

Master Thesis

**Intergenerational PTSD
transmission resulting from
russian invasion of Ukraine**

Thesis submitted in partial fulfillment of the requirements for
Master of Philosophy in System Dynamics from the University of Bergen

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Abstract

The merciless War against Ukraine, which started by a terrorist state – russia in 2014, has had a significant impact on the whole Ukrainian population. As a consequence of this invasion, not only hundreds, thousands, but millions of civilians became innocent victims. The surviving population is likely to suffer from long-lasting emotional and physical consequences. The purpose of this study is to examine the prevalence of post-traumatic stress disorder (PTSD) among parents and children who have been affected by the debilitating war, as well as the outcomes it caused for parent/child interconnections within the family. For this purpose, utilizing the system dynamics approach there has been developed a model that portrays the key drivers of PTSD, as well as main interconnections between children's and parents' mental health.

Our model reveals the mechanisms that can be used to mitigate the negative impact of the war on people's mental health, emphasizing the crucial importance of the healthcare system capacity, people's awareness in attending PTSD treatment (e.g., Cognitive Behavioral Therapy), along with resource allocation. Despite several limitation in our work, our model suggests a few scenarios, which can aid in reduction of the PTSD level among Ukrainian population.

Furthermore, this work provided support for the existing theoretical framework about children and parents interconnections within the family and its influence on their mental health and potential development of PTSD.

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Chapter 1: Problem Introduction

1.1. Background information

In recent years, Ukraine has faced immense challenges and undergone significant transformations. The country has been grappling with a complex political and economic landscape, and its people have demonstrated remarkable unity and the spirit of invincibility for their independence even in the face of adversity. Day by day Ukraine continues to defend its independence in the war started by Russia. Courageous soldiers are fighting in the conditions of a long and unpredictable threat to their lives and the lives of their fellow citizens. However, beneath the surface, there lies a silent crisis that demands everybody's attention – the psychological impact of the ongoing conflict resulting from the Russian invasion. Ukrainian civilian population suffers from daily news about senseless and unprovoked killings and torture in the occupied territories, comes under rocket and shell fire, and survives under enemy pressure in the occupation conditions (Radchenko, 2022, p. 42).

Despite the immense courage displayed by the Ukrainian people during these times of crisis for the country and the world, the psychological impact of military events has had a significant effect on the health of the population, particularly the younger generation (Forbes, 2022). Considering that in this turbulent environment, it is the most vulnerable members of society – the children and parents, which are extremely concerned for the health and life of their kids. Amidst the chaos and destruction, the psychological toll on children and parents has become increasingly apparent. People, who are living under constant threat, are witnessing violence, and enduring the upheaval of displacement, will inevitably have lasting scars on their memory.

The United Nations (UN) reported that only during the first month of Russian invasion over 10 million people were forced from their homes in order to find safety and security (United Nations, 2022). This includes an estimated 6.5 million men, women and children who are internally displaced, and almost 3.5 million who crossed the border out of Ukraine as refugees. According to IOM's data, 13.5% of individuals who were recently displaced had previously experienced displacement during the years 2014 and 2015, when Russia's military annexed the Crimea from Ukraine, and backed separatist militants in the eastern regions of Luhansk and Donetsk (International Organization for Migration, 2022).

With each passing day continuation of the war, the number of people who will experience consequences for their mental health will increase. Even those who were able to withstand the first months of the war will suffer mental exhaustion, because getting used to being in a constant war can also have a negative impact on mental health.

The World Health Organization (WHO) estimated that, 20% of the population living in areas affected by armed conflicts in the last 10 years have some form of mental disorder, from mild depression and anxiety to psychosis, and almost every eight person have a mental disorder of moderate or severe severity (World Health Organization, 2022). Furthermore, in recent years, extensive research has shed light on the high prevalence of post-traumatic stress disorder (PTSD) and major depression (MD) among populations affected by war from 1989 to 2019 (Charlson et al., 2019; Steel et al., 2009; Thole H Hoppen et al., 2021; Stevenson et al., 2020; Morina et al., 2018;). For instance, the results of the study by Thole H Hoppen et al. (2021) revealed a significant mental health burden among adult war survivors globally. The extrapolation indicated that in 2019 alone, approximately 316 million adult war survivors experienced PTSD and/or MD.

According to the Michel L. A. Dückers et al. (2018), even before full-scale russian invasion, Ukraine occupied the sixth place among 24 countries on PTSD prevalence (Figure 1). This suggests that the current war conflict has obviously further exacerbated the prevalence of PTSD and its associated challenges.

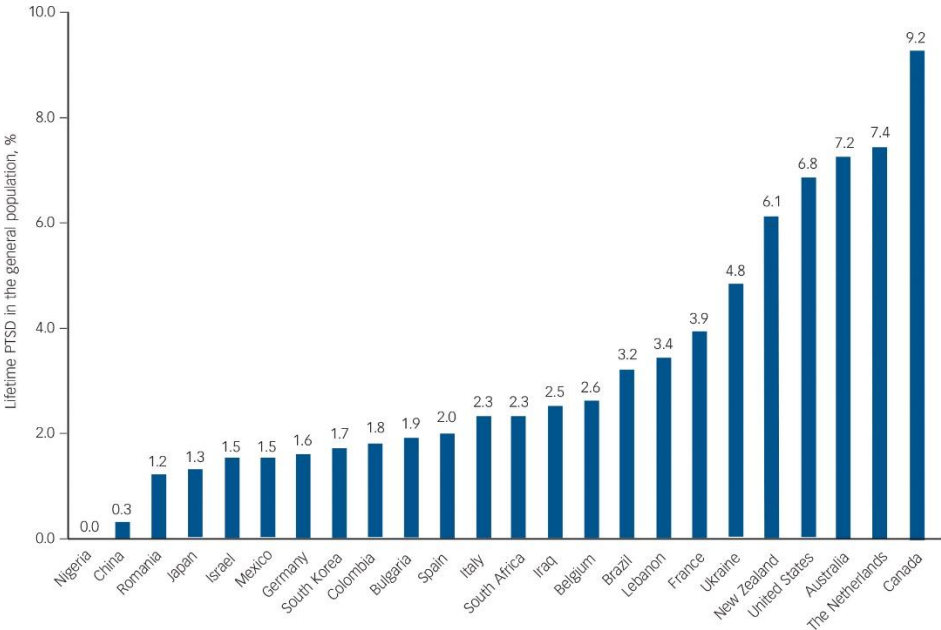


Fig. 1 Lifetime PTSD prevalence in 24 countries (Michel L. A. Dückers et al., 2018, p.301)

1.2. Problem Formulation

It becomes perfectly clear that started by Russia War against Ukraine destroyed the sense of security and led to enormous stress, the psychological consequences of which can be irreversible for the healthy future of both adults and children. A traumatic experience, characterized by an overwhelming sense of fear, helplessness, or horror, can profoundly impact an individual's mental and emotional well-

being, potentially leading to the development of post-traumatic stress disorder (PTSD). As a proof of this it is important to point out that the Ministry of Digital Transformation of Ukraine has already launched a new educational series on the “Diya. Digital Education” portal about techniques that will help relieve the first symptoms of post-traumatic stress disorder (Government portal, 2022).

PTSD (post-traumatic stress disorder) is a mental health problem that some people develop after experiencing or witnessing a life-threatening event, like combat, a natural disaster, a car accident, or sexual assault (National Center for PTSD, 2019). Symptoms could possibly comprise flashbacks, nightmares, and severe anxiety, as well as uncontrollable thoughts about the event. If the symptoms get worse, last for months or even years, and interfere with person’s day-to-day functioning, then person may have PTSD (Mayo Clinic, 2022).

Pursuant to the literature, the first unambiguous risk group is children. Because among children the risk of having PTSD is higher, and PTSD statistics in general are higher than in adults, even if we are talking about peacetime (National Institute of Mental Health, 2020). Therefore, children are less resistant to stress because they cannot protect themselves. The research conducted in 2016 analyzed age trends and revealed a notable increase in the prevalence of PTSD during childhood and adolescence. The data presented in figure 2 below evidently demonstrates that the prevalence of all anxiety disorders, including PTSD, shows the most significant growth between the ages of 10 and 25.

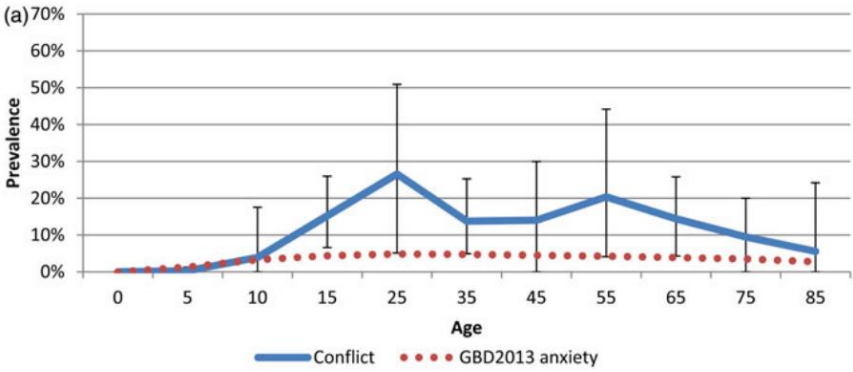


Fig. 2 Age-specific prevalence of PTSD in conflict-affected populations (F. J. Charlson et al., 2016)

Abundance of recent researches confirm the appearance of PTSD symptoms and its gradual but substantial increase among Ukrainian population, especially children and adolescents (Robert J. Johnson et al., 2022; Martsenkovskiy et al., 2022; Thanos Karatzias et al., 2022). According to the survey based on the parental reports conducted only six months after the full-scale Russian invasion, 18.5% of pre-schoolers and 14.2% of school-age children met DSM-5 criteria for PTSD (Martsenkovskiy et al., 2022). Signifying that because of Russian aggression the most vulnerable segment of the population experienced at least one of the next criteria (American Psychiatric Association, 2013):

- was exposed to actual or threatened death, serious injury, or sexual violence;
- felt intrusion symptoms (such as unwanted distressing memories, nightmares or flashbacks);
- avoidance of trauma-related stimuli after the trauma;
- negative alterations in cognitions and mood;
- alterations in arousal and reactivity.

Compounding the severity of the issue is the fact that PTSD not only affects individuals directly exposed to trauma but also has ripple effects on their families (Creech S.K., 2017). A great deal of studies raises the importance of interdependence between mental health problems and systemic family dynamics. Michael S. Scheeringa (2008) stated that the number of PTSD and MD symptoms among the children was strongly positively correlated with the prevalence of PTSD and MD symptoms in the caregivers. Besides this, there also exists evidence that mothers who likely have both PTSD and depression had more physical and psychological abuse at the hands of their children as well as more parenting stress. The children who have mothers with PTSD, experienced a greater number of traumatic events compared to children of mothers with depression or no disorders (Chemtob et al., 2013). The review article by Beardslee W.R et al. (1998) emphasizes how crucial it is to comprehend family dynamics, including communication styles and parenting methods, in order to understand how mental health issues are passed down through generations. The researchers estimate that *“by the age of 20 a child with an affectively ill parent has a 40% chance of experiencing an episode of major depression”*.

Furthermore, it is important to point out not only harmful, but also positive outcomes in parent/child interconnection. Yang Zhe et al. (2021) investigated the favorable influence of a peaceful home atmosphere and harmonious relationships within the family on children’s mental health and the maturity of a child’s problem-solving skills. Family dynamics and children’s mental health have a bidirectional relationship, according to Barbara H. Fiese (1989), who emphasizes the significance of considering systemic aspects when diagnosing and treating mental health issues.

The implications of PTSD are devastating. Not only does it lead to individual suffering and impaired functioning, but it also can place an enormous strain on healthcare systems and social support networks. Moreover, individuals who experience PTSD have an increased likelihood, approximately 80% higher, of exhibiting symptoms that meet the diagnostic criteria for at least one additional mental disorder, such as depressive, bipolar, anxiety, or substance use disorders (American Psychiatric Association, 2013). That in a consequence can trigger disrupted interpersonal relationships, reduced productivity, and decreased educational attainment, which in turn can weaken social cohesion, and hinder post-war recovery and development efforts.

Another proof of the vital importance of investigating and forecasting children’s mental health is that after the COVID-19 pandemic there is a growing crisis in mental health. In 2021 for the first time,

the focus of UNICEF's flagship report, *The State of the World's Children*, was on the mental health and wellbeing of children and adolescents (Nature, 2021).

That is why this thesis will be aimed at researching the development of PTSD among individuals affected by the Russian invasion of Ukraine and investigating interconnections between children's and parents' mental health. The purpose of this research is to obtain crucial insights about the prevalence and intergenerational effects of PTSD among Ukrainian population and to explore policy initiatives in order to mitigate the psychological consequences of war.

1.3. Research Objective and Research Questions

Despite the existing body of literature about PTSD, there remain notable gaps in research specific to the Ukrainian context. Thus, I would like to expand on current literature to understand the interconnections between children's and parents' mental health, and further development of PTSD resulting from Russian invasion of Ukraine. By using system dynamics, I want to analyze the ongoing situation and build applicable model structure which could show the prevalence of PTSD among Ukrainian population and provide policy initiatives in order to stimulate sooner recovery.

Using system dynamics for modeling PTSD is not new. There already exists a system dynamics simulation model of the population of military personnel and veterans affected by PTSD described by Navid Ghaffarzadegan, Alireza Ebrahimvandi, and Mohammad S. Jalali (2016). However, no studies have focused on modeling the interconnections between children's and parents' mental health in the development of children's PTSD. Furthermore, this topic is vital for raising a future healthy generation in Ukraine.

The main objective of this work is to explore the influence of war for children's and parents' PTSD growth and its development in the postwar era, and identify the optimal strategies for health's improvements.

The main research questions are:

1. What are the main drivers of children's and parents' PTSD?
2. What are the interconnections between children's and parents' PTSD development?
3. Which feedback loop structures can capture the interconnections between children's and parents' PTSD?
4. How does the increase in children's and parents' PTSD impact the healthcare system?
5. What are the leverage points of the model, which could be used for the policy recommendations?
6. Which robust policies stimulate PTSD recovery most effectively?

Chapter 2: Hypothesis

“Producing such a logical and theoretically driven narrative effectively, involves maintaining a balance between engaging previous research and carefully developing one’s novel insights”

(Sparrowe & Mayer, 2011)

2.1. Literature Review

The purpose of this literature review is to critically examine existing research and scholarly works related to the psychological impact of Russian war against Ukraine on individuals and their families. This subchapter is aimed to provide a comprehensive understanding of the main interconnections between children’s and parents’ PTSD development, key trends, and research gaps in the field, and along with this to answer two first research questions.

To identify academic papers on the children’s and parents’ PTSD development resulting from Russian invasion of Ukraine, a systematic search was conducted across electronic databases, including PsychInfo, JSTOR, National Library of Medicine, Google Scholar, Scopus, Science Direct and Research Gate. The search for scientific articles was carried out from January till May 2023 using the key words such as “PTSD”, “war”, “trauma”, “Ukraine”, “children’s PTSD”, “adolescents’ PTSD”, “influence of parents’ PTSD on children’s mental health”, “influence of children’s PTSD on parents’ mental health” and “mediator variables between parents’ and children’s PTSD”. The inclusion criteria mainly focused on studies published in the last 10 years, peer-reviewed articles, and research conducted in war-affected regions. However, due to the novelty of this topic and the lack of new research and to some extent statistical data, which specifically relate to the impact of Russian aggression on the development of PTSD among the population of Ukraine, the preprint servers PsyArXiv and MedRxiv with NOT peer-reviewed articles were used as well.

