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Resilience Development in Multiple Shocks: Lessons in Mental Health and Well-Being Deterioration during COVID-19

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Abstract: Resilience describes individuals' and organizations' recovery from crises and adaptation to disturbances and adversities. Emerging research shows the deterioration of the population's mental health and well-being during the multiple waves of the COVID-19 pandemic, suggesting that the resilience developed is insufficient to address the system's persistent shocks. Drawing on the findings on mental health and well-being during the COVID-19 pandemic and the psychological and organizational resilience theories, we developed a system dynamics theory model exploring how the presence of multiple shocks to the system challenges the population's health and well-being. We initiated the model with three shocks with the same intensities and durations, and then experimented with scenarios in which the strength of multiple shocks (duration and intensity) was attenuated and amplified. The model showed that temporary environmental adjustments with limited long-term stabilized solutions and a lack of health service provision can increase the accumulative risks of health and well-being deterioration. We highlight the role of essential health service sectors' resilience and individuals' and organizations' tolerance of adversities and disturbances in providing sustainable resilience. We conclude by discussing critical factors in organizational and psychological resilience development in crises with multiple shocks to the system.

Keywords: COVID-19; resilience; system dynamics

1. Introduction

As of August 2022, COVID-19 has caused over six million deaths and approximately 600 million confirmed cases worldwide [1]. While many of us hoped that COVID-19 would be over before the summer of 2020 after the first wave, the pandemic continued with multiple ongoing waves of increasing diseases and cases. Despite the attempts and responses to the pandemic from multiple levels, the system has not developed enough resilience to address the ongoing shocks and waves of the crisis. In the U.K., multiple studies have shown the population's deterioration in mental health and overall well-being between March and May 2020 [2]. Followed by a period of improvement in the summer of 2020, there was a second deterioration in population mental health and well-being between October 2020 and February 2021. Studies have shown that inequality in population mental health and psychological distress was significantly higher in the second wave [3]. The threat of persistent stress on health is also lasting. Trajectory analysis of psychological well-being in the COVID-19 waves showed that nearly two-fifths of the population experienced elevated distress risk [4]. The risk of persistent deterioration shows that the experience of distress in the first wave was not transformed into resilience to respond to following shocks in the second and third waves.

Resilience describes how the system recovers and adapts to the disturbances in crises. At the individual level, resilience refers to how individuals retrieve stability in healthy functioning and develop insights and learnings to positively adapt to future disturbances [5,6].

Crises bring multiple shocks to a complex system in which individual resilience interconnects with social and physical ecology factors at the group and organizational levels [7–9]. Pandemics require integrated systems to provide prevention and treatment services [10], as well as require organizations and their members to provide and adjust to new norms of collaboration and communication. However, mitigation measures might upend people's economic and social lives, leading to increases in psychological distress [4]. The mental health and well-being deterioration during the COVID-19 pandemic indicates that resilience development has not been activated or is insufficient for handling persistent stress, strains, and adversity.

While the resilience literature views adversity, strain, and significant barriers as bringing opportunities for adaptation and development [11,12], it is unclear how human–environment resilience is interconnected and provides the population and system with sustainable recovery during the multiple waves of crises.

System dynamics modeling offers opportunities to explore and theorize resilience development by exploring the causal and feedback mechanisms of the risk of accumulative interruptions and resilience development [13,14]. System dynamics focus on the feedback structures that underlie complex behaviors [15]. Through computer-aided simulation models, we can explore the underlying mechanisms to advance theory development [16,17]. By drawing on the findings of mental health and well-being during the COVID-19 pandemic and psychological and organizational resilience theories, we developed a small system dynamics theory model exploring how the presence of multiple shocks to the system challenges the population's health and well-being.

Our contributions are two-fold: First, drawing on the psychosocial (individual) and organizational resilience literature, we contribute to the theorizing of multisystemic approaches in resilience development, especially when the system is exposed to risks of multiple shocks. Second, we explore the accumulative risk of the population's health and well-being deterioration and propose interventions that can help mitigate and protect population well-being in long-crisis events such as COVID-19.

2. COVID-19 and Multisystemic Perspectives in Resilience Development

This section summarizes the resilience perspectives in relation to COVID-19 and provides an overview of psychological resilience and organizational resilience theories.

2.1. Resilience Development during COVID-19

The systematic review revealed that the deterioration of health and well-being, especially the negative impact on mental well-being, including high rates of anxiety, depression, posttraumatic stress disorder, and psychological and emotional distress, is widespread worldwide [18]. In the U.K., the COVID-19 mental health and well-being surveillance report [2] published by Public Health England showed that mental health and well-being during the pandemic has demonstrated an "up-and-down" pattern, in that there have been continuous deteriorations in health and well-being throughout the multiple waves. The report synthesized insights from multiple data sources, such as the University College London's COVID-19 Social Study and national data from the Office for National Statistics. The report highlighted a general increase in psychological stress during the pandemic, particularly for young people aged between 18 to 34 years. Analysis from the U.K. Householder Longitudinal Study further suggested that the second wave of COVID-19 was associated with a significant increase in psychological distress [19]. As Figure 1 shows, the proportion of people with clinically significant levels of psychological distress rose from 20.7% to 29.8% compared to the pre-pandemic levels. Between October 2020 and February 2021, a second deterioration in the population's mental health and well-being was observed [19]. By March 2021, the distress levels increased to 27.1%, significantly higher than the pre-pandemic level [19]. Even though the majority of the population are resilient or recovered quickly, two-fifths of the population experienced significant and severe distress repeatedly and continuously [4].

Proportion of people with clinical significant level of psychological distress
(adults aged 18 and over)
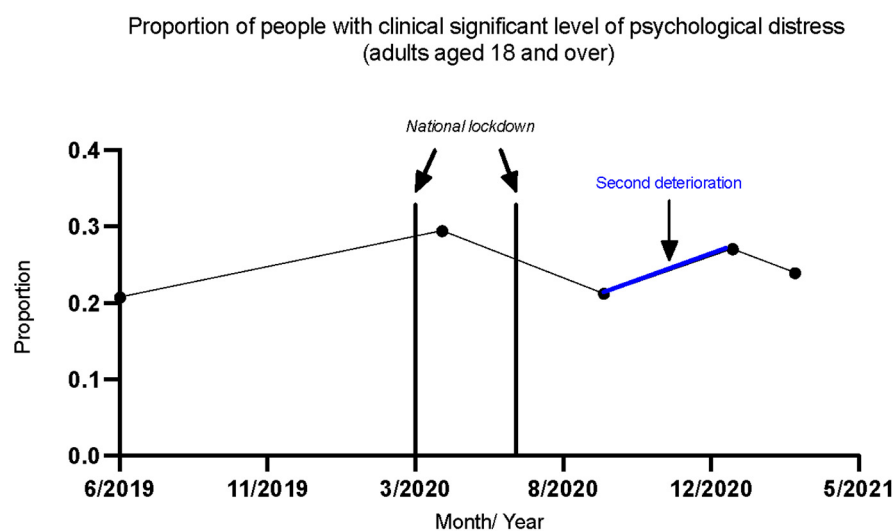
Figure 1. Changes in population mental health and well-being. Adapted from Daly and Robinson [19]. Copyright (2022), with permission from Elsevier.

Long-term distress exposure increases mortality risk and results in poor health outcomes [20]. Due to the nature of the long-lasting and prolonged effect of COVID-19, researchers pay increasing attention to trajectory changes in the multiple waves of crises [3,4,21,22]. Health systems' resilience in governance, health workforce, provision of medical products, and health service delivery has been stressed [23]. Aside from vaccination and hospital capacity, health workers' well-being also influences service capacity. Greenberg et al. [24] suggested that the National Health Service (NHS), as an organization, needs to provide post-trauma social support to healthcare workers during the COVID-19 pandemic facing increasing numbers of working hours.

Emerging research presents a resilience perspective that the unprecedented and prolonged pandemic brings shocks to individuals' health and well-being [22], and the health service system [25], and significant disturbances at all societal levels [26]. However, despite the attention to resilience development in relation to COVID-19, there is limited knowledge and theory of resilience development in crises with multiple shocks.

2.2. Clinical and Multisystemic Perspectives in Psychological Resilience

Psychological resilience at the clinical level promotes personal assets and protects them from the adverse effects of stressors [6]. Psychological resilience indicates less appraisal of negative emotions, higher capacity of meta-cognition in response to felt emotions [5,6], more insights and self-reflection [27], positivity [28], psychological flexibility [29], and adaptive coping strategies. A multisystemic perspective in psychological resilience theory concerns a process where various systems (biological, psychological, social, and ecological) interact in ways that help individuals to regain, sustain, or improve their mental well-being in contexts of adversity and distress [9]. Psychological resilience can vary among different populations and cultural communities. It reinforces positive and protective/presentive aspects at different stages of the stress process.

The multisystemic perspective has broadened the understanding and facilitation of psychological resilience. At the individual level, the study of children with abuse experience recognizes cognitive appraisal, high rumination, high distress tolerance, low suppression of emotion, low expression of aggression, and a secure attachment relating to high psychology resilience [30]. Family- and community-level factors such as family cohesion, parental involvement, social support, and household income contribute to psychological and behavioral changes in resilience [30]. Recent findings have recognized that biological genes, confounded by factors such as the environment, population, and demographic features, are associated with the complexity of individual resilience [31]. Furthermore, cultural

dynamics and contexts and environmental safety and security also impact how individuals adjust to adversity [8]. Compared to narrow perspectives on individual dynamics, the multisystemic perspective stresses that psychological resilience is a complex phenomenon of intersectionality, which dynamically varies and shifts alongside individuals, communities, and societal systems.

Clinical facilitation of psychological resilience may relate to interventions on the individual psyche to achieve protective psychological features and personal development, as mentioned above, to prevent individuals from being overwhelmed by emotional distress and adversity. By strengthening one's tolerance of distress, individuals are equipped with a range of coping skills and strategies for adjusting and coping with adversity. Clinical contact, as a kind of interpersonal contact with its frame, provide relational social support, companionship, and a process where the individual has the space to explore and experience their own resilience and personal assets. Relevant psychoeducation, taking into account intersectionality, can include contextual factors, such as cultural identity, community environment, and external systems, in interventions. Lastly, community clinical settings can identify and bridge an individual with needed social welfare support, resources, and social advocacy, so that one may regain homeostasis in their social and ecological systems.

2.3. Organizational Resilience and Impact

Exploring interconnections between individual and organizational resilience is crucial from the multisystemic perspective as organizations underly the complex system and generate mitigation and actions [32]. Discontinuity and disruption not only cause adversity for individuals to respond to [7], but also raise a question regarding to what extent the environment is stable for people in acute distress. Crisis events such as climate change, energy (gas) crises, and extreme weather events leave high-level complexities and uncertainties for organizations to adapt to [33]. Thus, the idea of organizational resilience and how organizations adapt to exogenous changes are becoming increasingly relevant and essential. For example, Bryce et al. [25] argued that the U.K. government and NHS need to "readjust" to the new environment by operating through national emergency preparedness, aside from coping with the challenge of inadequate resource provision in terms of virus tests, ventilators, and personal protective equipment.

