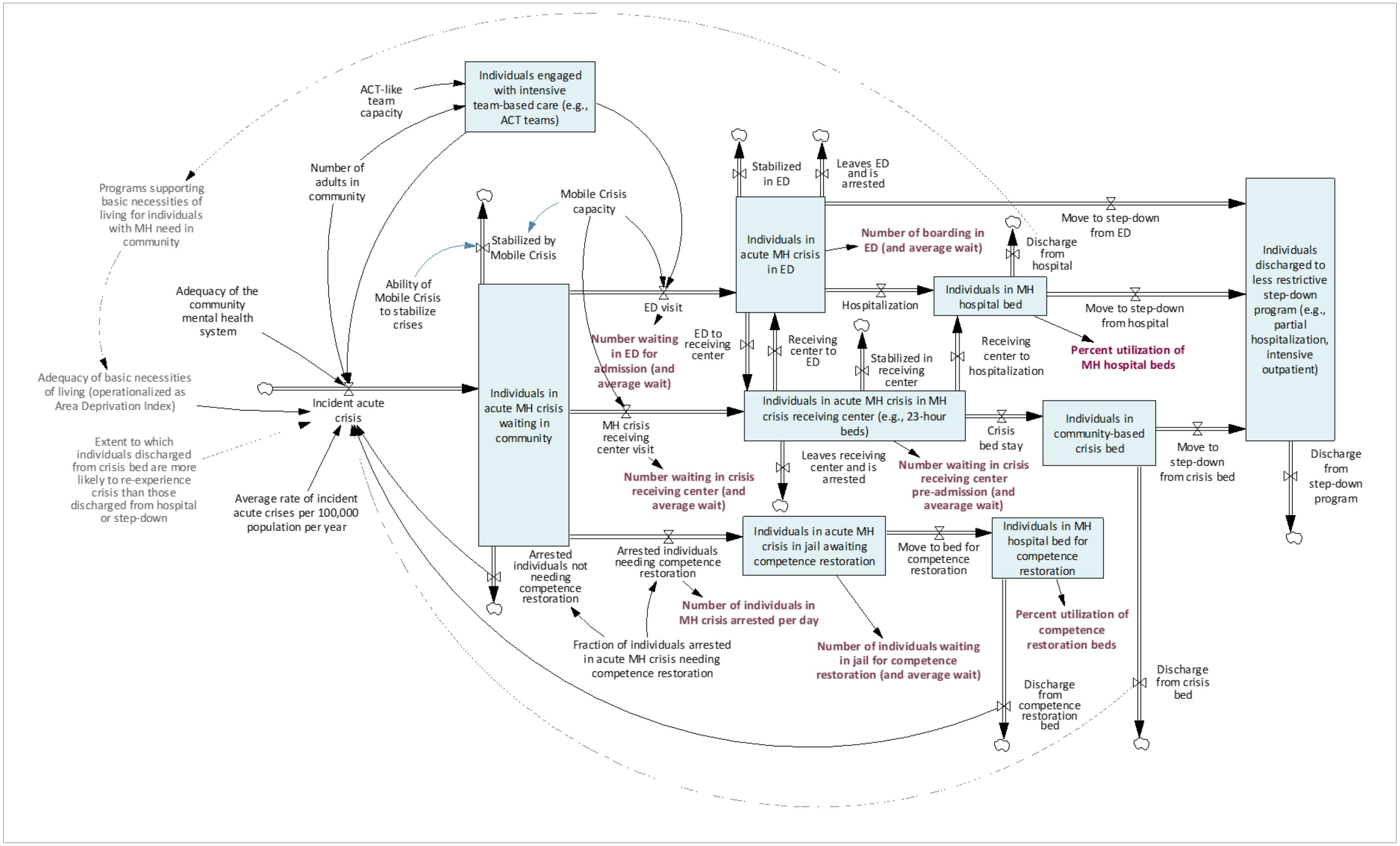

Figure 2 Panel F: Full model structure diagram, adding simulated outcome variables in bold plum-colored font. NOTES: ACT = Assertive Community Treatment; ED = emergency department; MH = mental health.

E. Anytown, US Model Parameters, Results, and Dashboard Overview

1. Anytown, US Model Parameters

The current version of the model includes placeholder input values based on a hypothetical community, Anytown, US. These input values are based on expert clinical opinion, published literature, and/or assumptions. 3 presents the key model input parameters, including default values, sources, and assumptions.