Impact of Russian aggression against Ukraine on people’s mental health

As it was previously stated in the first chapter the bunch of scientific researches confirm the harmful impact on mental health and high prevalence of mental health disorders among people living in war-afflicted regions. But let us delve into the Ukrainian context and demonstrate an enormous pressure and impact, arising from unprovoked Russian war against Ukraine.

Above all, it is vital to recall, that Russian aggression commenced many years prior to 2022, while Russia’s military annexed the Crimea from Ukraine, and backed separatist militants in the eastern regions of Luhansk and Donetsk. Numerous studies have demonstrated that it had a significant impact

on people's mental health, causing an increased risk of developing PTSD and other mental illnesses. Dmytro Martsenkovskiy et al. (2020) were examining how PTSD and other associated risks contributed to the emergence of depression in young people who had experienced war-related trauma. Young people with PTSD were more likely to acquire MD than those without it, with a rate of 32.9% among the 92.6% of research participants who had experienced war-related trauma and displacement as a result of the war in Eastern Ukraine. In the study on the prevalence of PTSD symptoms among children done in ten schools in Lviv (West Ukraine), Klymchuk and Gorbunova (2018, p. 162) report that 28% of the sample (consisting of 1505 pupils overall) is at risk. Additionally, it demonstrates that girls are substantially more likely than boys to experience PTSD symptoms (35%) compared to 23% for boys. The study, conducted more than two years after Russia's initial invasion of Ukraine in 2014, assessed how war experiences affected adolescents' levels of PTSD, anxiety, and depression in both tranquil (Kirovograd) and war-torn (Donetsk) regions of the country. Direct exposure to conflict was linked to a higher chance of developing PTSD. According to Osokina et al. (2022) adolescents who experienced violence had a greater than 4-fold increased risk of developing PTSD. Finally, Osiichuk and Shepotylo study (2020) looking at how conflict affects civilians living outside the conflict zone, revealed that the percentage of the Ukrainian population with chronic disorders climbed from 44% to 50% between 2014 and 2016 (see figure 3 below), although there had been a minor decline before 2014.



Fig. 3 Mental health in Ukraine in 2012-2016 (Osiichuk and Shepotylo, 2020)

It is easy to see how people's mental health suffered even before full-scale invasion. However, there is a vital importance to investigate, which changes it caused after 2022. According to the research, which were investigating was affect the mental health of adults and their children throughout different regions of Ukraine, there were revealed that 25.9% of the participants met the criteria for PTSD (Karatzias et al., 2022). As it was already mentioned in the previous chapter, the survey based on the parental reports conducted only six months after the full-scale russian invasion, 18.5% of pre-schoolers and 14.2% of school-age children met DSM-5 criteria for PTSD (Martsenkovskiy et al., 2022). Pursuant to an examination of replies from refugees who fled to Poland, 73% of respondents had depression, anxiety disorders, or PTSD (Długosz, 2023).

Impact of parental PTSD on children's mental health

War has an undoubtful influence on an individual's mental health. However, in the absence of extraneous factors, there is also a chance of acquiring mental disorders such as PTSD. As it was discussed in the last chapter, there exists strong interconnection of mental health symptomatology within family (parents and children). And in this section, there are presented main influences of parental mental health conditions on their children.

Family distress is the first and the least harmful impact that could be a result of parental PTSD. It may be described as any stressor that affects one or a few family members and has an influence on the emotional connection between relatives, their mood and well-being. To be precise, family distress includes harsh and hostile parenting, adverse environment, child's control, or overprotection. Findings from studies state that parental PTSD corresponds to a higher frequency of poor parenting practices such as hostile parenting, overt anger, and controlling tendencies (Christie et al., 2019; Bryant et al., 2018). Overprotective parents generally are obsessed with their children's physical safety, even despite typically living in a safe environment. Protection levels are greater than the actual danger, which is substantially lower. As a consequence, a child may become dependent, unable to make vital decisions, and have a much higher possibility of developing childhood anxiety disorders (Clarke et al., 2013).

A large number of research verifying that depression and other mental health issues (including PTSD) in adulthood are preceded by childhood exposure to violence and interpersonal trauma (Christie et al., 2019; Kumar et al., 2018; McCloskey & Walker, 2000; Sim et al., 2018; Mattejat & Remschmidt, 2008). According to Saile et al. (2014) the largest predictors of self-reported violent parenting actions against the kid were caregivers' personal histories of childhood abuse, followed by PTSD symptoms. Besides, current study reveals that war-related violence leads to the persistence of violence towards children in the postwar era.

Moreover, scientific studies confirm that children of parents with PTSD may be at greater risk of developing internalization and externalization problems (Kumar et al., 2018; Selimbasic et al, 2012; Selimbasic et al, 2017), signifying that children might have poor social skills and be unable to manage their emotions (Salavera et al., 2019). Thus, the study by Kumar et al. (2018) verified that if mother has moderate to severe mental disease, the risk of having externalization and internalization child's problems equals 10.2% and 15.6% respectively.

Nonetheless, besides all the negative aspects that can appear resulting from bad health conditions, in stark contrast there exists a favorable influence of parents' mental health on their child. Responsive parenting can help to minimize the negative impacts of mother PTSD symptoms (Greene et al., 2020).

Impact of children's mental health on parents' well-being

In parent-child interrelationship, children affect parents through their behavior, emotions, requirements, and development (Belsky, 1984; McElwain et al., 2007; Pomerantz et al., 2007).

Children may influence their parents through their behavior, such as when they display their positive abilities, skills, and achievements in school (Pomerantz et al., 2007); this can offer parents delight and pride. On the other hand, when children demonstrate poor behavior or suffer difficulties, parents may experience anxiety and parental stress (Loose et al., 2023; Barroso et al., 2018). Furthermore, the latter study found that parenting stress is substantially associated with kid externalizing difficulties, which in turn, as is well known, are the consequence of childhood exposure to traumatic events, interpersonal trauma, or PTSD (Dvir et al., 2014).

Besides it, the recent research of Loose et al. (2023) demonstrated that relationships between children and parents' mental health were more significant in disadvantaged families. Vinson et al. (2007) describes disadvantage as a set of obstacles that limit people's life opportunities and prohibit them from being fully engaged in society. Poor health, financial hardship, disabilities, unfair treatment, and a lack of proper education are all examples. And since our work considering Ukrainian families, who are living under constant threat to their lives, experience displacement or violence, a large proportion of families could possibly be disadvantaged.

The mediating role of resilience

Particular challenge of people, living in war-afflicted regions, experiencing enormous stress, extreme adversity and trauma, is the loss of resilience (Cicchetti, 2010), which diminishes individuals' competence to withstand stressors and thus real or perceived threats (American Psychological Association, 2023). As a consequence, people may feel incapable of being concerned not only about their loved ones, but also about their own well-being.

Past years, many studies concentrating on the importance of mediating role of resilience, especially between parental well-being, parenting style, and child mental health (Widyorini et al., 2022; Yanxue Zhai et al., 2015; Moon et al., 2017). According to Yanxue Zhai et al. (2015), parenting style has a direct and substantial effect on resilience (0.70, $P < 0.01$), and resilience, in turn, has a direct and significant impact on post-traumatic symptoms (-0.43, $P < 0.01$). In addition, a significant indirect influence of parenting style on posttraumatic symptoms was discovered via the effect on resilience $-0.43 \times 0.70 = -0.30$, $P < 0.01$). Another vital finding, which later have emerged as a basis of parental mental

health influence on children in our model, is that resilience serves as a mediator between parental rearing behavior (such as emotional warmth, rejection, punishment, control, and overprotection) and children's mental disorder symptoms, specifically depressive symptoms (Moon et al., 2017). Overprotection, punishment, rejection, and control have been reported to be correlated with diminished resilience, whereas increased resilience resulted from positive parenting style (such as emotional warmth). Furthermore, a Russell et al. study (2022) reveals that the link between resilience and parenting stress starts a chain reaction with strong links to parental mental health, and parent-child relationship quality.

Beyond that Dhungana et al. (2022) investigated that resilience has a significant yet negative connection with serious mental diseases such as anxiety, depression, and PTSD, which are usually encountered as a result of any traumatic experience. That is why resilience can also be useful in mitigating/reducing the impact of the situation on an individual's mental health (Ghaffarzagdegan et al., 2016; Rutter, 2006; Bonanno, 2004; Windle, 2011; Masten, 2014; Southwick et al., 2014).

Role of CBT in mitigation/reduction of PTSD

Cognitive Behavioral Therapy (CBT) has been identified as an efficient treatment technique for lowering and moderating PTSD symptoms. CBT is a type of psychological treatment that has been shown to be efficient in dealing with a variety of problems such as depression, anxiety disorders, eating disorders, alcohol and drug use issues, and severe mental illness (American Psychological Association, 2017). Numerous studies have discovered that it reduces PTSD symptoms and improves general functioning in both parents (Kowalski et al., 2023; Zemestani et al., 2022; Kar, 2011) and children (Thielemann et al., 2022; Thomas et al., 2022; Gillies et al., 2012).

CBT has a positive impact on the quality of social support (Fredette, et al., 2016), as well as the potential to significantly improve an individual's resilience (Şahin & Türk, 2021; Happer et al., 2017) by evolving effective coping practices for dealing with stress, difficult circumstances, and challenging situations. Moreover, the findings of Happer et al. (2017) give evidence of an additional indirect impact of CBT on PTSD symptoms reduction. That is, the gain in resilience caused by CBT preceded the related decrease in posttraumatic stress and depressive symptoms.

In addition, in response to Russian aggression against Ukraine, in March 2022, the Project "TF-CBT Ukraine" was started, with the goal of introducing trauma-oriented cognitive-behavioral therapy (TF-CBT) for children and their families in Ukraine along with training Ukrainian mental health professionals (Pfeiffer et al., 2023).

Literature Review Summary

Throughout conducting this literature review, there were identified few main concepts and variables and they are presented in the following table 1.

Table 1 Relevant Concepts found in the literature

Concept	Definition	Source
<i>Family Distress</i>	Any stressor that affects one or a few family members and has an influence on the emotional connection between relatives, their mood and well-being. Family distress includes harsh and hostile parenting, adverse environment, child's control, or overprotection.	(Christie et al., 2019) (Clarke et al., 2013) (Sim et al., 2018) (Mattejat & Remschmidt, 2008) (Bryant et al., 2018)
<i>Family Violence</i>	Family violence is defined as any harmful, forceful, domineering, or abusive behavior between family members that produces fear in the individual experiencing the behavior.	(Christie et al., 2019) (Kumar et al., 2018) (McCloskey & Walker, 2000) (Sim et al., 2018) (Mattejat & Remschmidt, 2008)
<i>Responsive parenting</i>	Parental knowledge of their children's emotional and physical needs, including emotional warmth, support, and respect, while avoiding needless involvement.	(Greene et al., 2020) (Moon et al., 2017)
<i>Resilience</i>	Successful adaptation to tough or difficult life situations, particularly via mental, emotional, and behavioral flexibility and accommodation to both internal and external pressures such as stress and violence in family.	(Widyorini et al., 2022) (Yanxue Zhai et al., 2015) (Moon et al., 2017) (Dhungana et al. 2022) (Ghaffarzadegan et al., 2016) (Cicchetti, 2010) (Russell et al., 2022) (Rutter, 2006) (Bonanno, 2004) (Windle, 2011) (Masten, 2014) (Southwick et al., 2014)
<i>Child's emotional dysregulation</i>	Child's difficulties recognizing emotions, reacting with sufficient emotions in social circumstances, and controlling emotional reactions. In context of this work, it can also include externalization and internalization problems.	(Dvir et al., 2014) (Kumar et al., 2018) (Loose et al., 2023) (Barroso et al., 2018) (Selimbasic et al, 2012) (Selimbasic et al, 2017)
<i>Cognitive Behavioral Therapy (CBT)</i>	Type of psychological treatment that has been shown to be efficient in dealing with a variety of problems such as depression, anxiety disorders, eating disorders, alcohol and drug use issues, and severe mental illness, as well as in improving individual's resilience.	(Kowalski et al., 2023) (Zemestani et al., 2022) (Kar, 2011) (Thielemann et al., 2022) (Thomas et al., 2022) (Gillies et al., 2012) (Pfeiffer et al., 2023) (Şahin & Türk, 2021) (Happer et al., 2017) (Fredette, et al., 2016)

2.2. Methodology

In this subchapter there is described the study's methodology, used during the research, including the research approach, data gathering techniques, and ethical considerations.

Research Strategy & Methodology Choice

The major methodological approach chosen for this work is system dynamic modeling, specifically utilizing Stella Architect 3.1 Modeling software. This choice is justified by the necessity to capture the system's interdependencies and feedback loops. System Dynamics (SD) is an effective analytical and modeling tool for analyzing the complexity of dynamic systems and gaining helpful insights about policy resistance (Sterman, 2000). It provides a paradigm for examining system behavior across time, highlighting the interconnections of diverse components and their feedback loops. SD requires that a system be represented by a collection of constants, variables, connections, and feedback loops that match to the real system's behavior (Forrester, 1961).

Furthermore, SD is widely used in the domains of mental health (Rahmandad & Sterman, 2008), public health (Homer & Hirsch, 2006), well-being (Poon et al, 2022), and for modeling mental diseases, notably PTSD-related problems (Ghaffarzadegan et al., 2016).

In the context of our research, system dynamic modeling allows us to investigate the numerous elements that contribute to the development of PTSD, including exposure to traumatic experiences (resulting from russian invasion), the role of resilience and social support systems, as well as capacity of mental health care systems. Beside this, SD can aid in the evaluation of the long-term impacts of the conflict on the mental health of children and their families, as well as in the identification of effective methods for health improvement by simulating alternative intervention scenarios aimed at lowering PTSD and boosting recovery.

Data Collection

The main purpose of the data collection is to capture all relevant information for future modeling. The main stage was the analysis of existing literature, which was detailed in the preceding section, according to the approaches of Webster and Watson (2002), who concentrated on creating and arranging the literature review. From the literature there were retrieved the main concepts (shown earlier in table 1), which afterwards formed the basis for model structure (please refer to the section of model description).

Research Ethics

This research was conducted, adhering to APA's guidelines and principles of research ethics (American Psychological Association, 2003). Research ethics ensures the integrity, appropriate study conduct, transparency, and respect for research participants' anonymity and privacy.

Researcher's Conduct in the Field

As the researcher, I maintained a high level of competence and integrity throughout the study, including using the best practices of the SD field such as development, validation, and documentation of the model, presented, for instance, by Barlas (1996), Sterman (2000), and Rahmandad & Sterman (2012). I remained transparent in defining the research questions, communicating model structure (along with its boundaries and assumptions) and outlining main structural relationships and model validity.

Research Participants

During this study, I did not collect any data through interviews or surveys, thus ethics code for the gathering, preservation, use, and dissemination of primary data is not applicable. This project relies entirely on publicly accessible information.

2.3. Model Description:

Following the comprehensive literature review and description of methodology used during this study, in this subsection there is presented model overview along with the main boundaries and assumptions. This model description together with the analysis chapter aimed to provide the simplified structure of the real system and analyze its outcomes.

Model Overview

Based on the main concepts, retrieved from the literature, in the modelling software Stella Architect 3.1 there was created explanatory model, in order to replicate the real system behavior. In this section there are presented the main sectors of the model, with the help of which there was examining the influence of russia's unprovoked invasion of Ukraine on the prevalence of PTSD among parents and their children, as well as the impact on their interconnections. It is crucial to note that this section provides just a general overview of the modeled structure, and the detailed variables description and their interconnections are presented in the model documentation (please, refer to the Appendix B).