Organizational resilience describes the environment attempting to adjust to disturbances in the environment. While turbulence and adverse events are often viewed negatively, resilience studies have the underlying aim of shifting from the tendency to focus on "failures, decline, and maladaptive or pathological cycles" to "how organizations continually achieve desirable outcomes amid diversity" [11]. Meyer [34] framed sudden and unprecedented events as "environmental jolts" that create transient perturbations and force organizations to adapt to the environment. The process of averting maladaptive outcomes involves the organizations, their units, and members developing and mobilizing cognitive, emotional, relational, and structured resources to cope with adverse events. When organizations face sudden and unprecedented events, according to Meyer [34], resilience occurs if the organization absorbs the environmental jolt's impacts and decreases deviation from the previous order. Specifically, the process of adapting to environmental stimuli includes three phases: Anticipating changes and risks of failure, responding to and providing changes, and then readjusting the strategies and resources after the shocks.

The psychodynamic perspective in organizational research has shed light on some of the unintended consequences of organizational defenses against disturbances derived from external threats, internal conflicts, or the nature of work [35]. Understanding the interplays of individual and organizational narratives in organizational changes is essential, as collective learning can develop "critical self-reflexivity and an identify-focused dialogue" to mitigate maladaptive defenses such as denial, rationalization, and idealization [36].

In facing threats and potential risks in functioning and performance, learnings and insights can inform strategy-making to be resilient to future disturbances [34]. Organizational adaptations and learnings are "dynamic" and require "multi-institutional working"

in broader systems [37]. Williams et al. [38] described that organizational members' and organizations' responses to disturbance can change over time and shape future interpretations and responses to adverse events. The responses depend on individuals' cognitive, behavioral, emotional, and relational capabilities and their interactions with organizational efforts in risk reduction and reliability, forming "feedback causal mechanisms" between individuals and organizations [38].

Although the connection between individual and organizational psychosocial resilience has been recognized—for example, individual employees' response to and coping with adverse or significant traumatic events may influence their capacity to perform their roles [33]—mainstream research on organizational resilience uses business performance as one of the key indicators. According to Ilseven et al. [39], the critical components in measuring resilience are the magnitude and rate of the both drop and recovery in organizations' performance. The operational or engineering frame of organizational resilience is helpful in that the functioning of organizations is essential. However, the frame misses the multisystemic perspective that individuals and members of organizations face psychosocial risk or challenges, which influences how individuals collaborate and perform. As Kahn et al. [40] suggested, if the relational systems that underlie organizations remain disturbed, even when operational performance interruptions have been resolved, organizations can still face dysfunctional patterns of behavior and longer-term performance issues.

3. Methods

System dynamics modeling is a methodology that explores the complexity of circular causality or feedback loops and how interactions between factors can result in non-linear behaviors in the systems [15]. It can be applied to generate robust policies in specific real-world issues such as public health (e.g., [41–43]), climate and environmental (e.g., [44,45]), and operational and managerial issues (e.g., [46,47]). It is also widely used to inform theory building and testing [48], especially in organizational and management theories (e.g., [49–52]). The significant difference between theoretical and applied system dynamics modeling regards the steps in the modeling process (if specifics of policy arrangements need to be provided), data (if the collection of primary data is needed), and model boundaries (if the omission of specific variables and relationships is acceptable) [17]. While applied modeling is about developing a model to develop specific policy suggestions for the phenomenon under investigation, theory-based modeling focuses on generalizability and providing incremental knowledge to explain and theorize a phenomenon without the absolute need to collect empirical data on a specific instance [16,17,48,53]. Through model-based theory building, more profound insights can be gained and tested to inform the development of "minor and middle-range theories" that attempt to build generic and overall explanations of a problem but have not yet been formed as a unified theory [53].

A theory-based modeling approach was chosen to contribute to the theorizing of resilience development in multiple shocks and to provide some generic learnings regarding health and well-being deterioration during the COVID-19 pandemic. A resilience model was developed via the following steps: First, health and well-being deterioration phenomena are defined through reports and data. The COVID-19 mental health and well-being surveillance report [2] was chosen mainly to aid in forming a definition of the problem, as it is one of the earliest publications synthesizing evidence in health and well-being deterioration during the COVID-19 pandemic. Second, a dynamic hypothesis was formed through reviewing the broader theories of psychological and organizational resilience. Third, the conceptualized model was developed iteratively by revising the initial structures and conceptualization [54]. Lastly, the model was tested and provided equilibrium runs and different combinations of shock duration and intensity, providing directions for policy testing and insight.
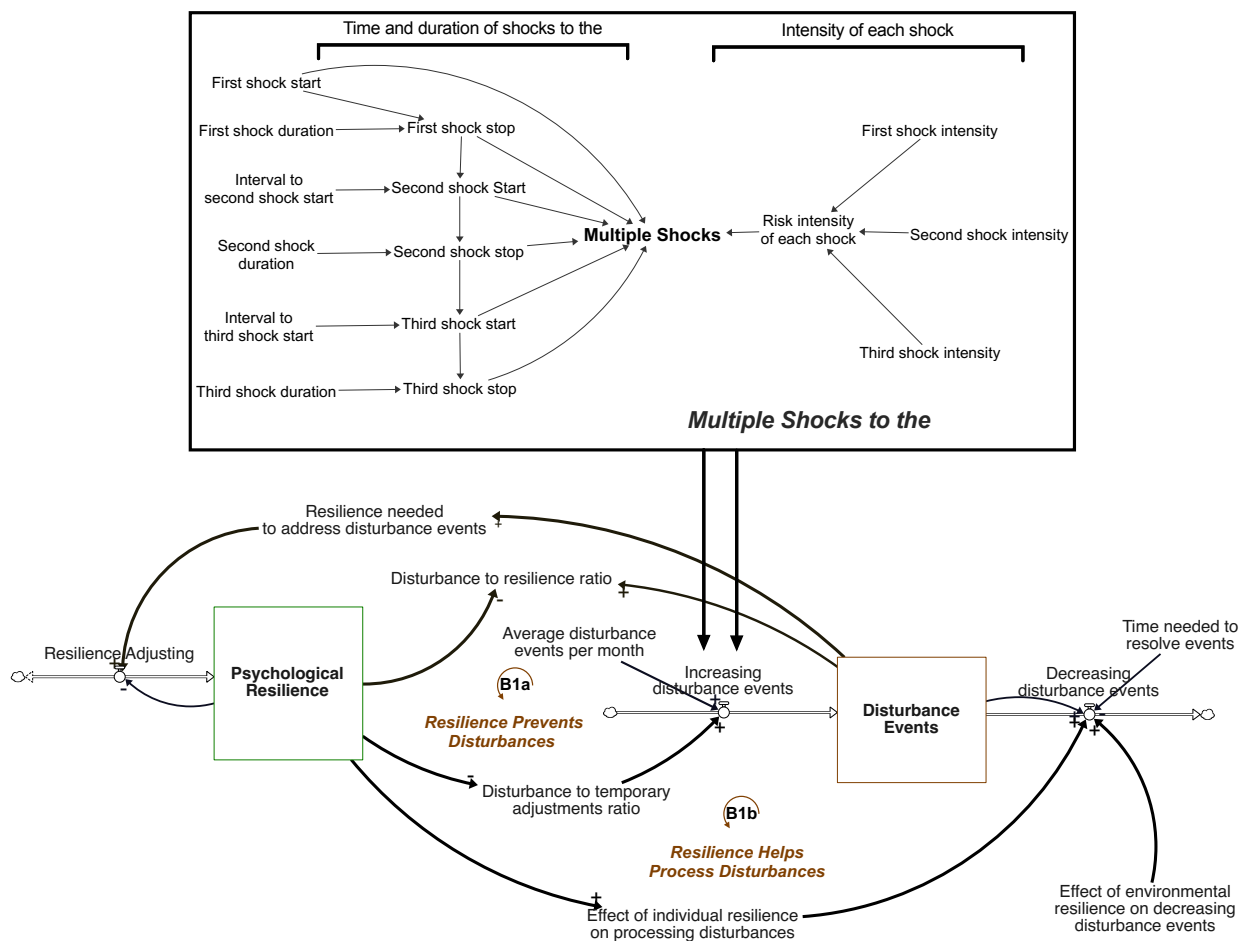
4. Model Conceptualization

This section describes the causal mechanisms and main feedback loops in the model conceptualization.

4.1. Resilience and Disturbance

The model starts with a stock of *Disturbance Events* (see Figure 2. Resilience and disturbance interconnections), representing the accumulation of disturbance events in the system. Disturbance events cause a departure from a standard or desired state [55]. We followed the definition of disturbance by White and Pickett [56] (p.7), that "a disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment." In the model, the stock of *Disturbance Events* increases with an inflow of *average disturbance events per month*, assuming that there is a constant exogenous inflow of disturbance events for individuals to address. The stock decreases after the disturbances are processed by individuals, which depends on the *time needed to resolve events, effect of environmental resilience,* and *effect of individual resilience* on *decreasing disturbance events*.

Figure 2. Resilience and disturbance interconnections. The top box describes the conceptualization of multiple shocks to the system. The bottom part of the figure shows the causal links between resilience and disturbance. *Note*: A positive (+) sign implies positive arrow polarity, meaning that an increase (decrease) in the cause variable will result in an increase (decrease) in the effect variable, compared to what would have been otherwise and if everything else stays the same. A negative (−) sign implies positive causality, meaning that an increase (decrease) in the cause variable will result in a decrease (increase) in the effect variable, compared to a what would have been otherwise and if everything else stays the same. 'B' represents 'balancing loops, meaning that an increase (decrease) of one variable would trigger a decrease (increase) of this variable after travelling the full loop.

Another stock in Figure 2 is *Psychological Resilience*, which represents the accumulation of resilience that individuals retain to address disturbances in the system. Resilience describes how individuals recover from shock, acquire stability in healthy functioning, and adapt to disturbances. *Increasing disturbance events* increases the *resilience needed to address disturbance events*, demanding individuals to develop resilience and decreasing the disturbance events perceived, which forms the first balancing loop—B1a: Resilience Prevents Disturbances. As individuals resolving disturbance events, the stock of *Disturbance Events* decreases, decreasing the demand for resilience, which forms another balancing loop—B1b: Resilience Helps Process Disturbances.

As shown in Figure 2, multiple shocks can create waves of disturbances in the system, increasing the inflow of the stock of *Disturbance Events*. To understand the impact of the multiple waves of crises on the system, we added three waves to the system, with the intensity and duration of each crisis that can be specified and changed.