Table 3. Preliminary Psychiatric Bed Needs Model Parameters

Input Parameter	Default Values	Sources and Assumptions
Population size (18+)	250,000	
Average annual rate of incident acute mental health crises per 100,000 population (Note: this excludes "high utilizers population" described in the next row)	2,400	Substance Abuse and Mental Health Services Administration (2020; estimated that each month 200 individuals per 100,000 population will experience a mental health crisis episode.)
Percent of the adult population who are "high utilizers" – defined as having an average of 12 acute mental health crises per year and eligible for intensive team-based care (if capacity allows)	0.1%	
Percent of individuals arrested who will re-enter the acute mental health crisis pathway within 30 days of release	85%	Assumption: high percent reflects fact that individuals were in acute mental health crisis when arrested. Note: If an acute crisis occurs, then the regular pathway distribution would be followed (0.475, 0.475, 0.050, see below).
Proportion of individuals in acute crisis entering Mental Health system through specific pathways		Expert clinical opinion
Arrival at ED	0.475	
Arrival at MH crisis receiving center	0.475	
Arrest	0.05	
Average capacity within the ED for adults in acute mental health crisis (varies over time to reflect fact that other patients compete for ED bed capacity)	50	Assumption (model starts initially with 3 individuals waiting to be seen, 8 being treated, and - 2 stabilized waiting for hospital boarding)
Number of individuals in acute crisis being treated/stabilizing in ED at start of simulation	8 people	Assumption
Average time spent waiting in community while in acute crisis before arrival at ED	0.25 days	Assumption
Average time before an individual leaving the ED due to excessive wait times is redirected back to care	0.25 days	Assumption
ED disposition (proportion of individuals, among individuals seen in ED)		Expert clinical opinion

Expected to stabilize in ED and return to community	0.4	
Admitted to MH hospital bed	0.6	
Average time for individuals to stabilize in ED	1.5 days	Assumption
MH crisis receiving center-specific input parameters		
MH crisis receiving center bed capacity	50 beds	Placeholder value: model starts initially with 20 waiting to been seen, 15 receiving treatment/stabilizing,10 waiting for community bed, 2 waiting for hospitalization, and 0 waiting for step down.
Average time spent waiting in community while in acute crisis before arrival at MH crisis receiving center	0.25 days	Assumption
MH crisis receiving center disposition (proportion of individuals, should sum to 1)		Assumption and expert clinical opinion (1/3 distributed to pathways not hospitalized)
Requiring MH hospitalization	0.35	
Requiring community-based crisis stay	0.35	
Moving directly to step-down program	0.15	
Expected to stabilize and return to community	0.15	
Average time for individuals to stabilize in MH crisis receiving center	0.75 days	Assumption
Community-based crisis bed-specific input parameters		
Community-based crisis bed capacity	48 beds	Assumption: Model starts with initial occupancy at 30 individuals
Average delay in admission to community-based crisis bed from MH crisis receiving center once capacity becomes available	0.125 days (3 hours)	Assumption
Community-based crisis bed disposition (proportion of individuals)		Assumption (Step-down care alternative currently does not enforce capacity limits in concept model.)
Discharged and returned to community	0.30	
Discharged and requires Step-Down program	0.70	
Average length of stay	14 days	Expert clinical opinion (length of stay distribution unknown but likely with an average of approximately 14 days with a long right tail implemented as a 3rd order delay to approximate an exponential service time)
MH hospital-specific input parameters		
MH hospital bed capacity	90 beds	

Number of MH hospital beds occupied at start of simulation	90 beds	Assumption – model initializes with 100% occupancy with varied time remaining before discharge.
Average delay in admission to MH hospital bed from ED or jail, given bed availability	0.125 days (3 hours)	Assumption
MH hospital disposition (proportion of individuals)		Assumption (Step-down care capacity does not currently restrict flow in concept model)
Discharged and returned to community (proportion directed to step-down program 0.2, discharged to community 0.8)		
Average length of stay for civil patients	7 days	Expert clinical opinion (length of stay distribution unknown but likely with an average of approximately 7 days with a long right tail implemented as a 3rd order delay to approximate an exponential service time)
Criminal justice system-specific input parameters		
Average time spent waiting in community while in acute crisis before arrest	3 days	Assumption
Average time required to determine competence restoration needs	5 days	Assumption
Proportion of individuals arrested who require competence restoration		Assumption
Required	0.20	
Not required	0.80	
Average length of stay in MH hospital bed to complete competence restoration MH forensic hospital bed capacity = 20 (with occupancy initialized with 12 individuals in care)	90 days	Expert clinical opinion (length of stay distribution unknown but likely with an average of approximately 90 days with a long right tail implemented as a 3rd order delay to approximate an exponential service time)
Intensive team-based care (e.g., ACT teams)-specific input parameters		
Average annual rate of incident acute crises per individual in ACT-like team	12 crises/year	Assumption
ACT-like team capacity	150 people	Placeholder values (assuming 0-3 ACT-like teams, with each team handling up to 50 individuals; model initiates with 1 team)
Proportion of ACT-like team interventions successful in avoiding ED visits	0.9	Individuals receiving ACT-like team care will avoid hospital admission 90-95% of time
Mobile crisis-specific input parameters		
Mobile crisis capacity	0	Assumption: Model allows 0 to 3 mobile crisis teams to operate. Initially the model is set to 0 teams. Each mobile crisis team can respond up to 4 acute crises per day

Ability of mobile crisis to stabilize crises	50%	Assumes each mobile crisis team can stabilize 50% of crises that they respond to; remaining crises are routed to the MH crisis receiving center (if the community has a MH crisis receiving center with capacity available; if not, the remaining crises are routed to the ED); of the routed crises, the model assumes 25% are directed to the ED, where they may be hospitalized, and 25% are directed to a crisis receiving center.

ACT = Assertive Community Treatment; ED = emergency department; MH = mental health.