This model is used to simulate and explore the dynamics of PTSD development, along with key drivers that cause its behavior before the full-scale war as well as after its beginning. A general overview

of the model structure establishes the foundation for the subsequent analysis and the main findings, and the future studies.

PTSD formation is a difficult and meticulous process. Thus, during this work, for simplification in the model there were depicted only main key variables which contributed to both parents' and children's PTSD formation. So let us first delve into the description of the latter, and along with this define the main parent/child intercorrelation, influencing child's mental health, which were managed to find in the literature.

Children's PTSD development Sector

Figure 4 below outlines the fundamental drivers which influence the development of children's PTSD.

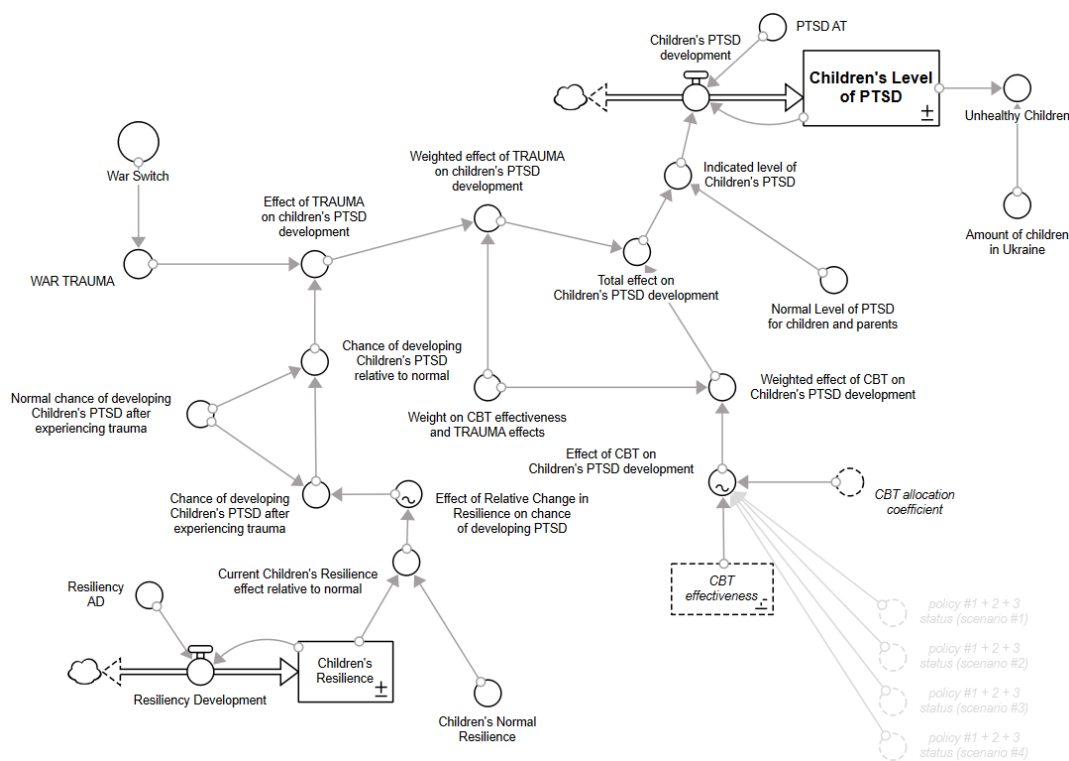


Fig. 4 Model Structure: Children's PTSD development

As can be observed from the stock and flow diagram above, the main drivers which contributed to the PTSD development among the younger generation are resilience, war trauma and therapy effectiveness. While resilience is at its normal level or even higher, it serves as a protective mechanism from external stimuli (e.g., conflicts with family members or peers, residence in a toxic environment, traumatic events). On the contrary, when a child has lack of resilience, it becomes challenging to cope even with regular routines. As a consequence, he becomes more vulnerable to developing PTSD after experiencing trauma, especially if we are considering war times. However, one more protective

mechanism, which is represented in the model as an independent from resiliency factor, that could help mitigate the trauma effect on PTSD development, is therapy. And the higher its effectiveness, the lower is the possibility of developing PTSD.

Compared to therapy, resilience is a natural mechanism, which could protect individual's mental health from the negative external factors. In the figure 5 below depicted the main drivers which contributes to children's resilience formation.

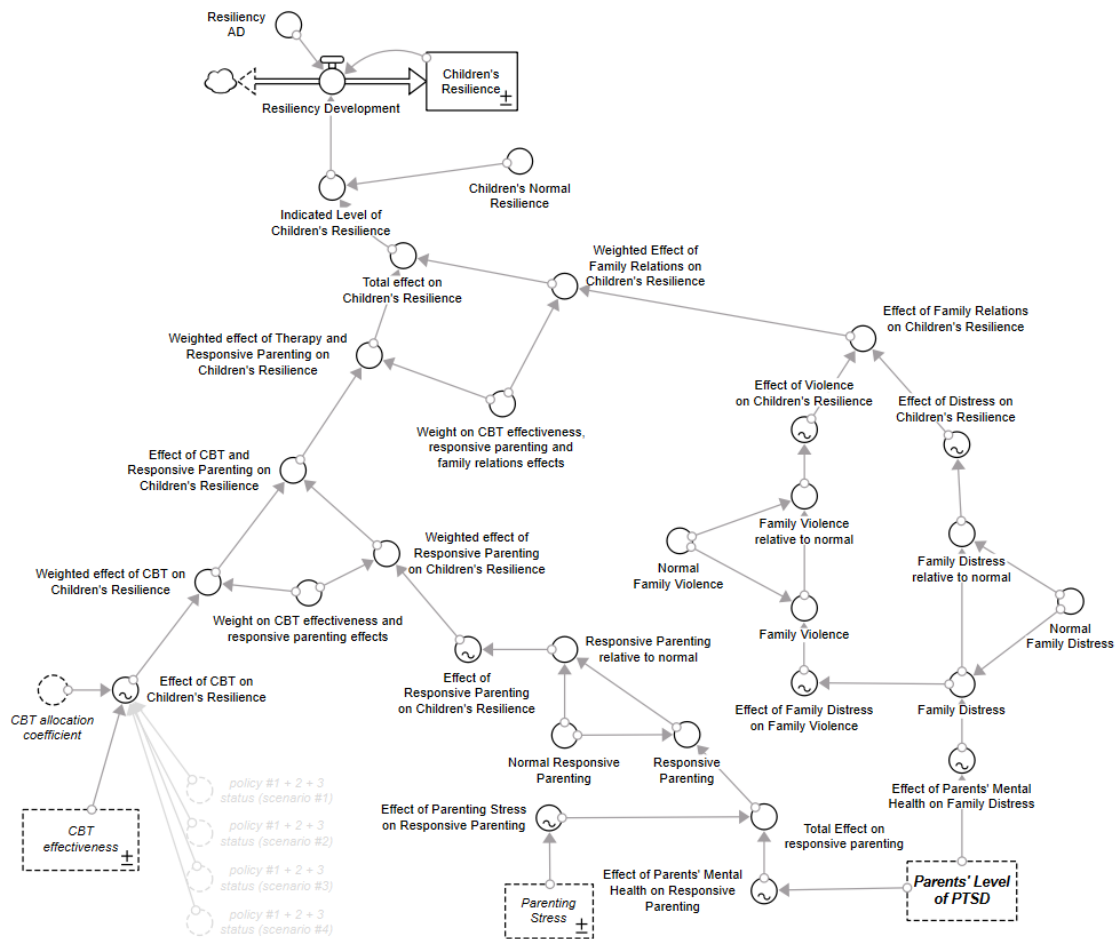


Fig. 5 Model Structure: Children's resilience formation

Parents are the most important people in the lives of their children. Moreover, as it was mentioned in the previous chapters, they have a tremendous impact on their resiliency formation. The first and the most crucial impact revealed from the literature is responsive parenting. While a child receives all necessary support, care, and emotional warmth, he becomes more resistant to the external stimuli, which can help to keep resiliency on the normal level or even to build it up. On the contrary, if parents' mental health is far worse than normal, it inevitably provokes distress in the family, which later can even be a driver of family violence and abuse relationship towards the child. Thus, this can only contribute to resiliency decline.

However, here therapy may also play a role of exogenous protective mechanism for resiliency enhancement. But since children are less socialized relatively to adults, therapy is assumed to not have such a huge impact on children’s resiliency as family relations.

Parents' PTSD development Sector

Next important part of the model, which represents the development of parents’ PTSD can be observed in the figure 6 below.

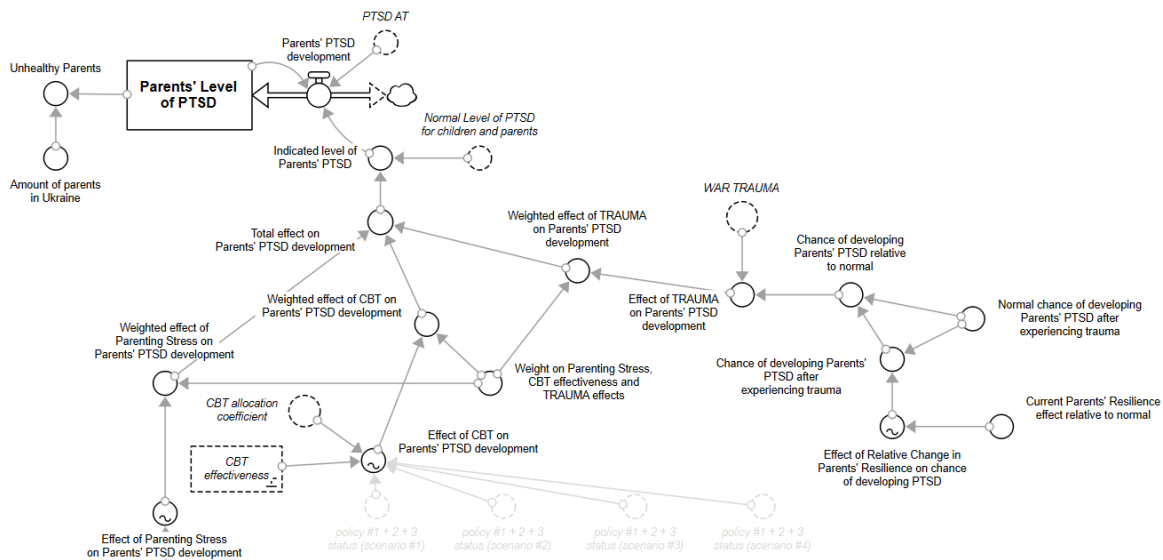


Fig. 6 Model Structure: Parents’ PTSD development

The formation of parent’s PTSD is assumed to reiterate the children’s PTSD development, with the only one exception, the existence of parenting stress, because as it was confirmed by the literature raising kids could be very stressful, especially when they have mental health disorders, such as PTSD.

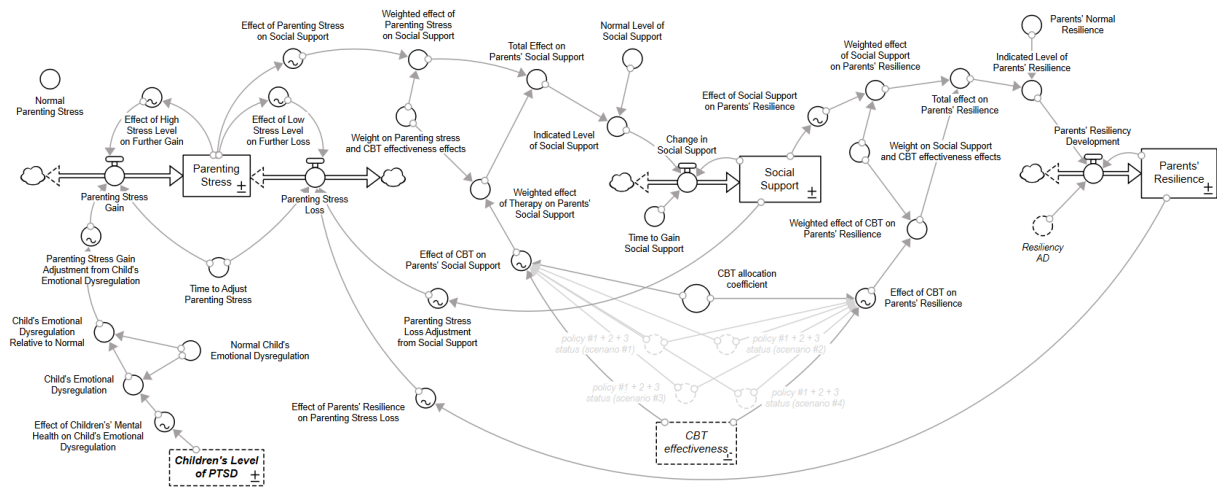


Fig. 7 Model Structure: Development of the parenting stress and resilience

When children are suffering from PTSD, there is a growing possibility of experiencing poor social skills and being unable to regulate their own emotions, as a result parents are more likely to have higher levels of stress and lower resilience. However, according to Zhao et al. (2021), social support can play a mediating role in mitigating a harmful impact of parenting stress on parents’ resiliency, by acting as a buffer. The concept of social support is incorporated into the model as an external source of improving parents’ well-being by providing emotional assistance and improving the perception of therapy (Fredette, et al., 2016). It can help mitigate parenting stress (Park & Lee, 2022) and contribute to the development of parents’ resilience, which in turn can also aid in reduction of stress.

Health Personnel Sector

In this sector there is presented the formation of the healthcare system (that is engagement of new therapists needed for PTSD treatment), depending on the population demand and the fraction of therapists that are actually hired.

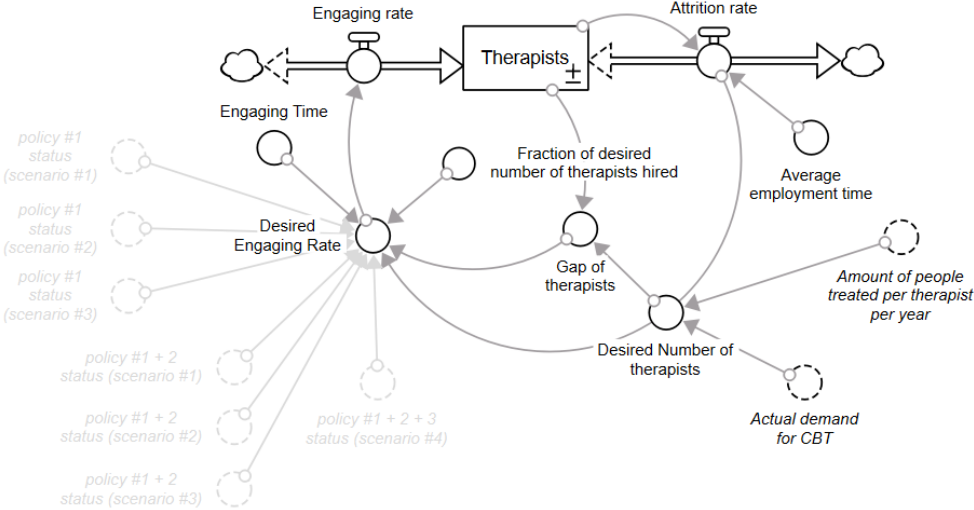


Fig. 8 Model Structure: Health Personnel Sector

Therapy Sector

In the figure 9 below there is represented therapy sector which symbolizes the delivery of Cognitive Behavioral Therapy (CBT) as an intervention for Ukrainian population who is suffering from PTSD, resulting from russian invasion. It is important to note that here we are not considering human and psychological factors, which can influence therapy effectiveness. This part of the model is simplified and represents the effectiveness of CBT, considering only the most important factors which contribute to its formation: supply and demand. By incorporating the CBT in the model, we can explore its impact on children's and parents' mental health outcomes as well as test different scenarios to develop new important insights.