4.2. Psychological Resilience at the Population Level

"Stress" describes people's general experience of psychosocial distress, including anxiety, depressive symptoms, sleep problems, self-reported mental health, loneliness, and general stress. We used three stocks in the population structure to describe changes in distress levels at the population level: *Low/mild Stress People*, *Highly Stressed People without Health and Well-being (HW) Services*, and *Highly Stressed People with HW Services* (see Figure 3). When low/mild stress people are exposed to crises or disturbance events, they move to the *Highly Stressed People without HW Services* through the flow *Stressing up*. The speed of moving to high-stress stock depends on two variables: (1) The *disturbance to resilience ratio*, which measures individuals' experience of disturbance level relative to their resilience level; (2) *time to change the stress level*. Although crises with multiple waves can hit all three population stocks, in the model, we assumed that the shocks do not bring additional adversities for the people who are already in the two high-stress stocks.
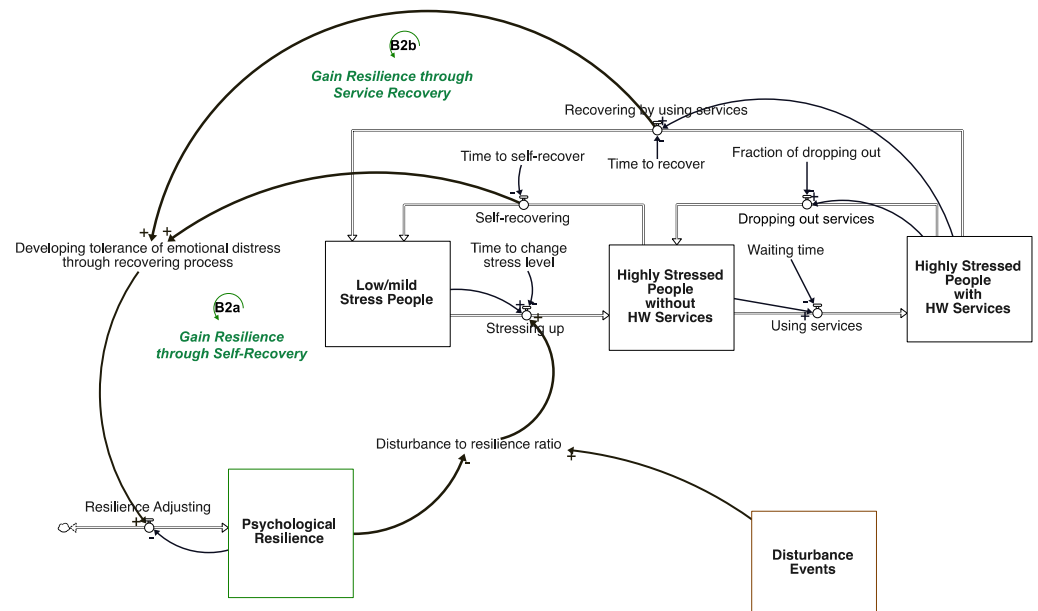

Figure 3. Population structure linking with resilience and disturbance.

Short-term deterioration in health and well-being does not directly indicate an increase in mental illness or a need for HW service support. As this model aims to understand the connections between individual and organizational resilience and potential policies, we assumed that a fraction of highly stressed people will use HW services and move to the third stock: *Highly Stressed People with HW Services*. A fraction of people from the service-using population might drop out and move to the *Highly Stressed People without HW Services*

stock. People from the two high-stress stocks can recover after a specific time (2.5–3 months in the model) and move back to the *Low/mild Stress People* stock. The flow *recovering by using services* describes the process for people to gain higher tolerance of emotional distress and disturbance. The recovering process increases *Psychological Resilience*, which decreases the *Stressing up* process, decreasing highly stressed people with or without HW services, forming two balancing loops—B2a: Gain Resilience through Self-recovery and B2b: Gain Resilience through Service Recovery.

4.3. Health and Well-Being Service Sector Resilience

At the organizational level, the health service sector is critical in supporting and helping highly stressed people recover and gain emotional tolerance to adversity and distress. HW services include a range of therapies, case management, and community-based support. For example, brief treatments provide clinical intervention to decrease emotional distress, identify and reinforce strength and protective factors, introduce coping skills, increase relative insights, and provide social support and relational connection. HW services include triage systems that refer people to the appropriate level of care services. The process includes assessing the severity of psychological distress and can provide case management services with needed resources.

We used the stock of *HW Service Staff* to measure the health and well-being service sector capacity (see Figure 4). We measured how many health and well-being support sessions can be provided monthly. In this model, *Highly Stressed People without HW Services* increase the *total sessions demand*, requiring HW organizations to hire more staff to increase the service capacity, forming the third balancing loop—B3: Reduce Out of Services. Here, we also considered the demand of the existing clients in the system. Highly stressed people using HW services are also part of the session's demand. Providing services to the people already in the HW system indicates a further increase in the *total sessions demand*, which increases *HW Service Staff* as the capacity increase, forming the first reinforcing loop—R1: Adjust HW Service Capacity. Prioritizing services to people indicates a decrease in the remaining capacity, creating the fourth balancing loop—B4: Prioritize Existing Clients.
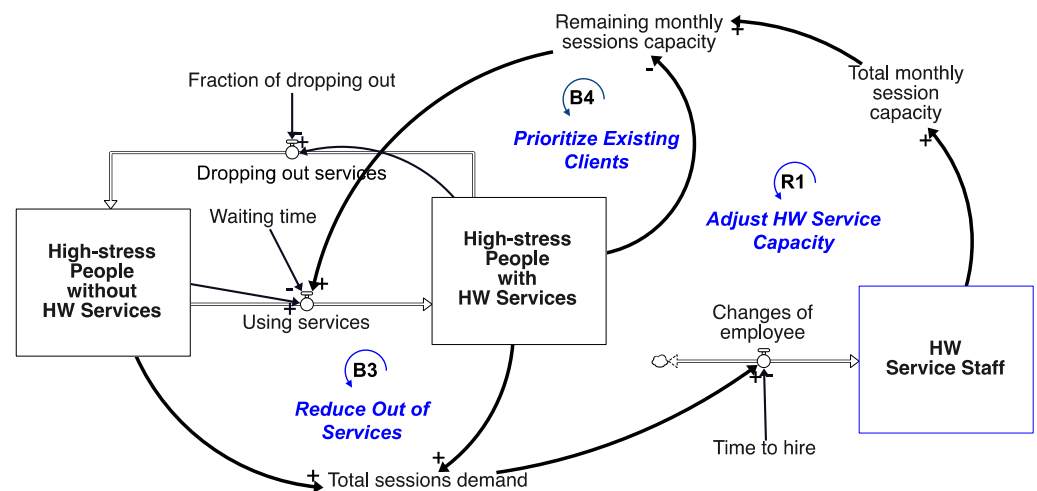

Figure 4. Health and well-being service provision. *Note:* 'R' represents 'reinforcing' loops, meaning that an increase (decrease) of one variable would trigger an increase (decrease) of this variable after travelling the full loop.

4.4. Organizational Resilience in the Environment

Aside from the health service sector mentioned above, another critical factor that connects individuals' and organizations' resilience is how the surrounding environment and organizations can mitigate the adversities and disturbances that individuals face. Multiple crisis events are "environmental jolts" that potentially bring opportunities for organizational transformation, which might also create disturbances for individuals. With

"crisis shocks" in the system, the average number of disturbance events increases, increasing the number of people experiencing increased stressing.

In this model, we used the stock of *Environment Temporary Adjustments* to describe the organization's attempts to provide solutions (see Figure 5). Increasing disturbance events requires organizations such as workplaces to accommodate the events and increase temporary adjustments, which increases the disturbance events that individuals need to adjust to, forming the second reinforcing loop—R2: Temporary Environmental Disturbance. *Environment Temporary Adjustments* are settled and moved to the stock of *Stabilized Adjustments*, forming the fifth balancing loop—B5: Long-term Stabilization. For example, vaccination programs, work-from-home guidelines, and traveling notices formed some of the stabilized adjustments during the COVID-19 pandemic. *Environment Stabilized Adjustments* could be revisited after a specific time in multiple shocks, being moved to *Temporary Adjustments*.
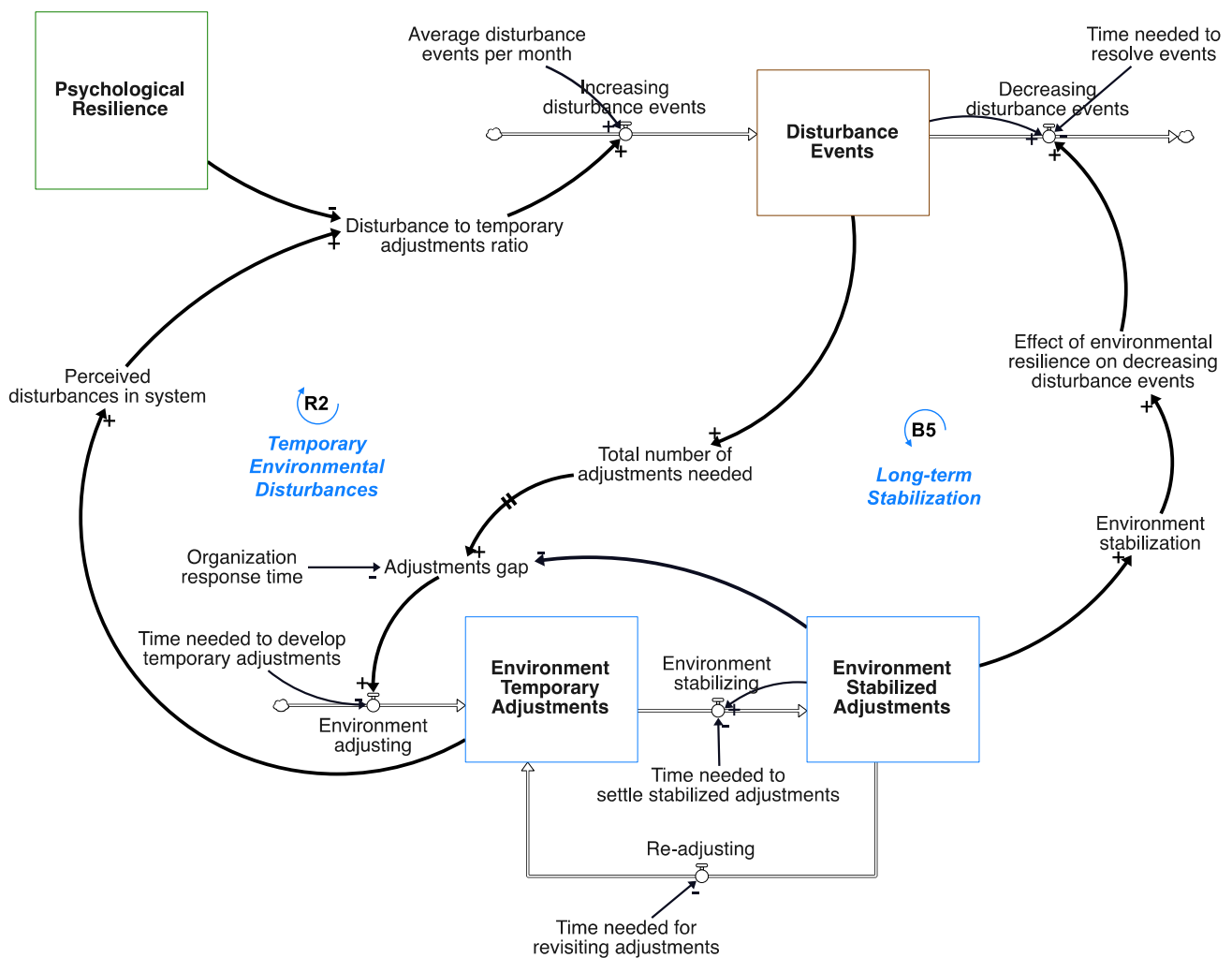

Figure 5. Organizational resilience in the environment.