We assume that individuals waiting in the ED or at the mental health crisis receiving center for long periods of time have some probability of leaving before being seen. We assume that this probability increases the longer they have to wait for admission. To accommodate model structure, we estimate this relationship as a function of the number of people waiting for admission when they arrive. Tables 4 Panel A (ED) and Panel B (crisis receiving center) map individuals waiting to the probability an individual will leave, with the time they leave drawn from an exponential distribution with a mean of 12 hours. Individuals leaving return to being in the community, where they will select any one of the pathway portals as before.

Table 4 Panel A. The probability an individual leaves the ED without being seen based on the number of others waiting when they arrive

Number waiting	Probability Leaves over 12 hours (0.5 day)
0-9	0.00
10-19	0.05
20-29	0.10
30-44	0.16
45-64	0.28
65-79	0.50
80-149	0.62
150-199	0.88
200+	1.00

Table 4 Panel B. The probability an individual leaves the mental health crisis receiving center without being seen based on the number of others waiting when they arrive

Number waiting	Probability Leaves over 12 hours (0.5 day)
0-24	0.00
25-49	0.12
50-74	0.45
75-99	0.75
100-149	0.85
150-199	0.95
200+	1.00

2. Results from the Anytown, US Adult Acute Mental Health Crisis Model

Key outcomes simulated by the Anytown, US concept model are denoted in bold plum text in the model structure diagram (Figure 2) and include the following:

- Emergency Department (ED)
  - Number of individuals waiting in ED per day
  - Average time spent in ED waiting to be seen
  - Number of individuals in ED boarding per day
  - Average time spent in ED boarding
  - ED bed capacity utilization (includes care and boarding)
- Mental Health Crisis Receiving Center (CRC)
  - Number of individuals waiting in CRC per day
  - Average time spent in CRC waiting to be seen
  - Number of individuals in CRC boarding per day
  - Average time spent in CRC boarding
  - CRC chair capacity utilization (includes care and boarding)
- Civil hospital beds
  - Civil hospital bed capacity utilization
- Community crisis beds
  - Community crisis bed capacity utilization
- Individuals arrested during acute mental health crisis
  - Number of individuals in crisis arrested and potentially divertible per day
  - Number of individuals waiting for competency restoration per day
  - Competency restoration bed capacity utilization

Status quo analyses are conducted for the hypothetical community, based on assumptions made about its current capacity, demand for, and utilization of mental health services. In this way, the model aims to approximate the real-world patterns observed within the community with regards to individuals experiencing acute mental health crises waiting for care and moving through the system. We have built a model interface that can be used to adjust (across plausible ranges):

- Number of mobile crisis teams.
- Number of intensive care teams.
- ED bed capacity.
- Crisis receiving center chair capacity.
- Civil mental health hospital care capacity.
- Competency restoration capacity.
- Community crisis bed capacity.

As capacity changes are made, simulated model results described above adjust, so the model user can learn how the system responds. All other parameters are set to default values described in Table 3. A screenshot of a simplified model interface is provided in Figure 3. To illustrate the impact of randomness (variation from day to day) on model trends and path dependence (e.g., what it can take to work through a long queue, when it happens), we present three versions of model runs (Panels A-C).

Figure 3 Panel A:

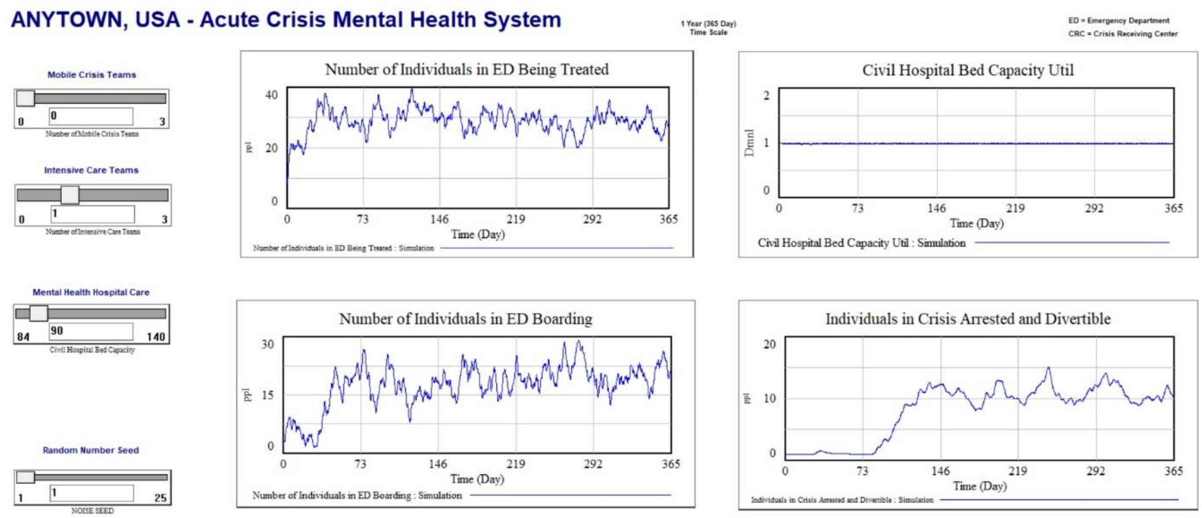

Figure 3 Panel B:

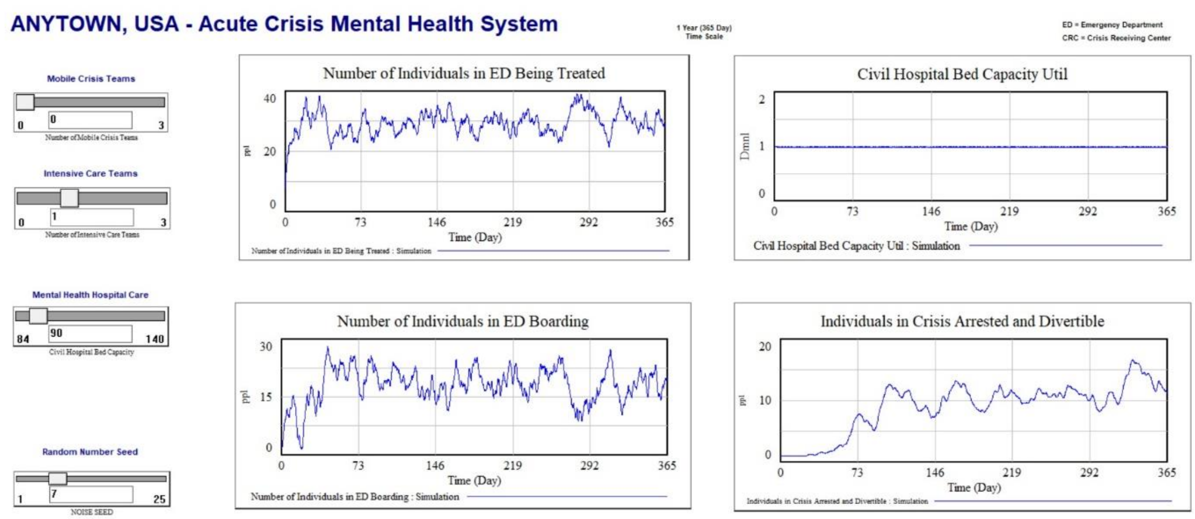

Figure 3 Panel C:

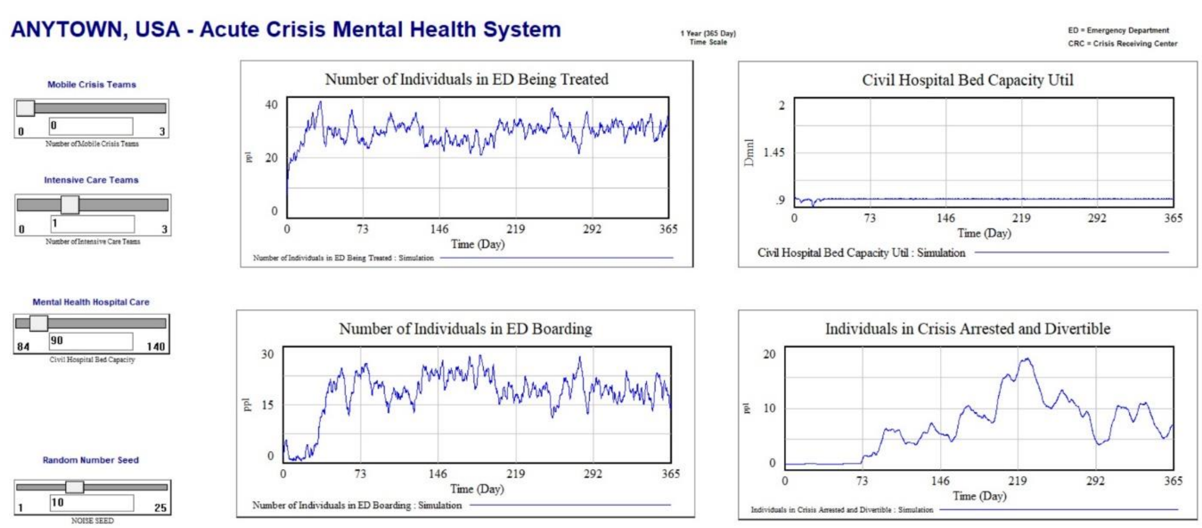

Figure 3 Panels A-C: Simplified model dashboard with three random number seeds (1,7 and 10) – to illustrate how randomness can affect model results over time.

Across 200 runs of the status quo model, the average number of individuals in the ED being treated at any point in time is 29.3, the number of individuals in the ED boarding is 18.7. An average of 98.4% of civil hospital bed capacity is utilized, and 8.4 individuals in acute mental health crisis are arrested and divertible per week.

The dashboard can then be used to learn how changing capacity affects outcomes. To illustrate, Figure 4 Panel A presents the status quo scenario, which you can compare to the dashboard (with the same random number seed) with the following changes, one at a time: two mobile crisis teams are added (Panel B), a second intensive care team is added (Panel C), and 10 additional civil mental health hospital beds are added (panel D). To understand the impact of these change scenarios with 200 replications of the model, see results in Table 5.