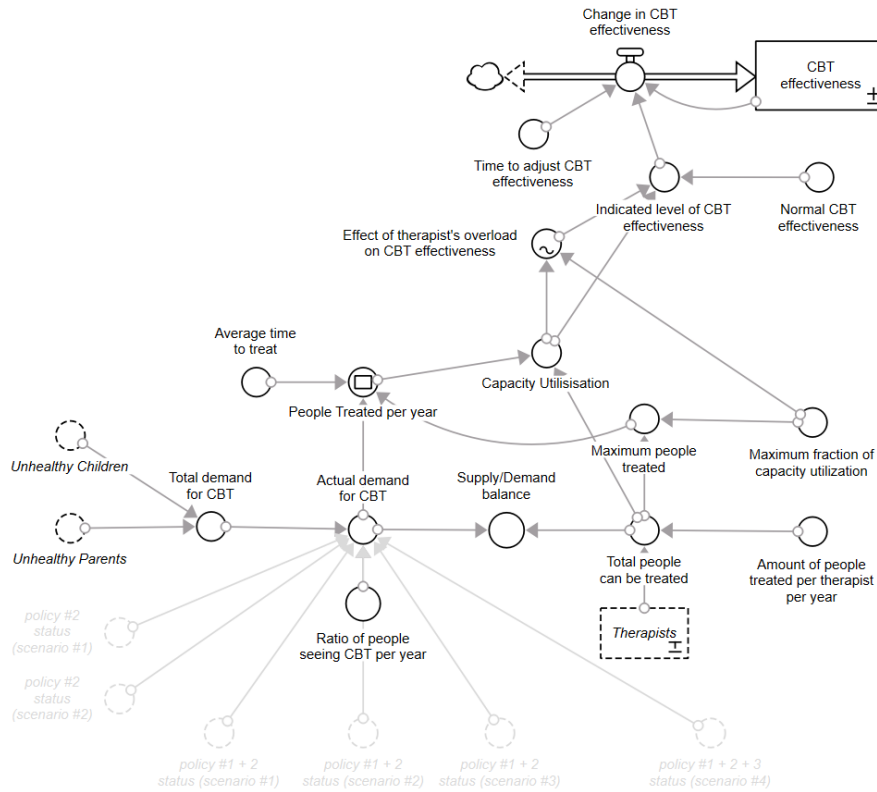


Fig. 9 Model Structure: Therapy Sector

Policies and Scenarios Sector

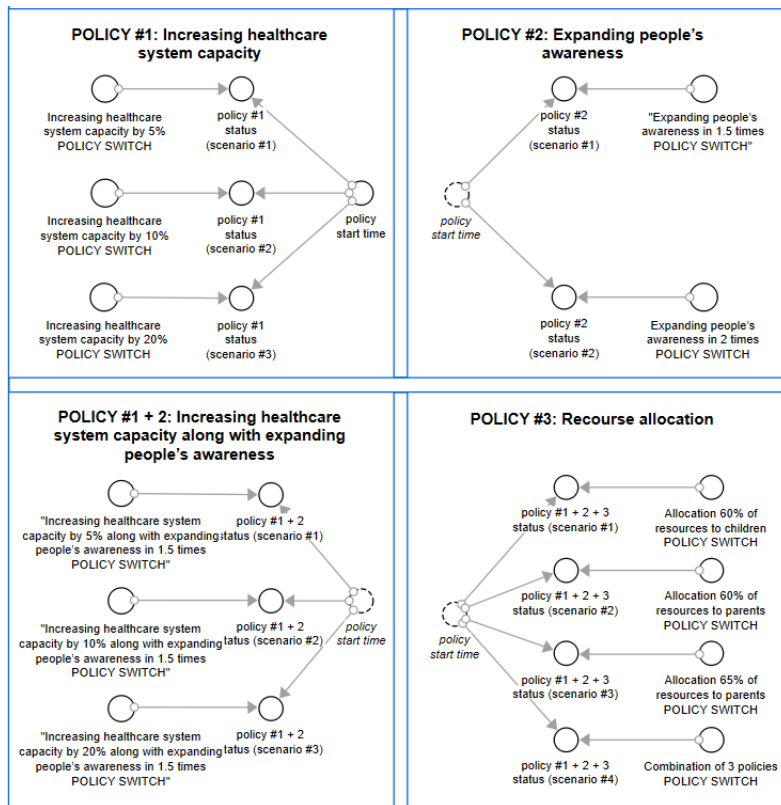


Fig. 10 Model Structure: Policies and Scenarios Sector

The last sector of the model (shown in figure 10) represents the various scenarios, according to the three suggested policies, which are discussed in the analysis chapter and detailed in the model documentation.

Model Boundaries

In order to simplify the system structure, the model incorporated several boundaries. Firstly, the model does not include the extended sector of PTSD, resilience, and social support formation. The structure captures only the main drivers for the sake of reproducing parent/child interconnections and exploring their impact on the PTSD development in terms of war times.

In addition, the model does not take into consideration potential constraints on healthcare system capacity, such as limited funding, presence of qualified health personnel or absence of facilities (e.g., therapy rooms), all of which may conceivably affect the availability and delivery of high-quality CBT services.

Model Assumptions

To ensure the accuracy and limitations of the future model analysis, there were made a diverse assumption. First of all, in this work we are not concerned about the time-series data for population in Ukraine. The main point is to show interactions between parents and children within the family. Therefore, the population of children and parents represented in the model just as a constant, assuming that the number of children and parents will always be the same as of 2021.

Moreover, since the key indicators of the model are “soft” variables, there was no way of precise measuring normal level of resilience, stress, or social support. Thus, values for these variables were assumed and calibrated according to the logical and reasonable extent.

Finally, even despite finding a great deal of concepts for the model structure from the literature, it was difficult to measure the accurate shape and limits for the non-linear functions. Hence, the steepness and range of the effects between psychological variables was assumed in a way to prevent the system from behaving irrationally.

Chapter 3: Analysis

In this chapter, the reader can delve into the analysis of the model structure and the verification of its validity along with the discussions of the obtained model results and policy suggestions. The analysis aims to provide a deeper understanding of the psychological consequences of war against Ukraine on people's mental health by guiding the reader through the simplified model structure; and to uncover valuable insights that can inform interventions and support systems for individuals affected by the war conflict.

Validation

“Validation is a continuous process of testing and building confidence in the model” (Sterman, 2000, p.81). Jay W. Forrester and Peter M. Senge stated that validation begins as the model builder accumulates confidence that a model behaves plausibly and generates the problem symptoms or modes of behavior seen in the real system (1980). Moreover, Yaman Barlas (1996) introduced the logical sequence of selected tests for formal model validation (figure 11), which consist in testing the validity of model structure, and then start testing the behavior accuracy, only after the structure of the model is perceived adequate.

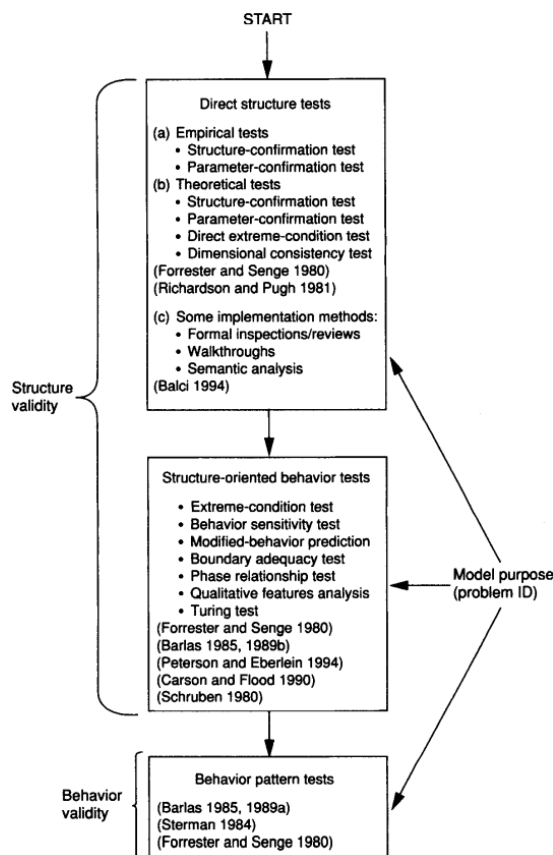


Fig. 11 Overall nature and selected tests of formal model validation (Barlas, 1996, p. 189)

Direct structure tests

Direct structure tests evaluate the integrity of the model structure by directly comparing it with existing knowledge of the actual system's structure. This process entails examining each relationship within the model, such as mathematical equations or logical relationships, separately and contrasting them with the available information about the real system (Barlas, 1996).

Structure Confirmation Test

According to Barlas (1996), as presented in figure 11, there exist two types of structure confirmation test, which entail the comparison of the model structure with: information acquired directly from the real system being modeled – *empirical test*; and generalized knowledge about the system that exists in the literature – *theoretical test*. The latter was used in this work for the validation during the modeling process (the detailed argumentation presented in previous chapters on this thesis and in the model documentation in Appendix B).

Parameter Confirmation Test

Parameter confirmation (verification) test is aimed at comparing exogenous parameter values to knowledge of the real system, both numerically and conceptually (Senge & Forrester, 1980; Barlas, 1996). The majority of the numerical parameters were retrieved from the existing knowledge and literature and correspond to the reality, however, due to the fact that the key indicators of the model are “soft” variables, there is no way in precise measuring normal level of resilience, stress or social support. As it was noted by Forrester (1971) “[m]ental models are fuzzy, incomplete, and imprecisely stated. Furthermore, within a single individual, mental models change with time, even during the flow of a single conversation”. Thus, these types of “soft” variables were calibrated according to the logical and reasonable extent, nonetheless can be the weakest points for confidence in the model.

Direct Extreme Conditions Test

The purpose of the direct extreme conditions test is to ensure that all equations of the created model are robust under extreme conditions. In order to evert unreasonable behavior and/or calculation errors, in the appropriate equations as well as table functions were applied certain boundaries (such as MAX/MIN functions). By performing the aforementioned precautions, in the model there weren't revealed any computing errors.

Dimensional Consistency Test

Dimensional consistency test requires that all variables and parameter values of the model do not incorporate no real life meaning. The modeling software (Stella Architect 3.1) did not detect any dimensional inconsistencies.

Structure-oriented behavior tests

Indirect Extreme Conditions Test

Indirect extreme conditions test, similar to the direct test, aimed to the verification of model robustness. The selected parameters are assigned extreme values, and the purpose is to compare model-generated behavior with the anticipated behavior of the real system under the same extreme conditions (Barlas, 1996). The first and the most obvious way to check this is to see what would happen to the model behavior if no war occurred.

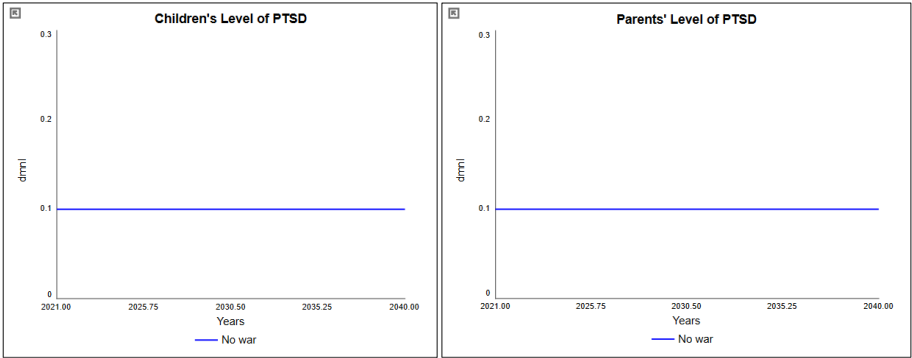


Fig. 12 System behavior if no war occurred

As expected, under this condition the model initializes in equilibrium. Meaning that if no full-scale war occurred in Ukraine, the mental health of people would be stable.

The second approach of testing this is to assume that the healthcare system capacity unexpectedly dropped to zero (meaning that the number of therapists who can treat the population with PTSD becomes zero and we cannot engage any new health personnel). Then the logical anticipated response from the system would be next: the effectiveness of the therapy would be reduced to zero and thus the percentage of unhealthy population inevitably would be increasing over time.

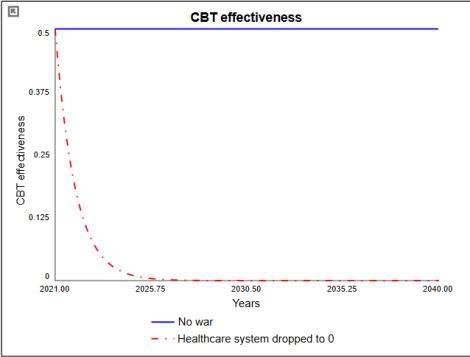


Fig. 13 CBT effectiveness behavior, if healthcare system dropped to 0

The system response regarding CBT effectiveness confirms the behavioral expectations. If the healthcare system capacity drops to zero, then there will be no therapists available to treat PTSD and

hence throughout the next years the therapy effectiveness will be exponentially decaying towards 0. The second our expectation is evident in Figure 14, where the number of children and parents with PTSD are exponentially decaying from 10% to 24.1% and 26.5% respectively (which is approximately 2.5 times higher than the initial value).

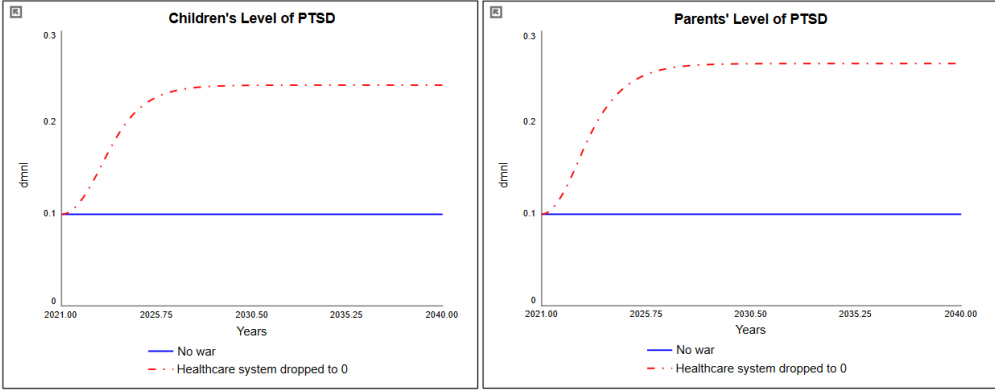


Fig. 14 PTSD behavior if healthcare system dropped to 0

Behavior Sensitivity Test

Behavior sensitivity test is aimed at identifying variables, which model are extremely sensitive to and compare results with the real system (Barlas, 1996). However, as far as there was no precise data found regarding parent’s or children’s PTSD in Ukraine, the results have to reflect the expected structure of the altered real system. The detailed results of carried sensitivity test can be found in appendix A, however, here are presented the main insights that were caught throughout the analysis.

- Models are mostly not sensitive to the adjustment times and normal values, and during the analysis the model was not found to be sensitive to any of eight adjustment times, which confirms its validity. However, among twelve normal values, the model appeared to be sensitive to two of them, which were not normalized and thus during sensitivity test entirely changed system behavior.
- As was anticipated, the model proved to be sensitive to the number of assumed parameters, which represent leverage points of the model for further policy suggestions.
- The model appeared to be sensitive to a larger or smaller extent to graphical functions, with four of them being moderately sensitive. Two of them, depicting the influence of therapy effectiveness on PTSD development, can be leverage points of the model. While the remaining was not expected to cause such sensitivity in the model behavior. As was before mentioned, these parameters were identified based on the literature and logical and reasonable calibration, nonetheless can be reformulated more precisely with the availability of real data to make the model more robust. Additionally, considering the long-term war in Ukraine which began in 2014, the mental health of people is not fully investigated and requires further study.