In Figure 6, we present an overview of the main causal mechanisms and the interconnections between four sectors that we described.
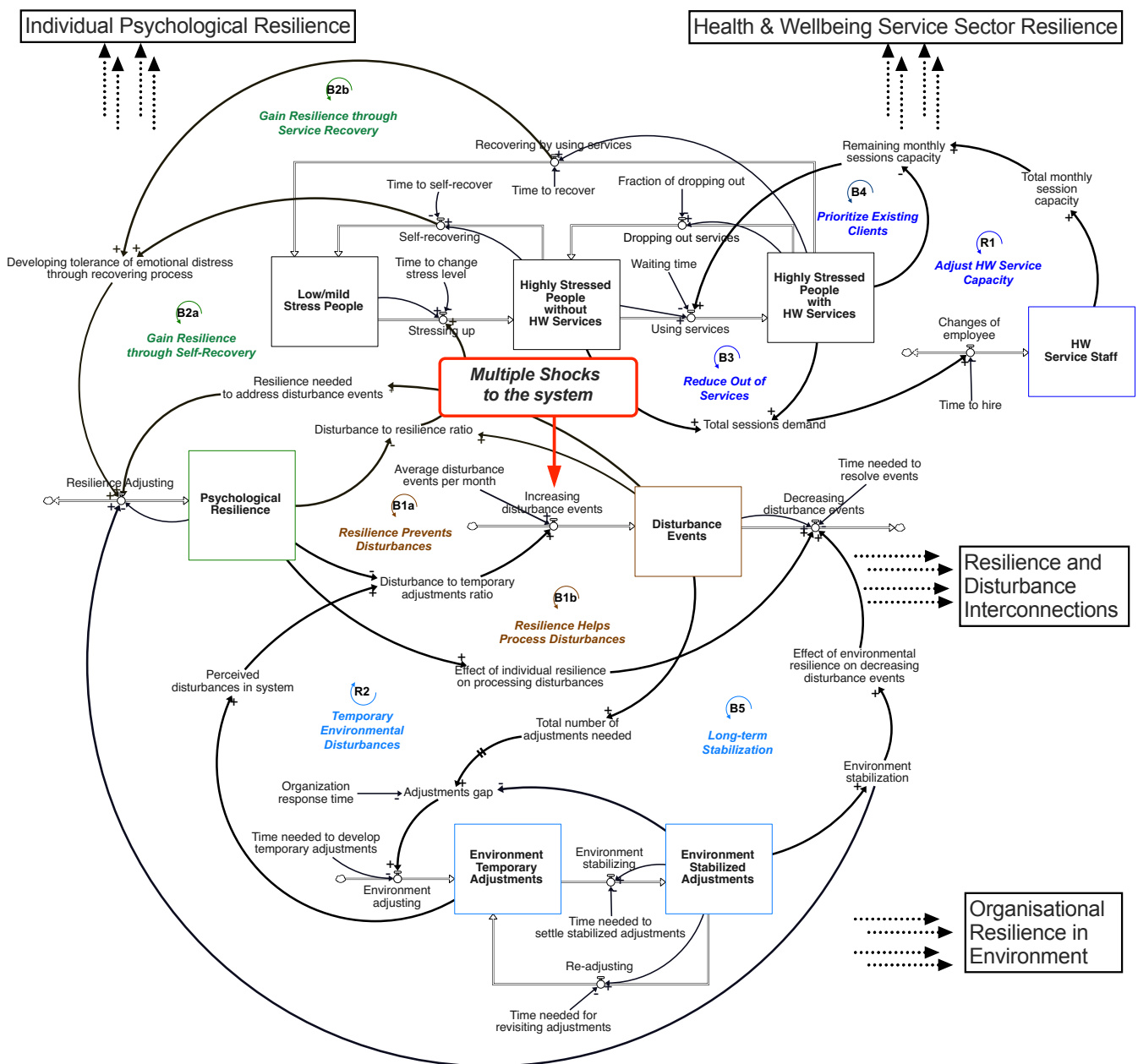
Figure 6. Stock and flow structure of the resilience model. The red box highlights the impact of multiple shocks to the system.

5. Model Results

The simulation model had a 200-month time horizon. In this section, we describe the model equilibrium conditions and how the model responds to different scenarios of multiple shocks.

5.1. Model Equilibrium

We initialized the model in equilibrium without any shocks to the system. The model equations are included in Appendix A. With an average of 2.5 disturbance events happening every month, the psychological resilience remained 0.6 throughout the model's running time of 200 months. The number of temporary adjustments remained the same as the adjustments demanded by the disturbance events, leaving the disturbance to temporary adjustments ratio at 1. The environmental stabilization ratio remained 0.23, indicating that the environment was stable in providing support. The model was initialized with

12,300 people, with 10,000 people having low/mild stress, 1.74k people not using HW services, and 543 highly stressed people using HW services. The mental health services had 57 staff throughout the model running time, providing 5700 sessions monthly to support the population's health and well-being.

5.2. Multiple Shocks in the Base Run

For the base run, we simulated the model with three consecutive shocks with equal intensities and durations. The model's time horizon was 200 months, while the shocks only presented in the initial 60 months, which is less than one-third of the running time. The reason is that a long time horizon can show the long-term impact and the process for the system to regain steady status. Each shock lasted five months, with an interval of six months and an equal intensity of three. The three shocks from month 20 to month 47 indicate that there were approximately two years of elevated disturbance, ensuring the investigation of the long-term impacts. A shock intensity of three increased the number of disturbances of events to 10 events per month. The first shock started by month 20. Figure 7 shows that the number of highly stressed people without HW services rose to 4200 by month 26.5, which shows that the peak of the first wave shocks had a 6.5-month delay. The maximum number of highly stressed people was a third of the total population. The next two waves displayed the same delays as the first wave. The peak of highly stressed people without HW services remained the same as in the first wave in the second wave, and then decreased to 3240 in the third wave. The psychological resilience ratio increased over the three consecutive shocks from 0.63 to 0.66, indicating that people recovering from using HW services or self-recovery gained tolerance toward the same intensity and duration of shock, increasing the population's resilience to future shocks. The psychological resilience ratio describes the general trend and changes in psychological resilience. The impact of the multiple shocks on the system lasted for the remaining simulation time, with a relatively stable increase in highly stressed people without HW services. Overall, the number of highly stressed people without HW services remained lower compared to pre-multiple shocks, due to the overall improvement in psychological resilience gained from the multiple shocks. The base run showed two interesting results:

- Resilience developed in multiple shocks can lower the number of highly stressed people without HW services compared to pre-shock conditions.
- Under the scenario of three consecutive shocks with the same durations and intensities, the psychological resilience at the population level increased over time, but was not sufficiently high enough to decrease the overall risk of deterioration of health and well-being.

5.3. Attenuation of Multiple Shocks

In the real world, the level of disturbances and adversities from crises varies. To explore the system's response to different crisis scenarios, we changed the durations, intervals, and intensities of the three consecutive shocks. The first scenario that we were interested in was the "attenuation of multiple shocks," in which the duration and intensity of the three shocks decreased over time. The first shock lasted 12 months with an intensity of six, the second shock lasted five months with an intensity of three, and the third shock lasted two months with an intensity of two. As Figure 8 shows, the number of highly stressed people without HW services increased immediately after the starting point of the first crisis in month 20 and kept increasing during the first wave for 10 months, reaching 6720 in month 30. Afterward, the number of highly stressed people without HW services started to decline before the end of the first wave, which occurred by month 32. Toward the end of the subsequent two waves of crises, the number of highly stressed people without HW services reached 3090 and 1670 per month.

The number of highly stressed people without HW services showed a stable decreasing-over-time pattern after the first wave, and the overall increase in psychological resilience was enormous compared to the base run throughout the 200 months. One of the reasons is that the duration and intensity of the shocks to the system decreased. Another reason

is that the amplified first wave increased the total number of environmental adjustments needed for stabilizing the environment in comparison to the base run. While it brought more short-term disturbances to individuals to adjust (see R2: Temporary Environmental Disturbance in Figure 6), in the long run, the temporary solutions were transformed to stabilized adjustments that were relatively more sufficient to address the second and third waves as the shocks to the systems were also attenuated (see B5: Long-term Stabilization in Figure 6). Moreover, as more people experienced disturbances and adversities in the first wave, the recovering process increased the population's psychological resilience by increasing the emotional tolerance of distress and prevented individuals from becoming more stressed when the second and third shocks happened (see B2a and B2b: Gain Resilience through Self-recovery and Service Recovery, respectively in Figure 6). The health service system tried to increase the number of staff in the first significant wave, reaching approximately 139 staff by month 36.5 (after 4.5 months of the end of the first crisis), which was approximately 40 more staff in the same month in comparison to the base run. Consequently, the maximum number of flows of people becoming more stressed was significantly lower in the second and third waves. The environment became stable, providing more transformational adjustments throughout the crisis. The attenuation run showed another significant result:

- When the intensity and duration of the shocks decreased over time, the system's rapid responses in providing health services and environmental stabilization in the first significant shock were critical in improving the population's resilience in addressing the risk of health and well-being deterioration in later shocks.
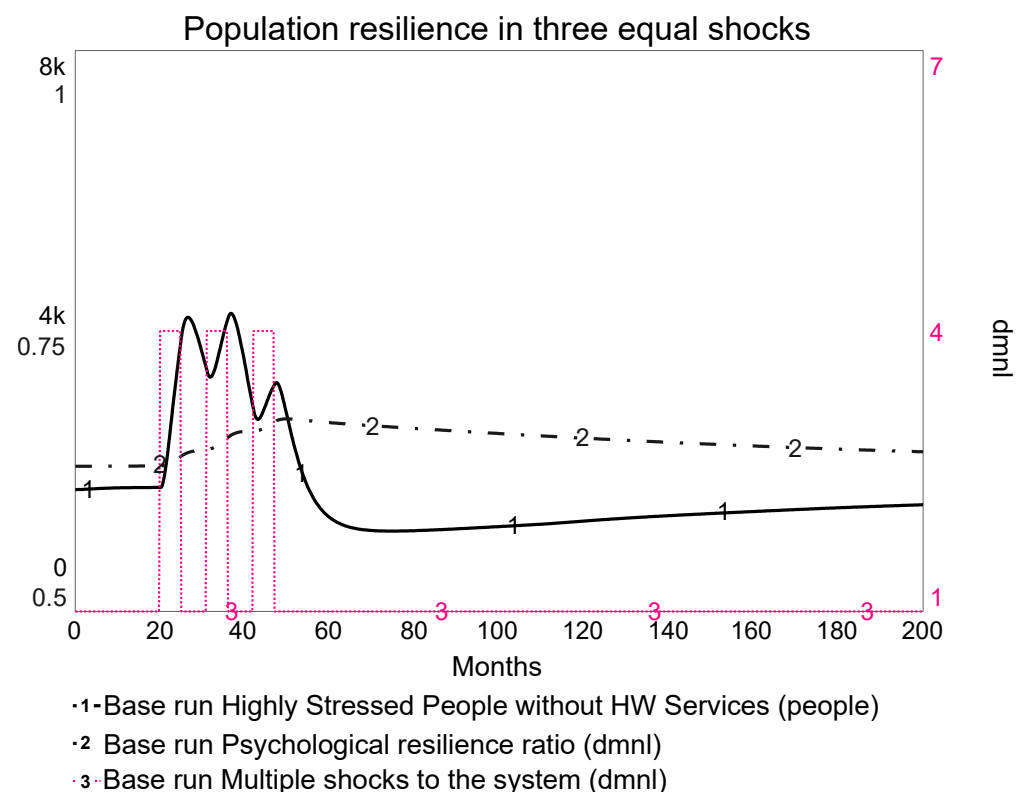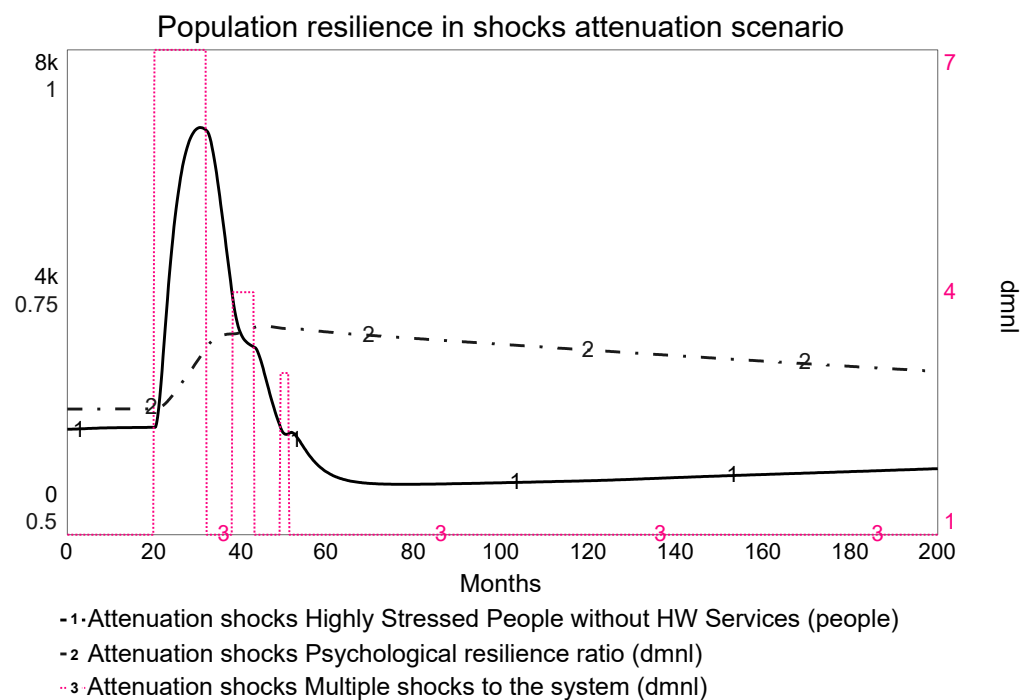

Figure 7. Population resilience with input of three shocks. Each shock lasted five months, with an interval of six months (dashed dot pink, right axis). Two indicators of population resilience were included: The number of highly stressed people without HW services (solid black, left axis, scale: 0~8000 people) and the psychological resilience ratio (dashed dot black, left axis, scale: 0.5~1).

5.4. Amplification of Multiple Shocks

The second scenario we were interested in was the "amplification of multiple shocks." The duration and intensity of the three shocks increased over time. In this scenario, we

reversed the setting conditions of the "attenuation of multiple shocks" scenario. Here, the first shock lasted two months with an intensity of two, the second shock lasted five months with an intensity of three, and the third shock lasted 12 months with an intensity of six. Figure 9 shows that the number of highly stressed people without HW services kept increasing during the first and second waves for 10 months, reaching 4350 by month 34, which is higher than the base run. Afterward, until month 48, the number of highly stressed people without HW services rose exponentially to 5620 as the third shock hit the system by month 39 for another 12 months. The number of people without HW services started to decline from month 48, three months before the third shock ended, indicating that the stabilized solutions and HW services provided by the HW sector were effective before the third wave ended.
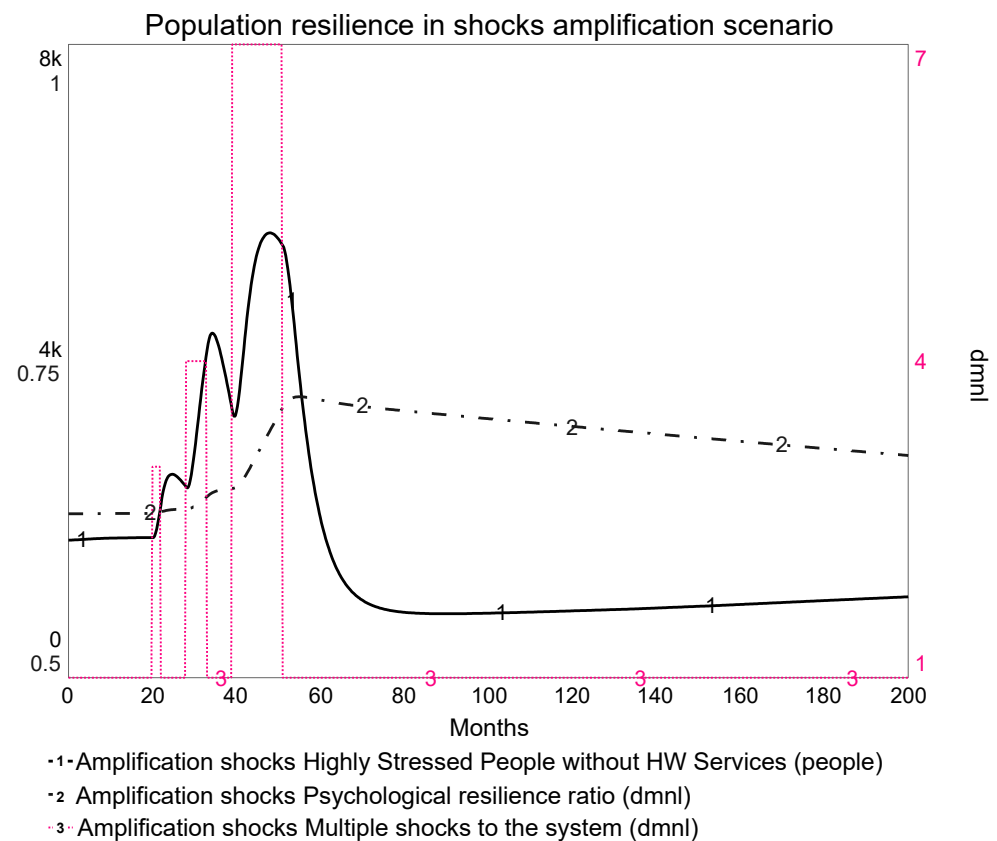

Figure 8. Population resilience with an input of three attenuated shocks. The shocks (right axis) are shown in dashed dot lines in pink. The first shock lasted 12 months with an intensity of six, the second shock lasted five months with an intensity of three, and the third shock lasted two months with an intensity of two. The intervals between shocks remained six months.

Changes in the sequence of primary, mild, and minor shocks resulted in changes in the number of people who were stressed. Figure 10 shows comparisons of the accumulation of people became increasingly stressed and highly stressed people without HW services in four runs: Equilibrium, base run, shocks attenuation, and amplification. Before month 50, the accumulative number of people who became increasingly stressed in the attenuation scenario was the highest among the four runs, as the first wave was primary, leaving 6700 people without HW services (Figure 10b). However, from month 48 onward, the accumulative number of people stressed in the amplification scenario was higher than in the attenuation scenario throughout the simulation time. The outbreak of the third wave in the amplification scenario between months 39 and 51 left 5600 people without HW services (Figure 10b), which is lower than the peak in the attenuation stage. However, in the case of shock amplification, the psychological resilience and environmental stabilization solutions developed in the last two waves were not sufficient to prevent deterioration in the third wave (see B1a and B1b: Resilience Prevents Disturbances and Resilience Helps Process Disturbances, respectively in Figure 6), the accumulative number of people without HW services remaining in the amplification scenario was higher in comparison to that in the attenuation stage. After the disturbances were processed and resilience development

caught up (see B2a and B2b: Gain Resilience through Self-recovery and Service Recovery, respectively, in Figure 6), the number of people who became increasingly stressed was lower than that in the equilibrium and base run. The amplification run and comparisons leave us with a final point that:

- When the intensity and duration of the shocks increased over time, while the direct consequences of the first minor and mild shocks can be relatively smaller, a higher risk of health and well-being deterioration can present in the following major shock if the resilience development process does not sufficiently prepare the system.

-1- Amplification shocks Highly Stressed People without HW Services (people)
-2 Amplification shocks Psychological resilience ratio (dmnl)
-3 Amplification shocks Multiple shocks to the system (dmnl)

Figure 9. Population resilience with input of three amplified shocks. The shocks (right axis) are shown in dashed dot line in pink. The first shock lasted two months with an intensity of two, the second shock lasts five months with an intensity of three, and the third shock lasted 12 months with an intensity of six. The intervals between shocks remained six months.
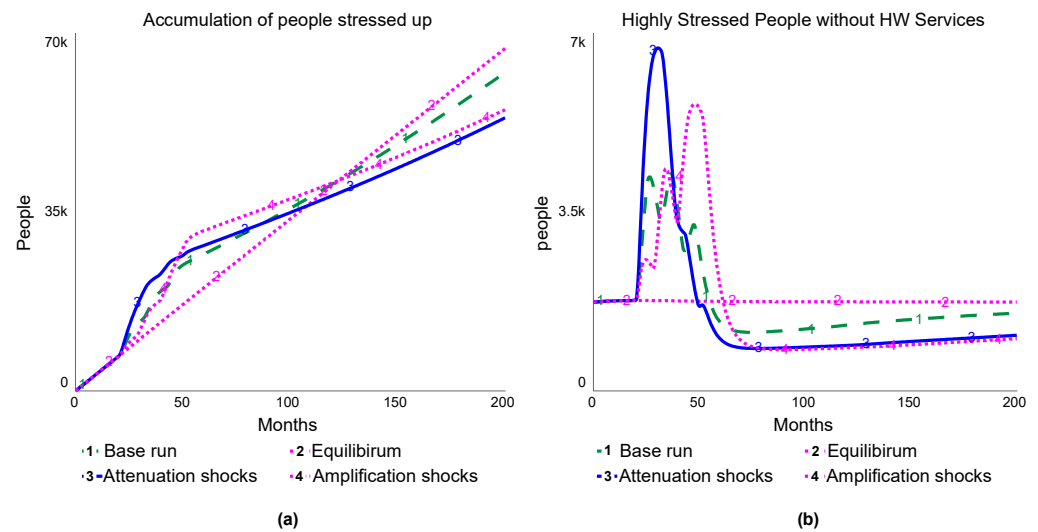
Figure 10. Comparisons of four runs: (**a**) Accumulation of people becoming increasingly stressed; (**b**) highly stressed people without HW services.
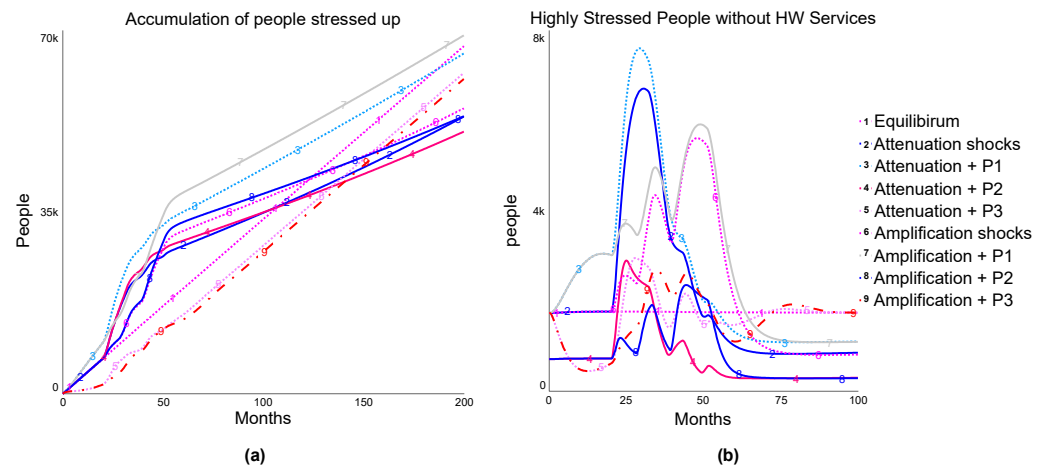
6. Policy Testing