Figure 4 Panel A:

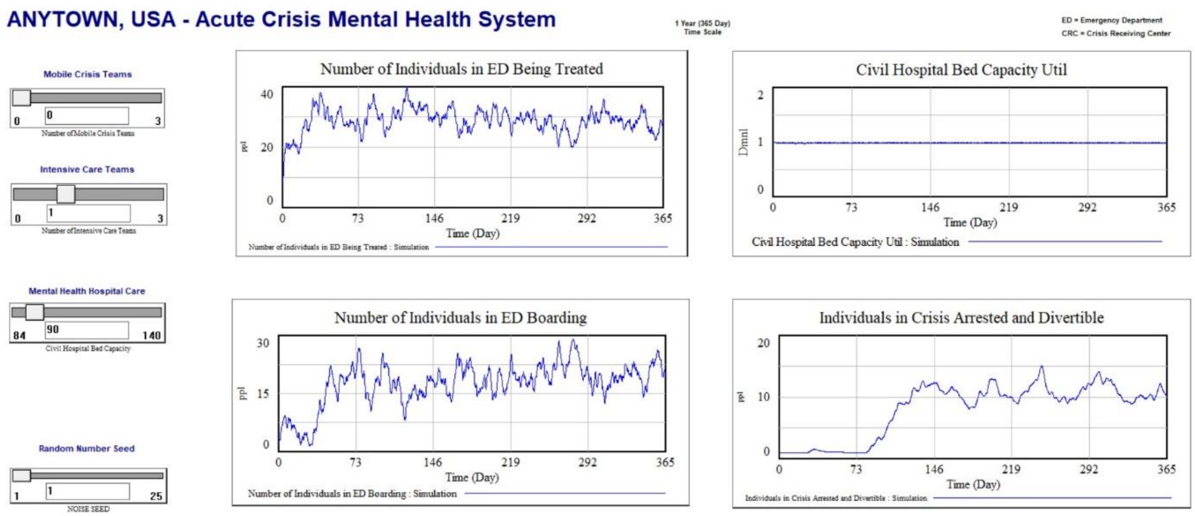

Figure 4 Panel B:

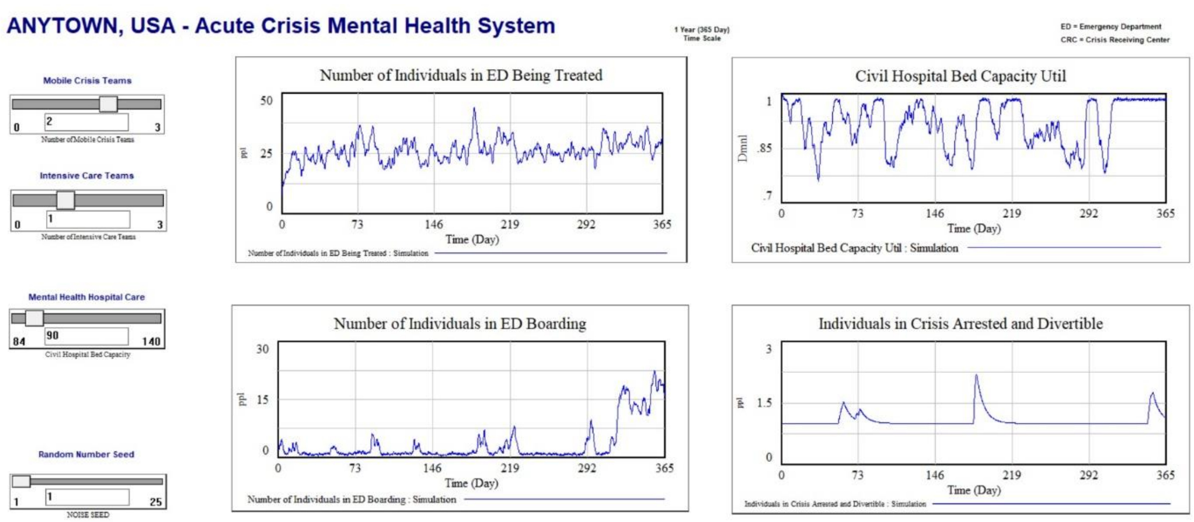

Figure 4 Panel C:

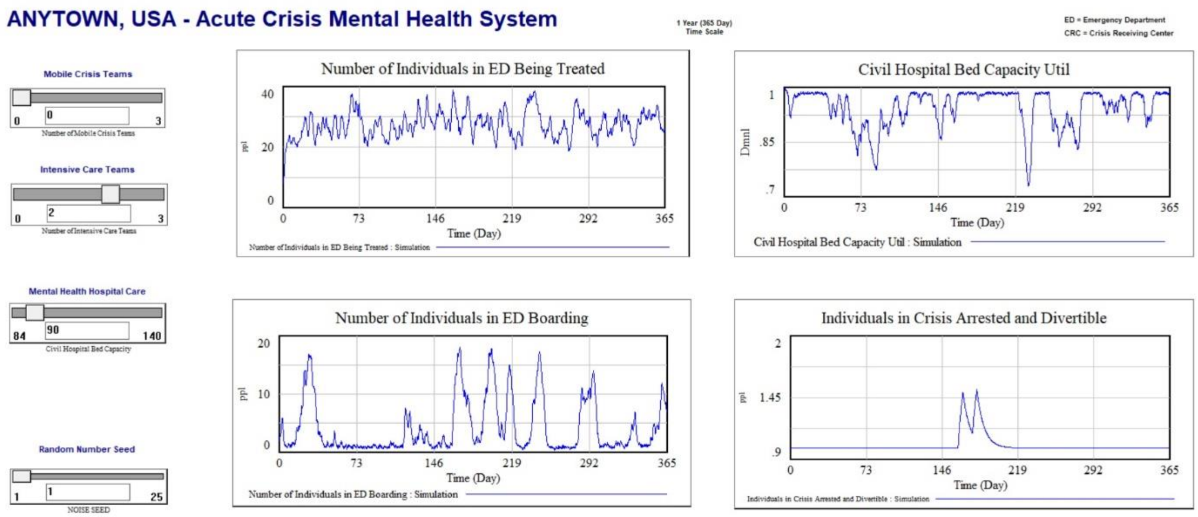

Figure 4 Panel D:

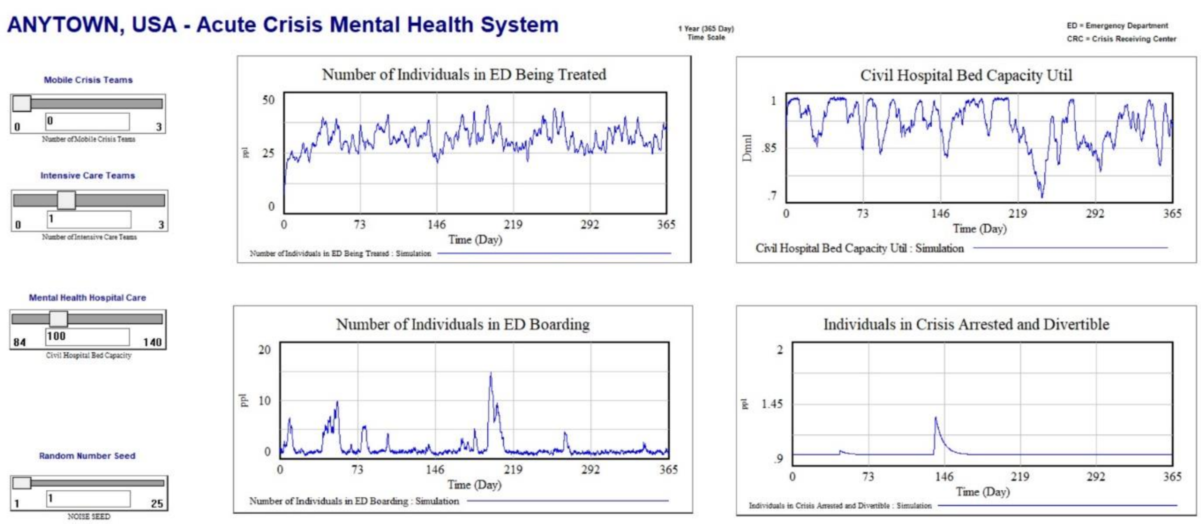

Figure 4 Panels A-D: Simplified model dashboard under status quo capacity scenario (Panel A) compared to a scenario where two mobile crisis teams are added (Panel B), a second Intensive Care Team is added (Panel C), or 10 additional civil mental health hospital beds are added (Panel D).

Table 5: Simulated outcomes under the status quo and three illustrative intervention scenarios, adding (one at a time): two mobile crisis teams, a second intensive care team, or 10 additional civil mental health hospital beds. Results are point-in-time averages (number in ED being treated, number in ED boarding, percent of civil mental health hospital beds in use) and seven-day averages (number in crisis arrested and divertible), along with 90% uncertainty intervals (5th percentile-95th percentile), across 200 replications of the model.

Scenario	Number in ED being treated (90% UI)	Number in ED boarding (90% UI)	% of civil mental health hospital beds in use (90% UI)	Number in crisis arrested and divertible (90% UI)
Status quo	29.3 (23.4 – 34.6)	18.7 (13.2-24.7)	98.4% (98.0-98.7)	8.4 (1.2-14.0)
Two additional mobile crisis teams	26.4 (19.8-34.2)	2.6 (0.6-12.3)	90.0% (76.6-98.4)	1.0 (1.0-1.2)
One additional intensive care team	27.6 (20.2-34.2)	6.2 (0.7-20.1)	94.0% (81.6-98.5)	1.2 (1.0-1.8)
Ten additional civil MH hospital beds	31.2 (24.1-40.3)	2.7 (0.8-9.8)	91.6% (81.1-98.5)	1.1 (1.0-1.5)

As you reflect on these results, ask yourself whether the impacts were what you expected? If not, why not? Substantial learning can happen with concept models such as this if you allow your own "mental model" – or understanding of how the system responds to changes in capacity of system components alone or in combination – to be tested. One potential reason is that the way an intervention is implemented in the Anytown, US model is not how you would implement it (for example, perhaps we assumed that mobile crisis teams serve too few or too many patients or are too or not effective enough – compared to your setting). Or perhaps the impact is due to capacity in other aspects of the model. Should you believe the parameters in the Anytown, US model do not reflect your community, consider working with us to modify the assumptions and simulate scenarios that better represent your community (see the next section to learn more about what that would take). What the Anytown, US concept model is doing is bringing the assumptions and parameter values described above to life in a virtual world and asking "if-then" questions. If we add capacity (to a specified component of the model and with a specified change), then what happens to the simulated outcomes?