Boundary Adequacy Test

The main purpose of this test is to analyze “*whether or not model aggregation is appropriate and if a model includes all relevant structure*” (Senge & Forrester, 1980). In order to check this, let us remind the reader the main purpose of this model: portray the key drivers of children’s and parents’ PTSD, as well as the mechanisms that can be used to mitigate the negative impact of the conflict on people’s mental health. The model not only generates the expected behavior, but also provides a valuable insight of how it is possible to lower the level of PTSD and what is more important indicates the weakest points, meaning which mechanisms should be explored more. Thus, the boundary of the model is determined to be adequate.

Behavior pattern test

According to Senge & Forrester (1980), the main aim of the behavior pattern (reproduction) test is to examine how well model-generated behavior matches observed behavior of the real system. Due to the lack of data, to complete this test there was conducted partial model testing, and the detailed full model results are presented in the next subsection of this work.

Partial Model Testing

The main concept of this test is to isolate the part of the model and substitute the endogenous structure (from another part of the model), which drives its behavior, with exogenous input. This test was conducted for the two main parts of the model: children’s PTSD development and parents’ PTSD development in order to test the adequacy of the system response with exogenous inputs.

- Children’s PTSD development
 1. Children’s Resilience = 0, CBT effectiveness = 0 (worse-case scenario).
 2. Children’s Resilience = 1, CBT effectiveness = 1 (optimistic scenario).
 3. Children’s Resilience = 0,6, CBT effectiveness = 0.5 (equilibrium).

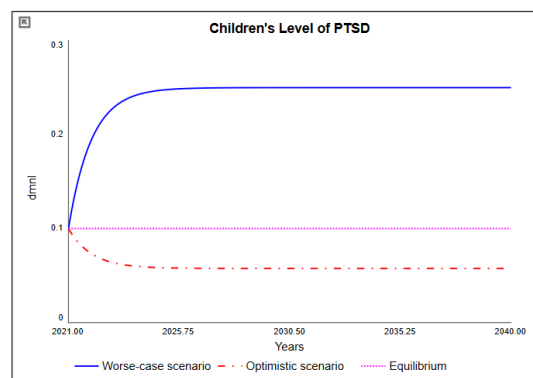


Fig. 15 Partial model testing of Children’s PTSD in worse-case scenario, optimistic scenario, and equilibrium

Partial model testing revealed that in extreme conditions the stock of children’s PTSD is averted from unreasonable behavior with the help of limits in graphical functions and matches the expected behavior of the real system. Even in case of therapy and resilience absence, children’s level of PTSD cannot rise above 25%. On the contrary, if therapy effectiveness along with resilience could reach 100%, PTSD would not drop under 5.75%, because there is always some percentage of PTSD among population. Finally, when CBT and resilience are at their normal level (i.e., in equilibrium), PTSD replicates the same pattern.

- Children’s Resilience

1. Parenting Stress = 1, Parents’ Level of PTSD = 1, CBT effectiveness = 0 (worse-case scenario).
2. Parenting Stress = 0, Parents’ Level of PTSD = 0, CBT effectiveness = 1 (optimistic scenario).
3. Parenting Stress = 0.3, Parents’ Level of PTSD = 0.1, CBT effectiveness = 0.5 (equilibrium).

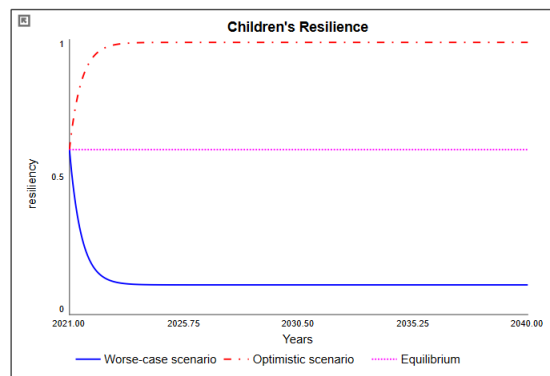


Fig. 16 Partial model testing of Children’s Resilience in worse-case scenario, optimistic scenario, and equilibrium

Partial model testing revealed that in extreme conditions the stock of children’s resilience is averted from unreasonable behavior with the help of limits in graphical functions and matches the expected behavior of the real system. Even if parental stress and PTSD were 100% and in case of therapy absence, children’s resilience would not drop under 10%, because child's interactions with peers, at school, and/or another extraneous relations beside family are not accounted in the model. On the contrary, if therapy effectiveness could reach 100% along with total reduction of parental stress and PTSD, children’s resilience cannot rise higher than 100%. Finally, when therapy effectiveness, parental stress and PTSD constantly stay at their normal level (i.e., in equilibrium), stock of children’s resilience replicates the same pattern.

- Parents’ PTSD

1. Parenting Stress = 1, Parents’ Resilience = 0, CBT effectiveness = 0 (worse-case scenario).
2. Parenting Stress = 0, Parents’ Resilience = 1, CBT effectiveness = 1 (optimistic scenario).
3. Parenting Stress = 0.3, Parents’ Resilience = 0.6, CBT effectiveness = 0.5 (equilibrium).

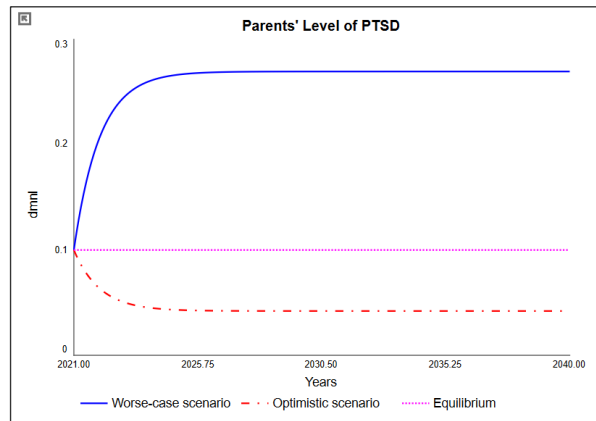


Fig. 17 Partial model testing of Parents' PTSD in worse-case scenario, optimistic scenario, and equilibrium

Partial model testing revealed that in extreme conditions the stock of parents' PTSD is averted from unreasonable behavior with the help of limits in graphical functions and matches the expected behavior of the real system. Even if parenting stress is at its maximum, and in case of therapy and resilience absence, parents' level of PTSD cannot rise above 27%. On the contrary, if therapy effectiveness along with resilience could reach 100%, and parenting stress decline to 0, PTSD would not drop under 4%, because there is always some percentage of PTSD among population. Finally, when CBT, resilience and parenting stress constantly stay at their normal level (i.e., in equilibrium), stock of parents' PTSD replicates the same pattern.

Model Results

In this section there are provided main model results, which were obtained during this study. As it was mentioned in the previous chapters, the model was created in Stella Architect 3.1 Modeling Software. And the simulation specifications are as follows:

- Integration method: Euler's integration
- DT = 1/64 Time
- Units: Years
- Start time: 2021
- Time horizon: 20 years

Baseline Scenario

The main simulation results of the baseline scenario can be observed in figure 18 below:

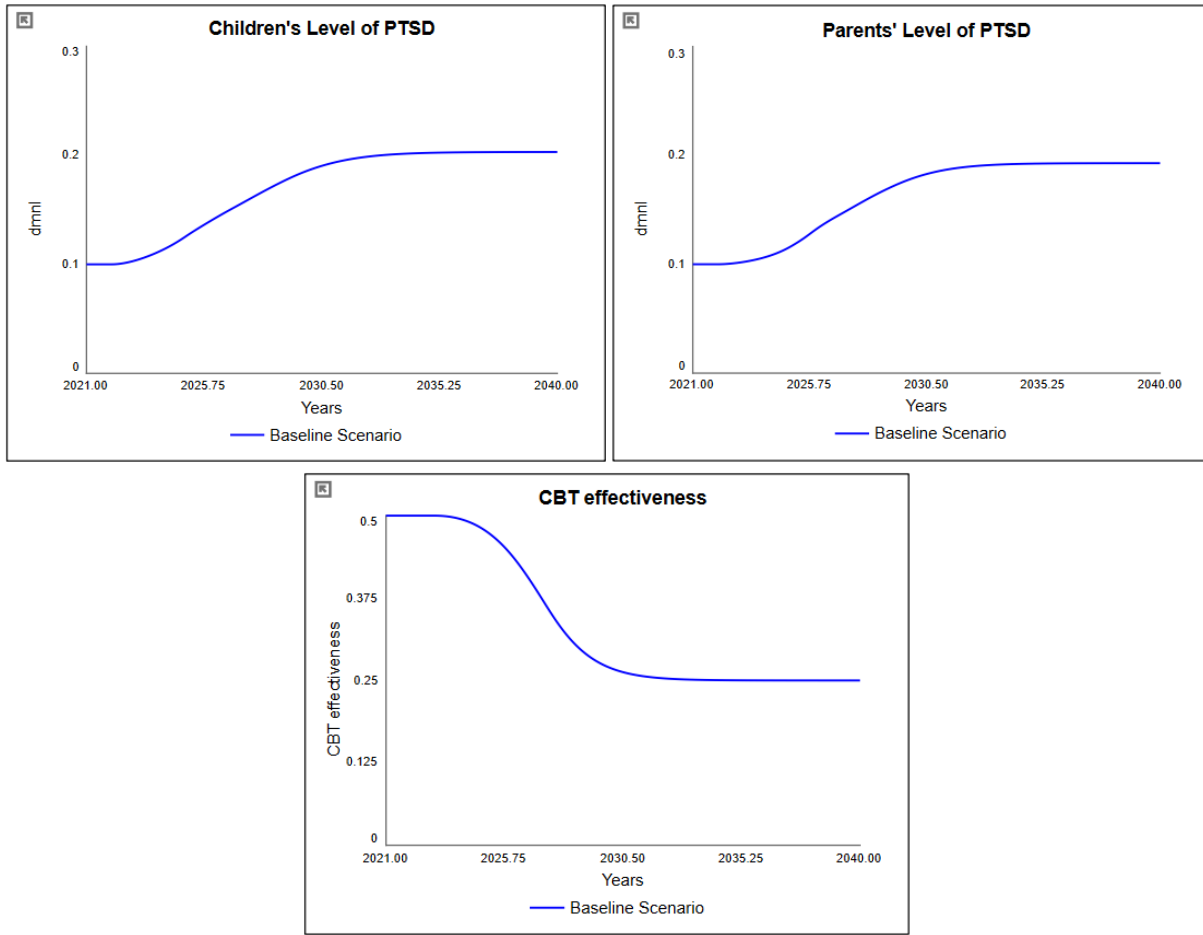


Fig. 18 Results of key indicators with baseline scenario

Initially, before the unprovoked full-scale Russian invasion of Ukraine, the system behavior was stable – the level of PTSD among population was 10% (as could be seen earlier in figure 12 of the previous subchapter). However, right after 2022 year, due to the war trauma, the percentage of PTSD cases begin to exponentially increase and after 2026 decaying to 2035 until reaches 19.3% and 20.3% for parents and children correspondingly. This in turn, has an enormous pressure on the healthcare system capacity, as far as existing number of therapists do not have enough capacity to treat twice as many people, therefore, CBT effectiveness start to decline and exponentially decaying towards 0.25, signifying the twice reduction.

WHO reported that Ukrainian's mental health is mirrored across other countries affected by the war conflicts and 22% of people in 10 years are expected to face depression, anxiety, PTSD, bipolar disorder, or schizophrenia (WHO, 2022). Hence, according to this preliminary data, the effect of war represented in the model is even underestimated.

Now, in order to understand the model interactions and system behavior more, let us present causal loop diagram (CLD), that outlines the most important loops of the model.

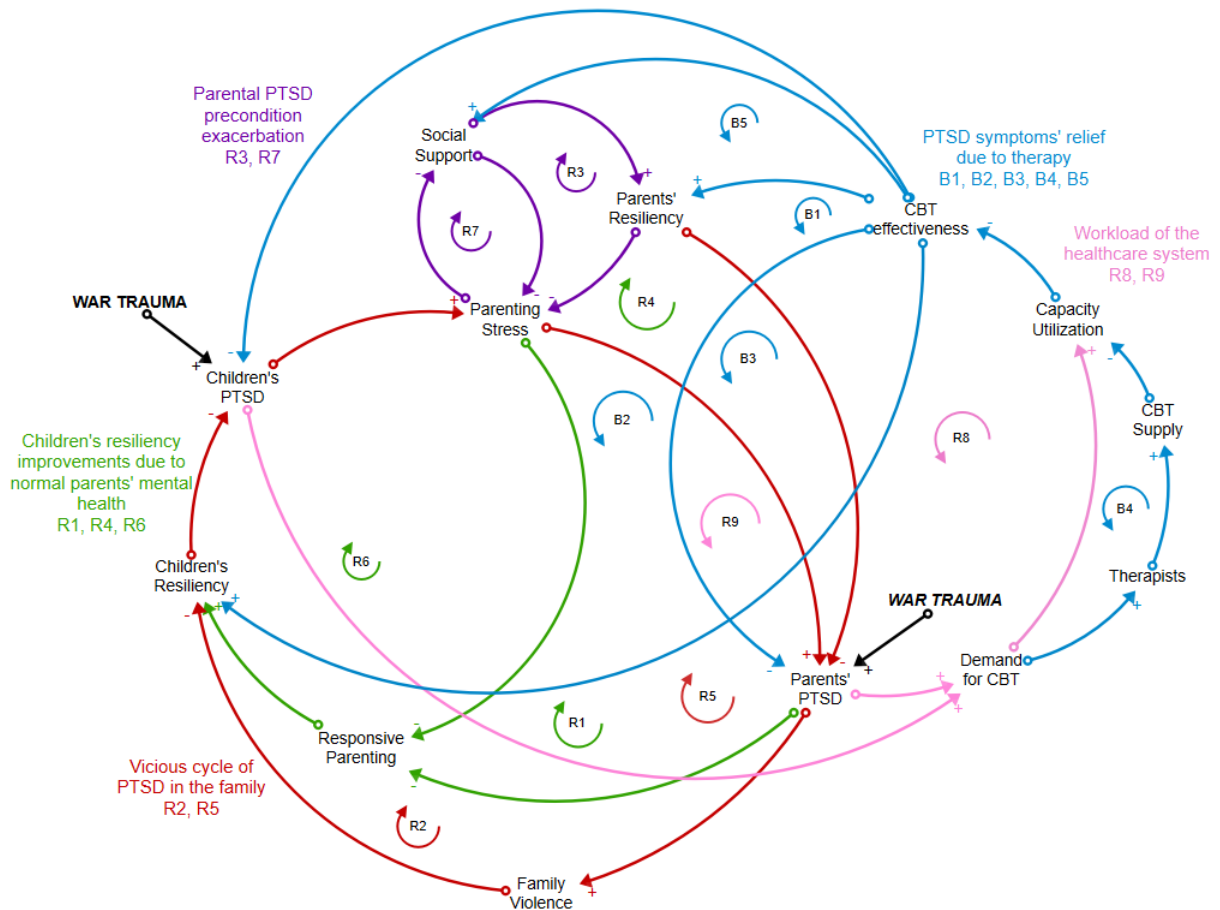


Fig. 19 Causal Loop Diagram of the main feedback loops of the model

Child's story always begins from the family; thus – from the parent's mental health. While parents are fully functioning, their level of stress at the optimal level and their mental health in appropriate condition, consequently, they are able to properly raise their children and perform the duties of responsive parents. And as far as they are the closest people in children's lives, they have a significant impact on their resilience formation, which appears to be the protective mechanism from the external stimuli and in particular from the possible development of PTSD. This in turn, reduces the likelihood of a child's emotional dysregulation and hence – parenting stress (R1, R6). As a result, they are more likely to perceive social support, that could increase their resilience and finally lower the chance of PTSD development (R4).