The four runs suggest the importance of policies that develop resilience pre- and during multiple shocks of crises to decrease the risk of health and well-being deterioration. In this section, we describe how different policies can potentially reduce the number of highly stressed people without HW services in crises and increase the system's resilience to withhold future shocks.

Table 1 shows three policies and their dynamic principles and target loops. The first policy (P1) focuses on organizational adjustments—specifically, how organizations respond to crises and help individuals adjust to crises early when the shock hits the system. The second policy (P2) focuses on the health service sector's response to health service demand. The third policy (P3) focuses on individual and organizational learning during crises, which can help individuals develop a higher tolerance of distress and adversities. Moreover, organizations require stabilized adjustment when there are multiple and consecutive shocks as waves of crises.

Table 1. Policies for enhancing individual and organizational resilience when facing multiple crises.

Policy	Policy Description	Dynamic Principle	Targeted Loops
P1: Environment-based fast adjustments	Speeding up the environment's adjustments in providing temporary solutions. Organizations monitor changes, quickly respond to crises, and attempt to develop temporary plans and revisit them quickly once the shock hits the system.	The organizational response time is one month (base run is three months), the time needed for temporary plans equals two months (base run is four months), and every six months (base run is 12 months), the organization revisits the plan.	B2, B1a, B1b
P2: Health service sector-based fast responses	Providing health services to support health and well-being throughout crises. The health service sector responds to the demands of health services quickly and provides programs to encourage the use of health services.	The fraction of people reaching out to health and well-being services is 0.8 (base run is 0.5). The waiting time to access these services equals two months (base run is four months), and the time to hire new staff is now three months (base run is 12 months).	R1, B3, B4, B2b, B1a, B1b
P3: Collective growth	Facilitating organizations' and individuals' evolvement and adjustment for long-term stabilization in crises. Specifically, individuals develop more resilience in tolerating distress and adversities through self-recovery and using health services. Moreover, organizations can provide stabilized adjustments (such as guidelines, arrangements, long-term strategies, and solutions) more quickly in crises.	The emotional tolerance acquired from the recovery process is four times that of the original baseline, which is now 4 (base run is 1), and the time for organizations to settle their stabilization adjustment is now three months (base run is 12 months).	B2a, B2b, B5, B1a, B1b

Figure 11a shows the accumulation of people becoming increasingly stressed, which is the sum of the flow "becoming increasingly stressed" over the 200 months. The accumulation shows the long-term impact of disturbance and resilience development. For the scenario of attenuation shocks (see runs 2~5 in Figure 11) and the scenario of amplification shocks (see runs 6~9 in Figure 11), while the first policy P1 managed to lower the number of highly stressed people with no HW services in the long run, it unexpectedly increased the maximum number of highly stressed people with no HW services in the major waves (runs 3 and 7 in Figure 11b), which suggests that the recovery from services cannot be placed to support the population's psychological resilience development, leaving more people at risk of becoming increasingly stressed. The unintended consequence of increasing the number of highly stressed people with no HW services is that the adjustment in P1 only considered the increase in short-time adjustments rather than stabilization of the long-term adjustment, which increased the disturbance level significantly in a short time, resulting in an increase in the number of highly stressed people with no HW services. As a result, the increased psychological resilience was not sufficient to address the increased level of disturbances in the environment.

Figure 11. Policy tests. Comparisons of the three policies P1, P2, and P3 for the scenario of attenuation and amplification shocks, in comparison to the equilibrium conditions: (**a**) Accumulation of people becoming increasingly stressed in 200 months; (**b**) highly stressed people without HW services in the initial 100 months.

P2 (see runs 4 and 8 in Figure 11) showed the best outcome in reducing the number of highly stressed people with no HW services, compared to all other runs. Under P2, more than 200 health service staff, four times the initial number of health service staff in the system, were hired to provide services and help individuals gain resilience through the recovery process in both the attenuation and amplification scenarios. P2 significantly reduced the accumulation of stressed people over the long run after month 150. However, between months 50 and 125, a significant number of people still experienced adversity and distress, which shows that the reliance on service capacity changes is not the best policy.

Policy P3, collective growth (see runs 5 and 9 in Figure 11), significantly reduced the maximum number of stressed people with no HW services. As Figure 11b shows, the number of highly stressed people without HW services started to decline before the onset of the first shock in both the attenuation and amplification shocks scenarios, and the peaks were reduced by approximately 50%, suggesting that the prevention and pre-crises responses were activated before the crises. Consequently, disturbances and adversities can be addressed without being stressed. As Figure 11a shows, the accumulation of people becoming increasingly was significantly reduced throughout the simulation time. However, the impact of the shocks did not reach equilibrium until month 60 in Figure 11b, showing the accumulative risk of multiple shocks in the system again.

In summation, the policy test showed the critical role of health services in hiring staff to meet the service demand. However, it did not solve the fundamental problem of how multiple crisis shocks increase disturbance and stress for individuals, thus not sufficiently addressing the challenges of multiple shocks. Moreover, without long-term stabilization adjustments, rapid temporary adjustments can create unintended consequences in terms of increasing the number of disturbances over a short time, challenging the resilience of the system. Furthermore, providing individuals' and organizations' learnings and reflections on tolerating adversities and disturbances seems vital to improving resilience and preventing a significant level of distress at the population level.

7. Discussion, Limitations, and Implications

This paper adopted a feedback view of resilience development and drew theories of psychological and organizational resilience to determine how resilience is developed during multiple shocks in crises. The multisystemic perspective in connecting psychological and organizational resilience was used to develop a simulation model based on the learnings from mental health and well-being deterioration during the COVID-19 pandemic, which extends resilience theories. Model analysis illuminated that multiple shocks in crises,

the rise of temporary adjustments, and limited service provision resources can increase the accumulative risk of the deterioration of health and well-being. Simulations and multiple combinations of intensities and durations of shocks demonstrated that the learnings developed during the first few shocks could potentially provide the system with a significant level of prevention that decreases the chances of continuous deterioration. In Figure 12, we show the how psychological resilience, environmental resilience, and the HW service provision form this "resilience," which can grow and buffer shocks in the multiple waves of a crisis. The simulation model contributed a few critical implications in theorizing the dynamics of resilience development in multiple shocks.
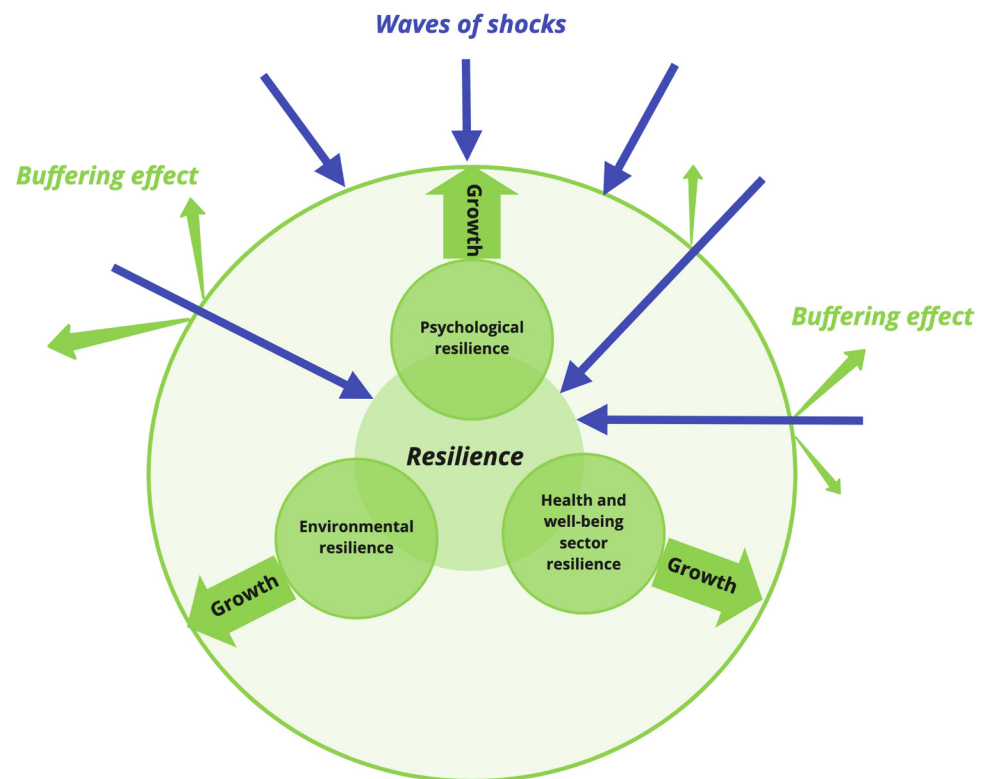
Figure 12. Resilience development in multiple shocks.

The first implication is extending the multisystemic perspectives in resilience development by seeing resilience as a complex adjustment process involving multiple systems and contexts. The risk of crises accumulates as the number of disturbance events rises beyond the resilience level. Abrupt, significant, temporary, and frequent changes in surrounding organizations may cause unintended difficulties for individuals, primarily when changes concern essential resources or support for one's immediate stabilization and grounding. For people who struggle with acute abruptions and disturbances, these changes may become another burdensome object that people need to become acquainted with quickly, which is likely to contribute to emotional disturbance in the sense of experiencing the unknown, uncertainty, and feelings of powerlessness, helplessness, and hopelessness.