3. Dashboard Overview

Before we leave the Anytown, US model results, we would like to share a screenshot of a more comprehensive dashboard. For an acute mental health crisis system with as many components as included in the Anytown, US model, we should not make decisions from as narrow an understanding of cross-system impacts of actions as depicted in Figures 3 and 4. Figure 5 presents a screenshot with a fuller set of simulated trends depicted in Figure 2 Panel F and includes sliders for changing additional capacity within the system (with three panels corresponding to three random number seeds).

Figure 5 Panel A:

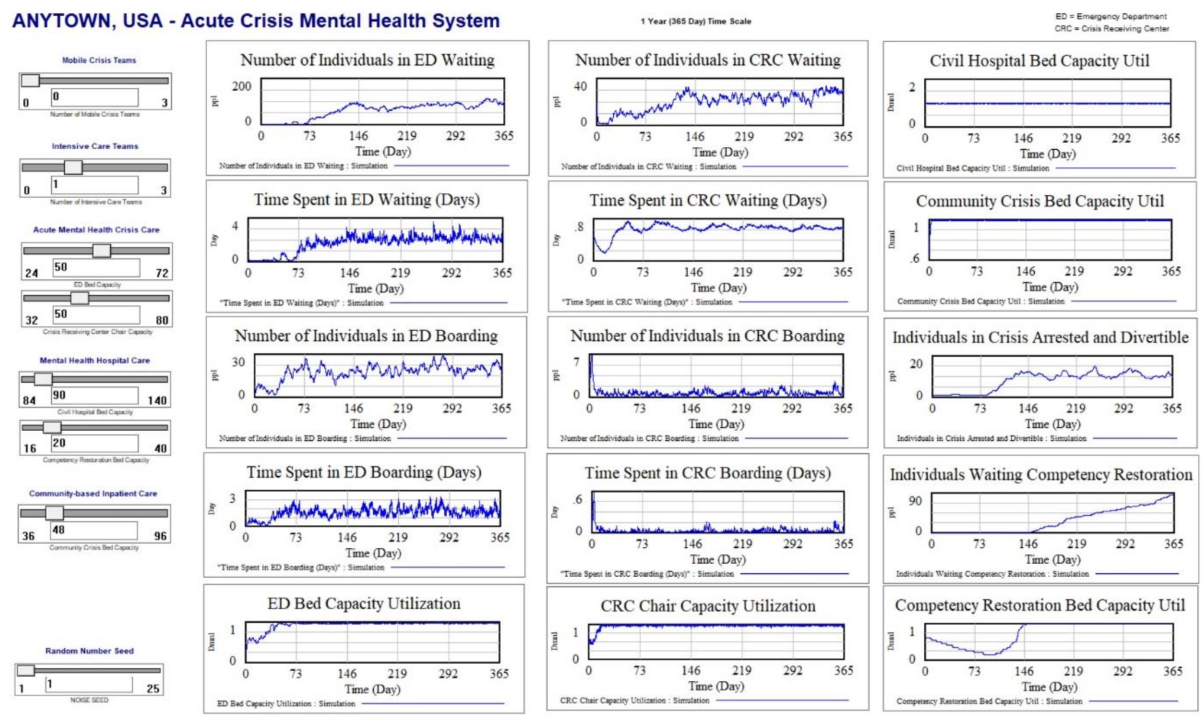

Figure 5 Panel B:

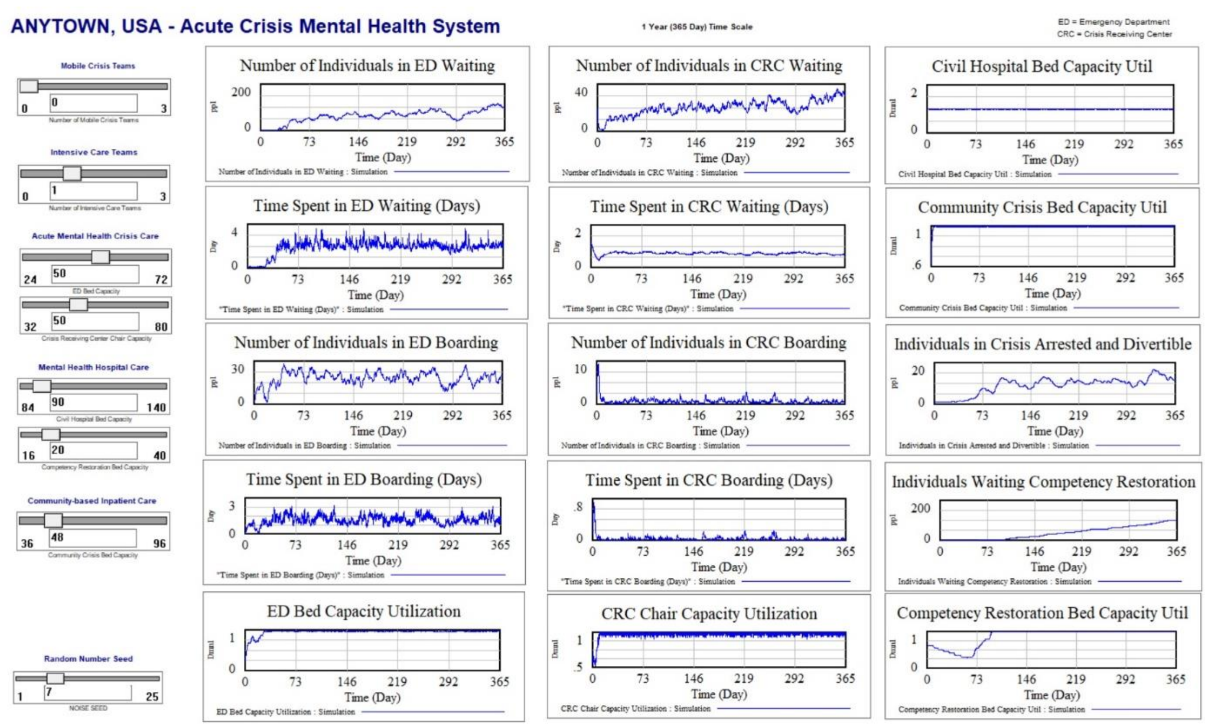

Figure 5 Panel C:

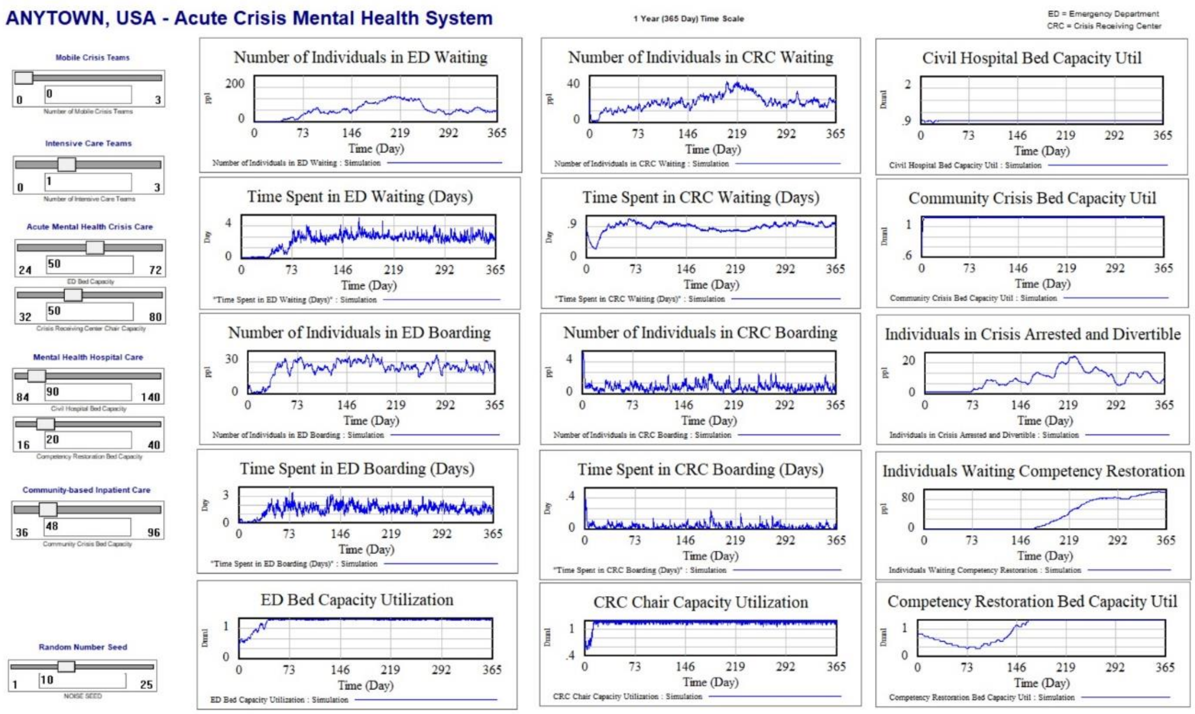

Figure 6 Panels A-C. Full Anytown, US model dashboard under the status quo scenario. Panels A-C present findings under the same three random number seeds as presented in Figures 3 and 4.

F. Conclusions

This section has described the methodology involved with the use of contemporary simulation modeling methods to build a model that will enable states, communities or other planning regions to address one of the most enduring problems in U.S. mental health services planning: the number of psychiatric inpatient beds needed to adequately address the needs of their people. As is the case with many emerging processes, this process is ongoing and at the time of writing this report is not complete. We have included in **Appendix E** a detailed accounting of the kinds of variables each community or planning region would need to consider to use this type of model. The current plan is to work to make the model available online where state and local planners can use it to facilitate planning for psychiatric bed and other service needs. This is an emerging model in the process of development, including participation by communities working with model developers to input the specific population and services variables. The APA together with model developers anticipate an effective tool that can be used by planning regions across the U.S. to provide a benchmark for services demand against available community services resources including inpatient psychiatric beds.

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