But what would happen if the mental health of parents was far worse than normal? They simply would not have the capacity to take care of their children, which in turn could lead to an unhealthy environment, distress in the family and/or even violence. This surely reduces a children's resilience and increases the risk of PTSD, along with emotional dysregulations. Realizing this, parents become even more stressed and less resilient, which can lead to the occurrence of PTSD. Consequently, this is creating a vicious cycle of PTSD in the family (represented by reinforcing loops R2 and R5 in CLD above).

However, there exists a way out.

CBT plays a significant role in the development of PTSD since it is a treatment strategy that can modify the dynamics of the system being modeled. While more people are suffering from PTSD, the demand for therapy increases, as does the number of therapists required to treat them. With the expansion of health care system, the supply (that is, the number of people who can potentially be treated) rises, and hence the effectiveness of therapy. Since the therapy has a direct effect on PTSD, it almost immediately reduces symptoms and the level of PTSD among children and parents (B2, B4). In addition, as noted in previous sections, CBT is a crucial component of the resiliency formation and has a favorable impact on parents' perceptions of social support. Thus, enhancing social support and improving resilience both contribute to PTSD reduction (B1, B3, B5).

But considering this situation what could possibly make it worse than that? War.

War is not only influencing parents and children separately, but also the entire family. And when their symptoms are mixing, it only exacerbates existing problem (through the beforementioned R2 and R5), creating an additional pressure on the healthcare system (R8, R9). Therapists are not able to handle such high demand and if no changes are made, according to figure 16 depicted earlier, therapy effectiveness will halve and not be able to recover. And in order to mitigate this problem, in the next subchapter there are presented three scenarios for further development.

Scenario Analysis

Increasing healthcare system capacity

As far as during the peaceful times, the level of PTSD among the population was stable, along with the number of people, there was no need to engage new health personnel. However, due to the enormous growth of PTSD, which was caused by unprovoked Russian invasion of Ukraine, there appeared a growing need of CBT and specialists who can provide it. Thus, the first and the most unambiguous policy suggested in this work – increasing the healthcare system capacity (that is engaging new therapists). It is important to point out, that at this point of study we are not concerned about financing, the main point is to explore the effectiveness of different scenarios, which can help mitigate negative psychological consequences of war and stimulate the recovery in Ukraine.

So, here we are going to investigate the influence of increased the fraction of desired therapists hired by 5, 10 and 20%, depending on policy scenario, on the system behavior.

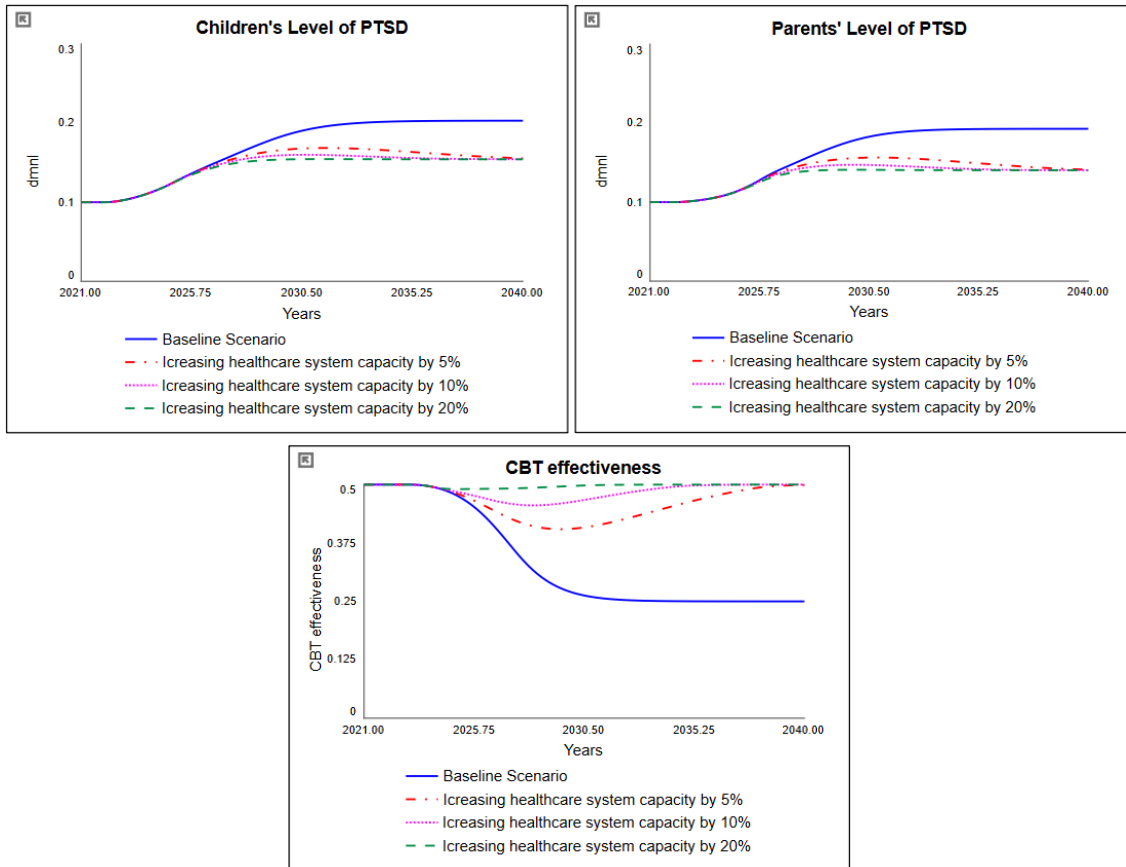


Fig. 20 Results of key indicators with increasing healthcare system capacity scenarios

Figure 20 above depicts the simulation results of the increasing healthcare system capacity scenarios. As it was expected, due to the increase in the number of therapists needed to treat people, the supply of CBT increasing, decreasing health personnel workload and as a result, CBT effectiveness does not decline that much. Moreover, as could be observed in the third scenario, hiring 20% out of desired health personnel is almost enough to prevent the collapse of CBT effectiveness. As a consequence of more high-quality CBT services, PTSD level among children and parents declining to 15,4% and 14% (that is by 4.9% and 5.3%) respectively. However, this is not enough to increase level of parents' resilience to the normal level and decrease parenting stress, which still produce a damaging impact on family relation, increases family violence, and provoke a tremendous decline of responsive parenting. As a result, children's resilience cannot become higher than two-thirds out of normal (i.e., 38%), making it impossible to reduce the level of PTSD to a normal one.

Expanding people's awareness

There are large variety of studies, that confirm the necessity of people's awareness increase regarding therapy advantages not only for individuals, but also for their families. Thus, Yang Zhe et al.

(2021) explored that “*education and interventions aimed at improving family dynamics may be useful for reducing the prevalence of mental health problems amongst adolescents*”. Moreover, according to the survey conducted by Roberts et al. (2019) among internally displaced persons, due to the Russian aggression in the eastern part of Ukraine, who has depression, anxiety or PTSD, there were revealed almost 75% treatment gap; meaning that only 25% of people who may require medical care actually receive it. That is why this policy will be aimed at expanding people’s awareness of attending CBT.

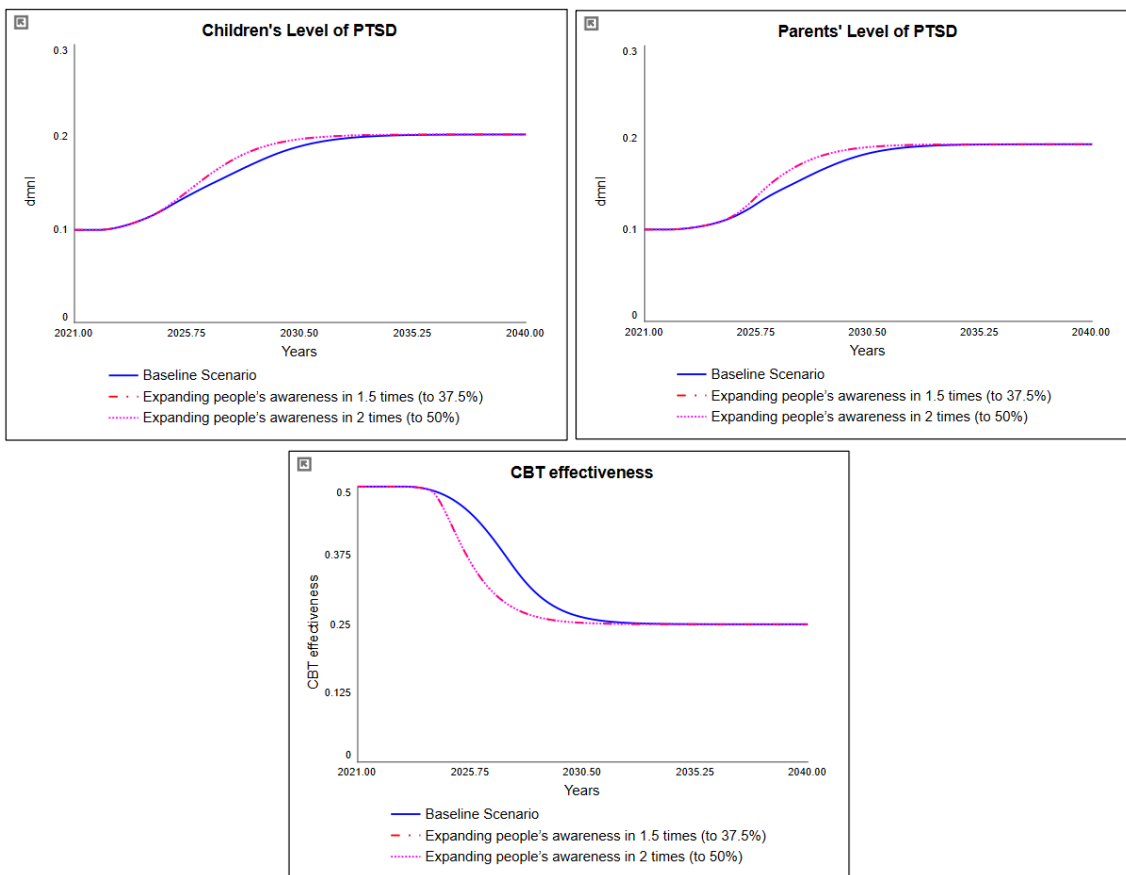


Fig. 21 Results of key indicators with expanding people’s awareness scenarios

At the figure 21 above there can be observed the simulation results of the expanding people's awareness scenarios. The results were anticipated and correspond to the real system behavior: as far as healthcare system capacity is not strong enough even in the baseline scenario, here, if we are increasing people’s awareness, and thus the amount of people seeing CBT, then the therapists will be overloaded and hence in 2024 therapy effectiveness begin to collapse, which causes PTSD level to increase even quicker. It is important to note that in this case there is not any difference between two scenarios, because according to the assumption, therapists cannot treat more than one and a half times of the usual amount of people, what was already accomplished even in the baseline scenario. The only distinction is that having implemented this policy, capacity utilization increasing exponentially (due to the higher demand) and reaching the maximum two years earlier, compared with the baseline scenario.

While implementing this policy, it is very important to remember about the healthcare system capacity. But what would happen to system behavior, if we try to engage new therapists along with increasing the ratio of people seeing CBT. Let us combine 2 policies.

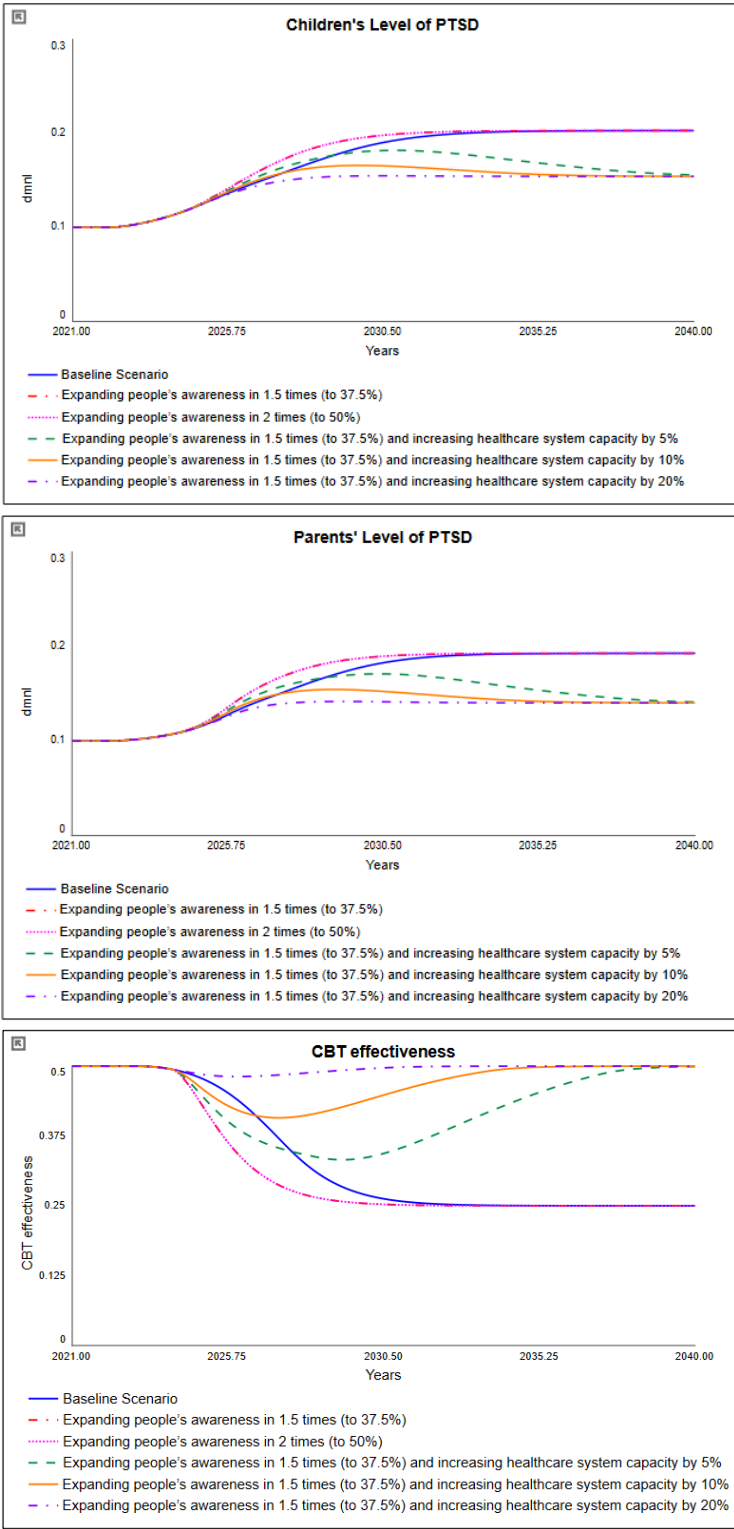


Fig. 22 Results of key indicators with increasing healthcare system capacity and expanding people's awareness scenarios

Here, as it was predicted, the effect of the combination of these two policies are better, than separately, however there was no huge difference on PTSD development from the implementation just first policy; despite sooner decline and sooner recovery of therapy effectiveness (which is happening due to the slightly closing treatment gap and increase of the ratio of people seeing CBT).