The second implication relates to strengthening and reinforcing protective factors in producing systemic efforts of strategy development and policy design in population resilience. At an individual level, resilience developed through recovering from previous shocks of the exact nature is critical as it provides higher tolerance of distress and adversity. The recovery process requires individuals to constantly build on personal assets such as self-esteem and emotional positivity. It is also critical to develop adequate insights into one's external reality, nuanced emotions, and intrapsychic experiences. Individuals can present with psychological flexibility, reflect, and wonder about goals and visions of oneself and life, as well as present with adaptive coping skills and strategies, which support

individuals' counter against appraisal of negative emotions and destructive responses. Involving multi-sector organizations such as the education, workplace, and public service sectors across systems is essential, as resilience development is a process of experiencing human relationships, connections, rapport, and trust across the boundaries of multiple systems. Resilience of multiple systems serves not only certain designed functions, but also forms stable systems to protect individuals, families, and even groups from being shattered by crises and forceful interruptions. As the model suggested, systemic efforts such as equipping parents with skills and knowledge about crises and providing supportive resources, strategic guidelines, and financial and employment security are needed to facilitate the growth of resilience.

The third implication is conceptualizing organizational resilience from individual resilience development perspectives. Persistent crises require organizations to respond with mitigations, but short-term adjustments that only focus on securing organizational performance and functioning without considering individual resilience can increase the accumulative disturbances individuals face within the short term, which hinders the development of psychological resilience during crises. Organizational and individual learnings are critical to help the growth of resilience and decrease the number of people becoming increasingly stressed during a crisis. When crises and shocks to the system regard health and well-being, such as COVID-19, measurements of organizational resilience should expand from organizational functionality and performance. An individual–environment view of organizational resilience should incorporate indicators such as to what extent the organization provides insights and learnings from the adverse events for individuals, and to what extent the organization's capacity to adapt to disturbances and mobilize resources to sustain changes and provide transformational adjustments.

The last implication regards COVID-19 lessons. Significant changes have been observed in conducting and receiving health and well-being services. As all parties strive to adjust to the long-pandemic, we wonder how we may learn and reflect from our experiences of the pandemic and continuously support people in need. When the population faces constant and enduring waves of a pandemic, policies and multiple sectors should facilitate the development of psychological assets such as self-esteem, psychological flexibility, adaptive self-care or coping strategies, and supportive social welfare. The present reality is that the pandemic has a high level of uncertainty, and the unknown may not be eliminated, which requires us to live with these disturbing and uncomfortable dynamics. A resilience perspective can cultivate tolerance of disturbances and distress, reinforcing the population's growth to strive for a happy life.

In terms of limitations, while we used the COVID-19 pandemic as an example to explore the interconnections between individual and organizational resilience, the model is not calibrated with empirical data and does not consider variations across subpopulations. Emerging longitudinal research shows that young generations aged 19–30 years and females had a higher risk of distress during the pandemic and its lockdowns [57]. Additionally, younger age (<40 years), female gender, psychological illness, student status, exposure to social media/news, and unemployment are common risk factors that have been shown to be associated with mental distress caused by the pandemic [18]. The model was not calibrated with empirical data, as the focus of this model is to provide theoretical exploration. Empirical evidence decides the realism and reliability of the model's validity, which requires both structural and behavior-over-time data [58]. While we believe theory-based modeling was useful and proper for the purpose of this paper, the model was not calibrated with behavior-over-time data; thus, the model should be considered exploratory with tentative and uncertain conclusions. To improve the evidence level of the model, future studies can calibrate the model using data on the population's health and well-being, service provision, and environmental changes. Future research can further include the impact of accumulative risk on different socioeconomic or age groups to show the different levels of vulnerability.

The model provided theoretical insights but was overall simplified at quite a high level. A more systematic review of theoretical orientations or models in clinical psychology can be used to improve the structural conceptualization. For example, resilience can be closely linked to psychological development, insights, judgments, resourcefulness, behavioral regulation, distress tolerance, etc. For organizational resilience, we simplified the conceptualization of organization resilience by using the number of staff in the health and well-being service sector. In practice, different agencies have broader approaches to health services, such as crisis intervention and community-based health services. Agencies that provide community health services and care might have more significant challenges in responding to crisis interventions during multiple pandemic waves. Future research can integrate broader service provision challenges by different agencies. Meanwhile, it could be meaningful to include resilience in different cultures, communities, and groups, so this concept and thinking can be further nuanced to different cultural norms and identities.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Model Equations

****

Crises_multiple_shocks:

****

First_shock_duration = 5
   UNITS: month
First_shock_intensity = 3
   UNITS: dmnl
First_shock_start = 20
   UNITS: month
First_shock_stop = First_shock_start+First_shock_duration
   UNITS: month
Interval_to_second_shock_start = 6
   UNITS: month
Interval_to_third_shock_start = 6
   UNITS: month
Multiple_Shocks[First_wave] = STEP(Risk_intensity_of_each_shock[First_wave], First_shock_start)-STEP(Risk_intensity_of_each_shock[First_wave], First_shock_stop)
   UNITS: dmnl
Multiple_Shocks[Second_wave] = STEP(Risk_intensity_of_each_shock[Second_wave], Second_shock_Start)-STEP(Risk_intensity_of_each_shock[Second_wave], Second_shock_stop)
   UNITS: dmnl
Multiple_Shocks[Third_wave] = STEP(Risk_intensity_of_each_shock[Third_wave], Third_shock_start)-STEP(Risk_intensity_of_each_shock[Third_wave], Third_shock_stop)

UNITS: dmnl
"MULTIPLE_SHOCKS_Switch_1=_crisis_on" = 1
    UNITS: dmnl
Risk_intensity_of_each_shock[First_wave] = First_shock_intensity
    UNITS: dmnl
Risk_intensity_of_each_shock[Second_wave] = Second_shock_intensity
    UNITS: dmnl
Risk_intensity_of_each_shock[Third_wave] = Third_shock_intensity
    UNITS: dmnl
Second_shock_duration = 5
    UNITS: month
Second_shock_intensity = 3
    UNITS: dmnl
Second_shock_Start = Interval_to_second_shock_start+First_shock_stop
    UNITS: month
Second_shock_stop = Second_shock_duration+Second_shock_Start
    UNITS: month
Third_shock_duration = 5
    UNITS: month
Third_shock_intensity = 3
    UNITS: dmnl
Third_shock_start = Second_shock_stop+Interval_to_third_shock_start
    UNITS: month
Third_shock_stop = Third_shock_start+Third_shock_duration
    UNITS: month
****
Disturbance_and_Psychological_resilience:
****
Disturbance_events_that_can_be_dealt_with_resiliency = Psychological_Resilience//Resilience_needed_per_disturbance_event
    UNITS: event
Fractional_emotional_tolerance_acquired_from_recovering = IF P3_Collective_growth =1 THEN Normal_fractional_emotional_tolerance_acquired_from_recovering*Intensity_of_P3_on_distress_tolerance ELSE Normal_fractional_emotional_tolerance_acquired_from_recovering
    UNITS: dmnl
Goal_of_resilience = Resilience_needed_per_disturbance_event*Disturbance_events
    UNITS: resilience
Initial_individual_resilience = INIT(Goal_of_resilience)
    UNITS: resilience
Normal_fractional_emotional_tolerance_acquired_from_recovering = 1
    UNITS: dmnl
Psychological_Resilience(t) = Psychological_Resilience(t - dt) + (Resilience_adjusting_by_Recovering_from_shocks) ∗ dt
    INIT Psychological_Resilience = Initial_individual_resilience
    UNITS: resilience
Psychological_resilience_ratio = EXP(Psychological_Resilience)/(1+EXP(Psychological_Resilience))
    UNITS: dmnl
Resilience_adjusting_by_Recovering_from_shocks = (Goal_of_resilience-Psychological_Resilience)*(Fractional_effect_of_tolerating_emotional_distress_through_recovering_process_per_month)*Environment_stabilization_ratio
    UNITS: resilience/month
Resilience_needed_per_disturbance_event = 0.053

UNITS: resilience/event

****

Environment_adjustments:

****

Adjustments_Gap = MAX(0, SMTH3(Total_adjustments_needed-Environment_Stabilized_Adjustments, Organization_response_time))

UNITS: adjustment

Environment_adjusting = MAX(0, (Adjustments_Gap)//Time_needed_to_develop_temporary_adjustments)

UNITS: adjustment/month

Environment_Stabilized_Adjustments(t) = Environment_Stabilized_Adjustments(t - dt) + (Environment_stabilizing - "Re-adjusting") * dt

INIT Environment_Stabilized_Adjustments = Initial_stabilised_adjustments

UNITS: adjustment

Environment_stabilizing = Fractional_adjustments_that_move_to_stabilized_adjustments* Environment_Temporary_Adjustments//Time_needed_to_settle_permanent_solutions

UNITS: adjustment/month

Environment_Temporary_Adjustments(t) = Environment_Temporary_Adjustments(t - dt) + (Environment_adjusting + "Re-adjusting" - Environment_stabilizing) * dt

INIT Environment_Temporary_Adjustments = Initial_temporary_adjustments

UNITS: adjustment

Fractional_adjustments_that_move_to_stabilized_adjustments = 0.3

UNITS: dmnl

Initial_stabilised_adjustments = Total_adjustments_needed

UNITS: adjustment

Initial_temporary_adjustments = Total_adjustments_needed*Time_needed_to_settle_permanent_solutions/(Time_needed_for_revisiting_adjustments*Fractional_adjustments_that_move_to_stabilized_adjustments)

UNITS: adjustment

Normal_organizational_response_time = 3

UNITS: month

Normal_time_needed_to_develop_temporary_adjustments = 4

UNITS: month

Normal_time_needed_to_revisit_adjustments = 12

UNITS: month

Normal_time_needed_to_settle_permanent_adjustments = 12

UNITS: month

Organization_response_time = IF P1:_Environment_Fast_Adaptation=1 THEN Normal_organizational_response_time/Intensity_of_P1_on_organizational_response_time ELSE Normal_organizational_response_time

UNITS: month

"Re-adjusting" = Environment_Stabilized_Adjustments//Time_needed_for_revisiting_adjustments

UNITS: adjustment/month

Time_needed_for_revisiting_adjustments = IF P1:_Environment_Fast_Adaptation=1 THEN Normal_time_needed_to_revisit_adjustments/Intensity_of_P1_on_revisiting_adjustments ELSE Normal_time_needed_to_revisit_adjust ments

UNITS: month

Time_needed_to_develop_temporary_adjustments = IF P1:_Environment_Fast_Adaptation=1 THEN Normal_time_needed_to_develop_temporary_adjustments/Intensity_of_P1_on_temporary_adjustment_time ELSE Normal_time_needed_to_develop_temporary_adjustments

UNITS: month

Time_needed_to_settle_permanent_solutions = IF P3_Collective_growth=1 THEN Normal_time_needed_to_settle_permanent_adjustments/Intensity_of_P3_on_stabilised-_adjustment ELSE Normal_time_needed_to_settle_permanent_adjustments

UNITS: month

****

Health and Well-being_service:

****

Changes_of_employee = CAPACITY_RESPOND_STWITCH* (Indicated_demanded-_number_of_MH_staff-HW_service_staff)//Time_to_hire

UNITS: people/month

HW_service_staff(t) = HW_service_staff(t - dt) + (changes_of_employee) * dt

INIT HW_service_staff = Initial_MH_service_staff

UNITS: people

Indicated_demanded_number_of_MH_staff = Total_sessions_demand/Number_of-_sessions_per_staff_per_month//Target_Waiting_Time