Resource allocation

As it was investigated during this study, parents have a profound impact on their children’s resilience formation, and thus on PTSD symptoms reduction, while parent’s mental health was found to be not that dependent on their child’s mental health. The main idea of this policy is to test what will happen to the system behavior if we allocate more available therapy resources to children or parents.

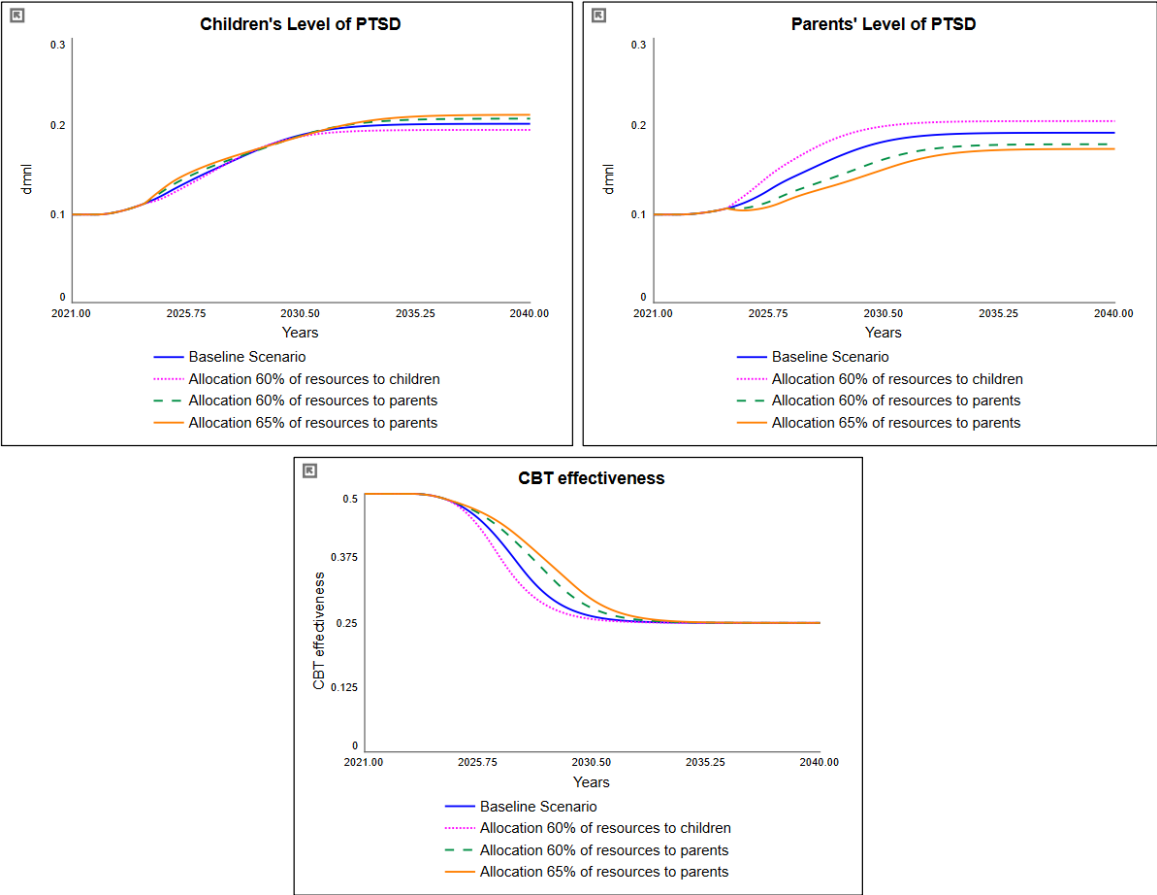


Fig. 23 Results of key indicators with resource allocation scenarios

At the figure 23 above there can be observed the simulation results of the experimentation scenarios of resource allocation. As it was anticipated, if children are a priority and 60% of resources are allocated for their treatment, parents’ treatment appeared to be not that effective, which causes parental level of PTSD along with parenting stress become even higher, than in the baseline scenario.

Because of this, parents become unable to provide their children proper responsive parenting and necessary support; moreover family distress and violence rise, causing children’s resilience to decline. As a consequence, these effects are almost outbalanced the effect from therapy and children’s level of PTSD stays approximately the same, even despite having more allocated resources for children’s treatment.

On the contrary, when we allocate more resources for parent’s PTSD treatment, their PTSD level decreases by 2%, without having such a negative influence on children’s mental health, as it had on parents in the previous scenario.

Finally let us combine 3 policies (meaning the increasing healthcare system capacity by 20%, expanding people’s awareness in 1.5 times and allocation 65% of resources to parents):

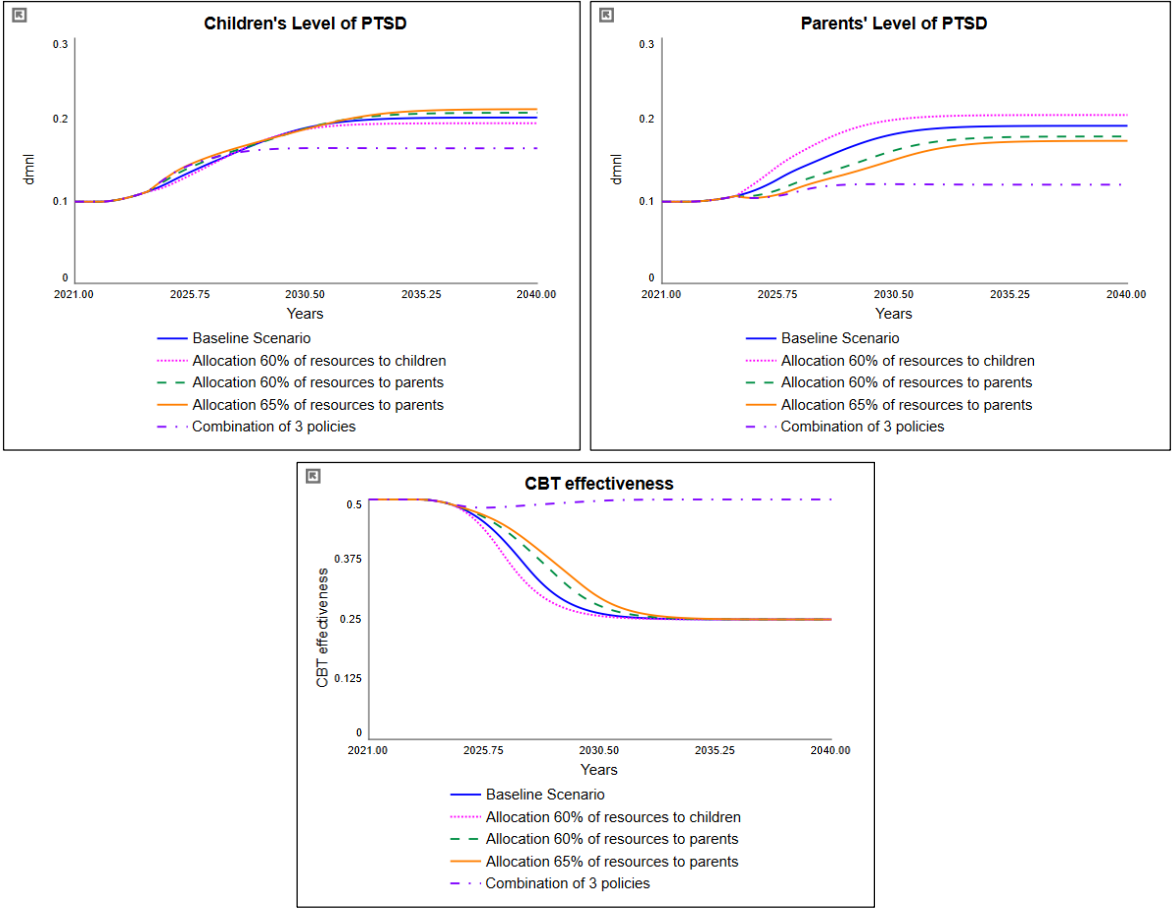


Fig. 24 Results of key indicators with the combination of three policy scenarios

As it can be observed on the figure 24 above, combination of three suggested policies appeared to be very effective for parents’ PTSD level reduction. It does not become lower than before full-scale invasion but still is reduced by 7%. On the other hand, children’s level of PTSD cannot be reduced with the same intensity, due to the lack of therapy resources. However, they can benefit from parent’s mental health improvements, obtaining more responsive parenting, and less family distress, including violence.

Hence, their resilience does not drop lower than two thirds of the normal value (i.e., 38%), causing PTSD to drop by approximately 4% (which is still not that beneficial, concerning the remaining 16.5 percentage of PTSD among younger generation). Precisely as a result of the sharper increase of children's PTSD, at the end of 2024 year parental PTSD begin to grow up (due to the quick increase in child's emotional dysregulations), increasing it from 10.4 till 12.1%.

This policy scenario appeared to be the most effective, compared to others, however not as much as anticipated. In order to reduce children's level of PTSD along with the parent's one, the model requires further detailed research.

Discussion

This chapter reveals the main findings, obtained from the current study on the impact of Russian aggression against Ukraine on people's mental health, and along with these answers the research questions put in the first chapter.

Findings

During this work there were created a system dynamic model, which portrays the key drivers of PTSD development, show the prevalence of PTSD among Ukrainian population, and suggest the mechanisms that can be used to mitigate the negative impact of unprovoked Russian invasion on people's mental health. And in this section, we are going to discuss the results of implemented various policy scenarios.

Effectiveness of increasing healthcare system capacity

The implementation of this policy, owing to the increase of CBT supply, yielded considerable improvements in the delivery of PTSD treatment and thus in children's and parent's mental health, having decreased the level of PTSD by nearly 1.5 times. The availability of additional health personnel and skilled cognitive behavioral therapists played a vital role in meeting the increased demand for therapy. As a result, Ukrainians who were mentally impacted by the unjustified Russian invasion now can have better access to timely and appropriate mental healthcare services.

Influence of expanding people's awareness

The findings demonstrate that having increased people's awareness of the importance of attending CBT in order to mitigate PTSD, did not have a positive impact on system behavior due to the lack of healthcare system capacity to serve so many people. For this reason, while implementing such policy, it is crucial to be aware that enhancing awareness alone might be insufficient to address such a complex mental health problem as PTSD confronting the impacted population. It should be supplemented by the availability of high-quality and easily accessible mental health services.

Role of resource allocation

Investigation into the role of resources allocation was crucial part of scenario analysis. Gained outcomes demonstrate that allocating more therapy resources to parents' PTSD treatment can have a profound impact not only on parent's mental health, but also reduce to some extent the level of PTSD among younger generation. However, while allocating more available resources for children could only exacerbate the current situation.

The obtained results revealed the importance of responsive parenting and harmonious relationships within the family and their favorable influence on children's mental health, which confirm the available literature.

Answers to Research Questions

In this section, there will be provided answers for the research questions, which were presented at the outset of our study. Data collection, methodology, and model analysis were all directed by these research questions:

What are the main drivers of children's and parents' PTSD?

A wide range of factors can contribute to the development of PTSD among children and parents. Among them can be experiencing or witnessing a life-threatening event (e.g., combat, rocket attack, or sexual assault), witnessing violence or loss of a family member. However, in the model created during this study, all these characteristics are represented as a single "war trauma", excluding the variations that different types of traumatic events may have on PTSD severity. In terms of the development of parental PTSD, parenting stress has been determined to be a significant contributor to parents' PTSD development. Moreover, during literature review conducted in Chapter 2 there were revealed two more drivers, which can have a favorable impact on PTSD reduction: resiliency and CBT, which was also proven throughout the analysis of this work.

What are the interconnections between children's and parents' PTSD development?

The research, including this work, confirmed the high interconnections between children's and parent's mental health and their relation within the family. Parents have a tremendous impact on children's mental health, particularly on their PTSD formation. When parents are fully functioning, their stress levels are optimal, and their mental health is in good shape, they are therefore able to properly nurture their children and fulfill the responsibilities of responsive parents. So, later, this has a substantial impact on the formation of children's resilience, which turns out to be a protective mechanism against external stimuli and, notably against the potential development of PTSD.

On the contrary, if parents' mental health deteriorates, it can impair their capacity to provide adequate care for their children. Parental stress induced by mental health decline can lead to an unhealthy environment, conflicts and even violence within the family. This weakens children's resilience and increases the risk of developing PTSD and further emotional problems. As a result, the child's emotional dysregulation worsens, and has a negative influence on parental stress, further exacerbating parents' PTSD. Thus, it can create a vicious circle of PTSD in the family.

Which feedback loop structures can capture the interconnections between children's and parents' PTSD?

According to the CLD presented in the model results section, it can be concluded that in terms of this study there exists five main feedback mechanisms, which can capture parent/child interconnections within the family, and they can be divided in two fundamental groups as follows:

1. *Children's resiliency improvements due to normal parents' mental health*, which are represented as reinforcing loops R1, R4, and R6 and can play a crucial role in decreasing the level of children's level of PTSD by improving their resilience to withstand stressors.
2. *Vicious cycle of PTSD in the family*, which are represented with reinforcing loops R2 and R5 and indicates that parents' mental health deteriorations can be a point of no return and not only worsen family relationships and reduce child's resilience, but also increase the likelihood of developing PTSD, which might subsequently only exacerbate the existing problem.

How does children's and parents' PTSD impact the healthcare system?

While people in Ukraine were living in terms of peaceful times, there were no negative impact on the healthcare system, because therapists were able to cope with their workload. However, right after the beginning of the war people's growing need to attend therapy created an additional pressure on the healthcare system (R8, R9). Therapists became unable to handle such high demand and in order to mitigate this problem, recover therapy effectiveness and decrease PTSD level among population, in the third chapter there were presented three scenarios for further development.

What are the leverage points of the model, which could be used for the policy recommendations?

During this work there were revealed several leverage points of the model, including:

- fraction of desired therapist which are recruited to provide necessary therapy for people
- ratio of people seeing CBT
- resource allocation

which later were used for policy suggestion, as reported in chapter 4.

Which robust policies stimulate PTSD recovery most effectively?

As it was mentioned before, during this study there were explores three policies which were aimed at decreasing PTSD level among Ukrainian population. However, not all of them appeared to be extremely effective, as it was predicted. And from the obtained results we can conclude that the most robust are the combination of suggested policies, namely the simultaneously increase in fraction of

desired therapist hired, expanding people's awareness in attending CBT along with allocation 65% of resources for parents' treatment, which can stimulate the reduction of parents' and children's PTSD by 7.2% and 3,8% respectively.

Limitations & Further research

Following the discussion of findings of the implemented policies, it is crucial to acknowledge the limitations of the study, which should be considered in future works.

The first and the most significant limitation, which triggered the others, was time. As a consequence of this the majority of the real system structures were simplified. There was not included the extended sector of PTSD, resilience, and social support formation, as well as children's interactions with peers, at school, and/or another extraneous relations beside family. The structure captures only the main drivers, although it would be extremely beneficial to model these structures in future research as well, in order to better understand system behavior and provide more high-quality policies in the future.

Furthermore, as it was aforementioned, the model does not take into consideration potential limits on healthcare system capacity, such as limited funding, presence of skilled health personnel, absence of facilities, or geographical location of people. However, all of these factors might potentially posed barriers to effective and successful therapy delivery, especially considering the fact of the occurring war in Ukraine.

Moreover, according to the second policy suggestion, the model does not reflect the mechanisms which can facilitate people's awareness in attending PTSD treatment. But we do have several options of how to implement this:

- Conducting public education (e.g., YouTube videos about the benefits from CBT for treating various mental health issues, including PTSD).
- Collaboration with primary healthcare systems (e.g., establishing new community centers)
- Launch online platforms to broaden the reach for CBT, what can also be beneficial for overcoming geographical barriers.