UNITS: people

Normal_target_waiting_time = 4

UNITS: month

Normal_time_to_hire = 12

UNITS: month

Number_of_sessions_per_staff_per_month = 100

UNITS: session/people/month

Remaining_monthly_sessions_capacity = MAX(0, Total_monthly_session_capacity-Total_monthly_sessions_occupied)

UNITS: session/month

Target_Waiting_Time = IF P2_Mental_Wellbeing_Service_Fast_Response=1 THEN Normal_target_

waiting_time/Intensity_of_P2_on_waiting_time ELSE Normal_target_waiting_time

UNITS: month

Time_to_hire = IF P2_Mental_Wellbeing_Service_Fast_Response=1 THEN Normal _time_to_hire/Intensity_of_P2_on_time_to_hire ELSE Normal_time_to_hire

UNITS: month

Total_monthly_session_capacity = HW_service_staff*Number_of_sessions_per_staff _per_month

UNITS: session/month

Total_monthly_sessions_occupied = "Highly stressed_people_with_HW_services" *Frequency_of_sessions_attended_per_month_per_people

UNITS: session/month

Total_number_of_service_sessions_needed_per_person = 10

UNITS: session/people

Total_sessions_demand = ("Highly_stressed_people_without_HW_services"+"Highly _stressed_people_with_HW_services")*Total_number_of_service_sessions_needed_per _person

UNITS: session

****

Initial_numbers:

****

Fractional_recovering_by_own = Fraction_of_self_recover/"Time_to_self-recover"

UNITS: 1/month

Fractional_Stressing_up = Normal_fraction_of_highly_stressed_symptoms/Time_to _change_stress_level

UNITS: 1/month

Fractional_using_service = Fraction_of_service_using_among_highly_stressed_ people/Target_Waiting_Time

UNITS: 1/month

INIT_highly_stressed_not_using_HW_services = INIT_low_stress_population*(fractional_Stressing_up)/(fractional_recovering_by_own+Fractional_using_service)

UNITS: people

INIT_highly_stressed_using_HW_services = INIT_highly_stressed_not_using_HW_services*Fractional_using_service*Time_to_recover/(1+Time_to_recover*Fraction_of_dropping_out_per_month)

UNITS: people

INIT_low_stress_population = 10000

UNITS: people

Initial_MH_service_staff = INIT(Indicated_demanded_number_of_MH_staff)

UNITS: people

Sum_of_population_stocks = "Low/mild_stress_people" + "Highly-stressed_people_with_HW_services" + "Highly-stressed_people_without_HW_services"

UNITS: people

****

Multiple_shocks_and_disturbance:

****

Decreasing_disturbance_events = (Effect_of_environmental_resilience_on_processing_disturbance_events*Effect_of_individual_resilience_on_processing_disturbances)*Disturbance_events/Time_needed_to_resolve_events

UNITS: event/month

Disturbance_events(t) = Disturbance_events(t - dt) + (Increasing_disturbance_events - Decreasing_disturbance_events) ∗ dt

INIT Disturbance_events = Initial_disturbance_events

UNITS: event

Disturbance_to_temporary_adjustments_ratio = Environment_Temporary_Adjustments//Max_adjustment_depending_on_resiliency

UNITS: dmnl

Effect_of_environmental_resilience_on_processing_disturbance_events = GRAPH(Environment_stabilization_ratio)

Points: (0.000, 0.000), (0.100, 0.360), (0.200, 0.660), (0.330, 1.000), (0.400, 1.100), (0.500, 1.200), (0.600, 1.300), (0.700, 1.400), (0.800, 1.600), (0.900, 1.800), (1.000, 2.000)

UNITS: dmnl

Effect_of_individual_resilience_on_processing_disturbances = GRAPH(Psychological_Resilience)

Points: (0.000, 0.0133857018486), (0.100, 0.0359724199242), (0.200, 0.0948517463551), (0.300, 0.238405844044), (0.400, 0.53788284274), (0.423, 1.000), (0.600, 1.46211715726), (0.700, 1.76159415596), (0.800, 1.90514825364), (0.900, 1.96402758008), (1.000, 1.98661429815)

UNITS: dmnl

Effect_of_temporary_disturbance_on_increasing_disturbance_events = GRAPH(Disturbance_to_temporary_adjustments_ratio)

Points: (0.000, 0.0133857018486), (0.400, 0.0359724199242), (0.800, 0.0948517463551), (1.200, 0.238405844044), (1.600, 0.53788284274), (2.000, 1.000), (2.400, 1.46211715726), (2.800, 1.76159415596), (3.200, 1.90514825364), (3.600, 1.96402758008), (4.000, 1.98661429815)

UNITS: dmnl

Environment_stabilization_ratio = (Environment_Stabilized_Adjustments)//(Environment_Stabilized_Adjustments+Environment_Temporary_Adjustments)

UNITS: dmnl

Increasing_disturbance_events = Effect_of_temporary_disturbance_on_increasing_disturbance_events*Number_of_disturbance_events_per_month

UNITS: event/month

Initial_disturbance_events = Normal_disturbance_events_per_month*Time_needed_to_resolve_events*2

UNITS: event

Initial_Disturbance_ratio_input = INT(Environment_Temporary_Adjustments//Max _adjustment_depending_on_resiliency)

UNITS: dmnl

Max_adjustment_depending_on_resiliency = Disturbance_events_that_can_be_dealt _with_resiliency*Number_of_adjustments_needed_per_disturbance_events

UNITS: adjustment

Multiple_shocks_to_the_system = (1+"MULTIPLE_SHOCKS_Switch_1=_crisis_on" *SUM(Multiple_Shocks))

UNITS: dmnl

Normal_disturbance_events_per_month = 2.5

UNITS: event/month

Number_of_adjustments_needed_per_disturbance_events = 3

UNITS: adjustment/event

Number_of_disturbance_events_per_month = Normal_disturbance_events_per_month *Multiple_shocks_to_the_system

UNITS: event/month

Time_needed_to_resolve_events = 2

UNITS: month

Total_adjustments_needed = (Disturbance_events*Number_of_adjustments_needed _per_disturbance_events)

UNITS: adjustment

****

Policy_switches:

****

CAPACITY_RESPOND_STWITCH = 1

UNITS: dmnl

Intensity_of_P1_on_organizational_response_time = 3

UNITS: dmnl

Intensity_of_P1_on_revisiting_adjustments = 2

UNITS: dmnl

Intensity_of_P1_on_temporary_adjustment_time = 2

UNITS: dmnl

Intensity_of_P2_on_fraction_of_dropping_out = 2

UNITS: dmnl

Intensity_of_P2_on_fraction_of_using_services = 1.6

UNITS: dmnl

Intensity_of_P2_on_time_to_hire = 4

UNITS: dmnl

Intensity_of_P2_on_waiting_time = 2

UNITS: dmnl

Intensity_of_P3_on_distress_tolerance = 4

UNITS: dmnl

Intensity_of_P3_on_stabilised_adjustment = 4

UNITS: dmnl

P1:_Environment_Fast_Adaptation = 0

UNITS: dmnl

P2_Mental_Wellbeing_Service_Fast_Response = 0

UNITS: dmnl

P3_Collective_growth = 1

UNITS: dmnl

****

Psychological_resilience_structure:

****

Accumulative_people_stressed_up(t) = Accumulative_people_stressed_up(t - dt) + (stressing_up_flow) ∗ dt
  INIT Accumulative_people_stressed_up = 0
  UNITS: people
Disturbance_to_resilience_ratio = Disturbance_events//Disturbance_events_that_can _be_dealt_with_resiliency
  UNITS: dmnl
Dropping_out_services = IF P2_Mental_Wellbeing_Service_Fast_Response=1 THEN "Highly_stressed_people_with_HW_services"*Fraction_of_dropping_out_per_month/ Intensity_of_P2_on_fraction_of_dropping_out ELSE Fraction_of_dropping_out_per_month *"Highly_stressed_people_with_HW_services"
  UNITS: people/month
Fraction_of_dropping_out_per_month = 0
  UNITS: 1/month
Fraction_of_self_recover = 0.2
  UNITS: dmnl
Fraction_of_service_using_among_highly_stressed_people = IF P2_Mental_Wellbeing _Service_Fast_Response=1 THEN Normal_fraction_of_service_using_among_highly _stressed_people*Intensity_of_P2_on_fraction_of_using_services ELSE Normal_fraction _of_service_using_among_highly_stressed_people
  UNITS: dmnl
Fractional_effect_of_tolerating_emotional_distress_through_recovering_process_per _month = ("Self-_recovering"+Recovering_by_using_services)*Fractional_emotional_ tolerance_acquired_from_recovering//Sum_of_population_stocks
  UNITS: 1/month
Frequency_of_sessions_attended_per_month_per_people = 4
  UNITS: session/people/month
Highly_stressed_people_reaching_out_services = "Highly_Stressed_people_without _HW_services" *Fraction_of_service_using_among_highly_stressed_people
  UNITS: people
Highly_stressed_people_that_can_be_scheduled = Remaining_monthly_sessions_ capacity//Frequency_of_sessions_attended_per_month_per_people
  UNITS: people
"Highly_Stressed_people_with_HW_services"(t) = "Highly_Stressed_people_with _HW_services"(t - dt) + (Using_services - Recovering_by_using_services - Dropping_out _services) ∗ dt
  INIT "Highly_Stressed_people_with_HW_services" = INIT_Highly_stressed_ using_HW_services
  UNITS: people
"Highly_Stressed_people_without_HW_services"(t) = "Highly_Stressed_people_ without_HW_services"(t - dt) + (Stressing_up + Dropping_out_services - "Self-_recovering" - Using_services) ∗ dt
  INIT "Highly_Stressed_people_without_HW_services" = INIT_highly_stressed _not_using_HW_services
  UNITS: people
"Low/mild_stress_people"(t) = "Low/mild_stress_people"(t - dt) + ("Self-_recovering" + Recovering_by_using_services - Stressing_up) ∗ dt
  INIT "Low/mild_stress_people" = INIT_low_stress_population
  UNITS: people
Normal_fraction_of_highly_stressed_symptoms = 0.2
  UNITS: dmnl
Normal_fraction_of_service_using_among_highly_stressed_people = 0.5
  UNITS: dmnl

Recovering_by_using_services = "Highly_Stressed_people_with_HW_services"//Time_to_recover

UNITS: people/month

"Self-_recovering" = "Highly_Stressed_people_without_HW_services"*Fraction_of_self_recover//"Time_to_self-recover"

UNITS: people/month

Stressing_up = "Low/mild_stress_people"*Disturbance_to_resilience_ratio*Normal_fraction_of_highly_stressed_symptoms//Time_to_change_stress_level

UNITS: people/month

Stressing_up_flow = Stressing_up

UNITS: people/month

Time_to_recover = Total_number_of_service_sessions_needed_per_person//Frequency_of_sessions_attended_per_month_per_people

UNITS: month

"Time_to_self-recover" = 3

UNITS: month

Time_to_change_stress_level = 6

UNITS: month

Using_services = MIN(Highly_stressed_people_that_can_be_scheduled, Highly_stressed_people_reaching_out_services)/Target_Waiting_Time

UNITS: people/month

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