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Appendices

Appendix A: Sensitivity Analysis

In this attachment there are presented all constants and table functions, which model is very sensitive to. Sensitivity analysis was conducted using Stella's Model Analysis Tools as part of validation and model testing without an implementation policy switches, however concerning an ongoing war in Ukraine, with activated "war switch", which equal to 1. A total of 24 table functions and 31 exogenous variables, which were previously divided into three conditional groups: adjustment times, normal values and assumed parameters, were tested during this analysis. Sensitivity tests of exogenous variables were held using Sobol Sequence Sampling and Uniform Distribution according to all of 9 runs.

Adjustment Times

As expected, the model appeared to be not sensitive to any of eight adjustment times, which confirms its validity.

Normal Values

Normal Level of PTSD for children and parents (value: 0.1, range: 0.075-0.125):

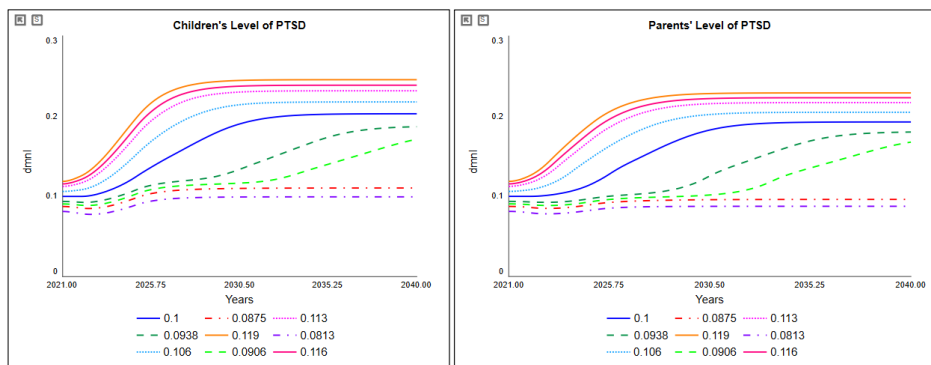


Fig. 25 Sensitivity Runs of children's and parents' PTSD levels for variation in normal level of PTSD

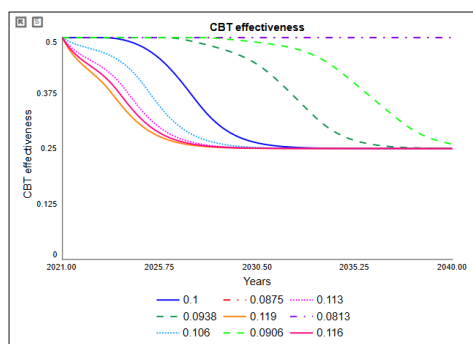


Fig. 26 Sensitivity Runs of CBT effectiveness for variation in normal level of PTSD

The model is highly sensitive to normal level of PTSD. However, it meets our expectations. Having crossed the equilibrium line (i.e., 0.1), model behavior changes completely. Furthermore, if normal PTSD level in the society was at least slightly lower than 9%, PTSD in a couple of years could stabilize in equilibrium, without sharp increase. On the contrary, higher normal PTSD level leads to more instability in the society, which is amplifying even more due to the war. Thus, parents become unable to raise their kids properly and provide them with necessary aid. At the same time, it can provoke more distress and violence within families, which later result in children's resiliency decrease and increase their PTSD level even more. Due to this fact, children's abilities to control their emotions decline, increasing parenting stress, which afterwards can result in even higher parental PTSD increase. Consequently, demand for therapy becomes more than two times higher, which inevitably causes CBT effectiveness to decrease.

Normal CBT effectiveness (value: 0.5, range: 0.375-0.625):

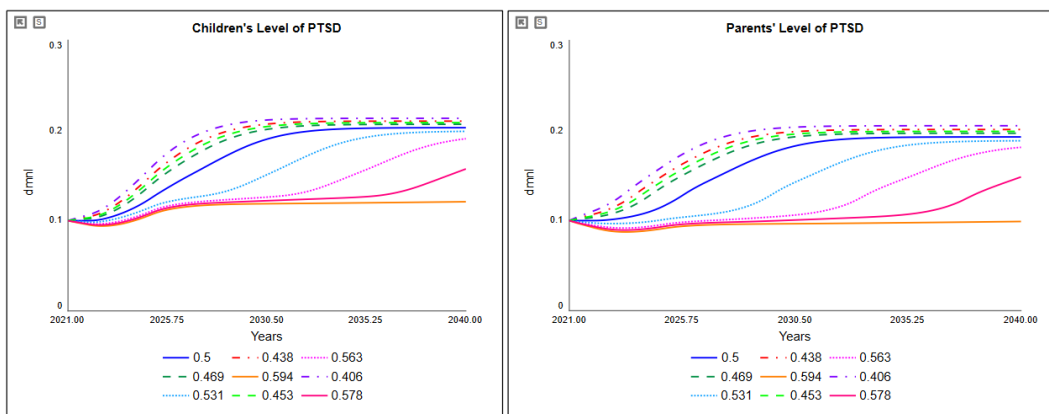


Fig. 27 Sensitivity Runs of children's and parents' PTSD levels for variation in normal CBT effectiveness

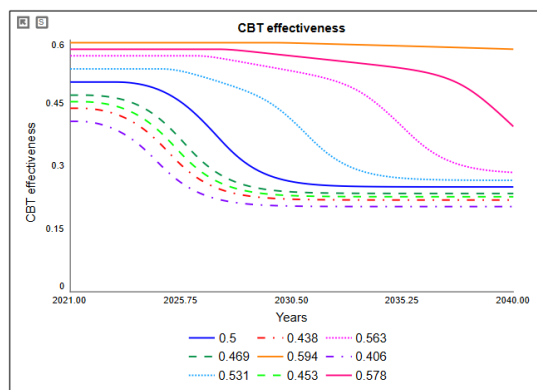


Fig. 28 Sensitivity Runs of CBT effectiveness for variation in normal CBT effectiveness

The model is extremely sensitive to normal CBT effectiveness. However, it completely meets our expectations. Having crossed the equilibrium line (i.e., 0.5), model behavior changes completely. If normal CBT effectiveness decreases, the desired outcomes of people's mental health improvements

become less efficient due to the decline in symptoms reduction, and level of PTSD among population increases even more. Therefore, family relations expected to worsen, which is only exacerbates the situation. Conversely, if normal CBT effectiveness could become higher, it could prevent the enormous growth of PTSD among Ukrainian population.

Assumed Parameters

Fraction of desired number of therapists hired (value: 0, range: 0-0.05):

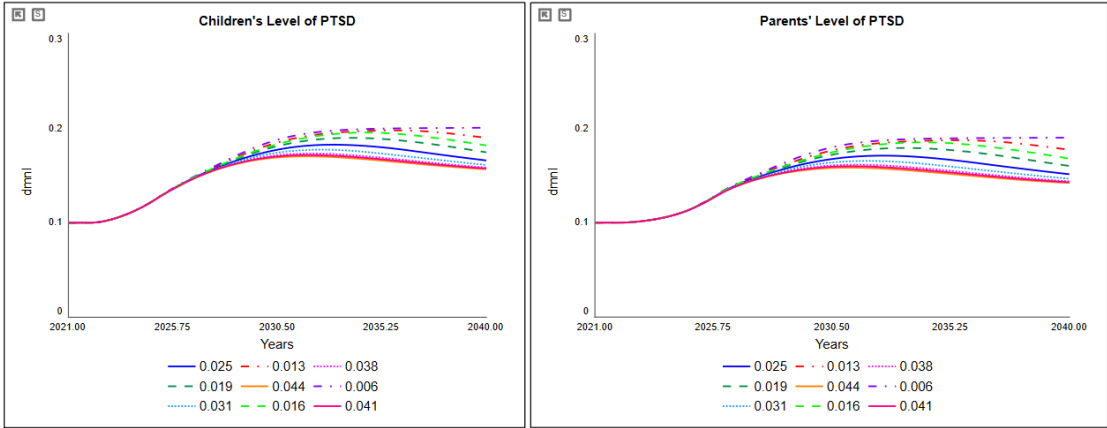


Fig. 29 Sensitivity Runs of children's and parents' PTSD levels for variation in fraction of desired number of therapists hired

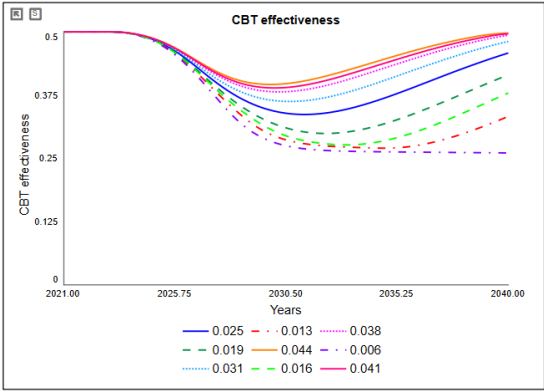


Fig. 30 Sensitivity Runs of CBT effectiveness for variation in fraction of desired number of therapists hired

As predicted, the model appeared to be sensitive to a fraction of desired number of therapists hired, as far as this variable represent a leverage point. Initially this parameter is assumed to be 0 (detailed explanation is presented in model documentation). However, while there are occurred even slightest changes in this parameter value, it immediately influences healthcare system capacity in providing people with necessary treatment. The more potential the healthcare system has, the higher therapy effectiveness is. The more high-quality therapy services are provided, the lower PTSD level becomes.

Ratio of people seeing CBT per year (value: 0.25, range: 0.1875-0.3125):

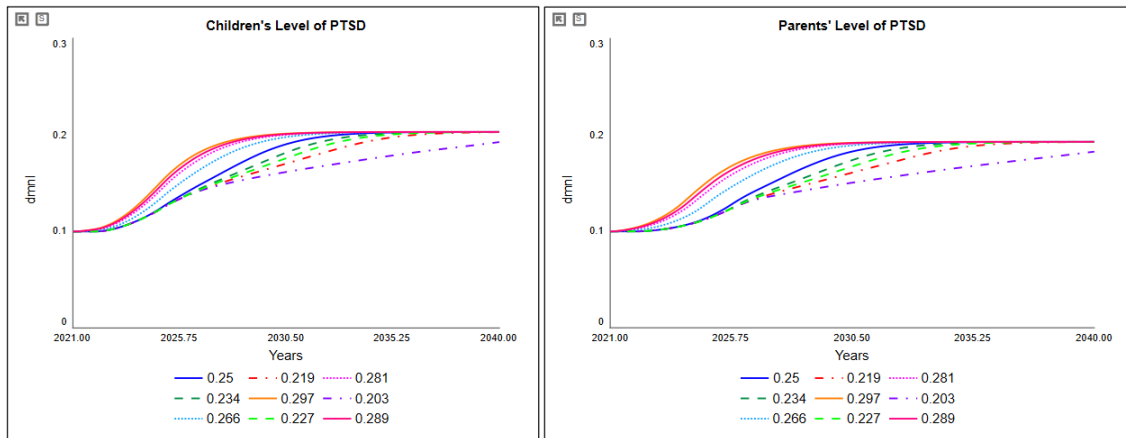


Fig. 31 Sensitivity Runs of children's and parents' PTSD levels for variation in ratio of people seeing CBT per year

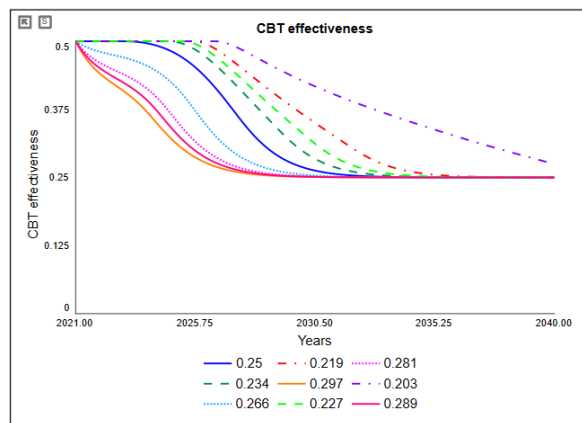


Fig. 32 Sensitivity Runs of CBT effectiveness for variation in ratio of people seeing CBT per year

As predicted, the model appeared to be sensitive to the ratio of people seeing CBT per year, as far as this variable indicates a leverage point. The explanation is following: when people are less acknowledged about the importance of CBT, they are less eager to attend it. Thus, the demand for CBT is going down, producing less impact on therapists' workload, which in turn prevents CBT effectiveness from such a sharp decline. As a consequence, more people can be treated. On the contrary, when the ratio of people seeing CBT per year is growing up, the situation is totally opposite. Therapists cannot manage to treat more people than they have capacity for, hence, their overload causes CBT effectiveness to decline faster. Lower quality services indicate less efficient PTSD symptoms reduction and the percentage of PTSD among population increase accelerating its speed.

However, even despite such an effect at the beginning, in a long-term perspective people's awareness appears to be not as important as, for instance, the capacity of healthcare system.

CBT allocation coefficient (value: 0.5, range: 0.375-0.625):

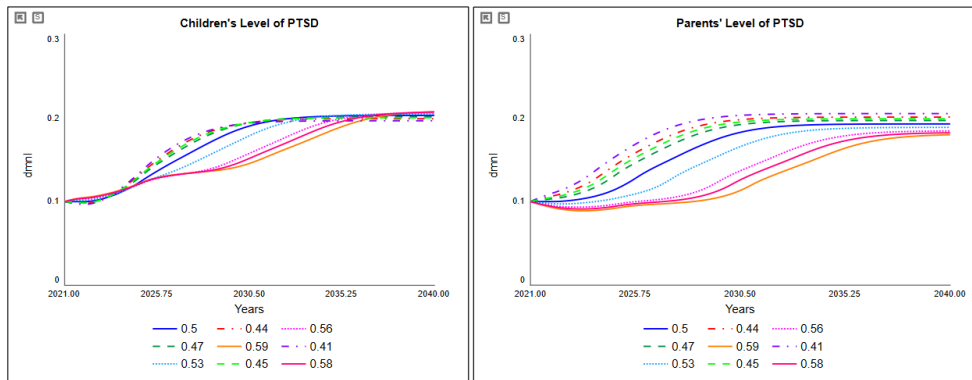


Fig. 33 Sensitivity Runs of children's and parents' PTSD levels for variation in CBT allocation coefficient

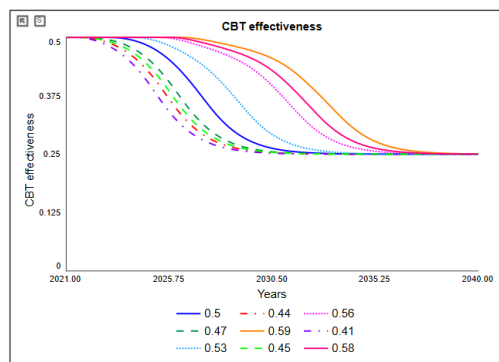


Fig. 34 Sensitivity Runs of CBT effectiveness for variation in CBT allocation coefficient

Not all the key variables of the model appeared to be extremely behaviorally sensitive to the changes in CBT allocation coefficient. However, there are noticeable changes in parents' level of PTSD, which is what was anticipated. When we are allocating at least 5% more therapists' resources for parents' treatment, only in a few years it has a profound impact not only on parents, but also on children's mental health. Meaning that having allocated more resources to parents, their treatment becomes a way more effective, their level of PTSD is going down, and as a result, they are becoming able to address a child's physical, emotional, and social needs. Additionally, along with this there is observed the contraction of pressure on healthcare system capacity, which is also aids in providing more effective therapy for children. As time passes, it can cause positive improvement in children's resilience and reduce so sharp growth of children's PTSD. However, it is not that beneficial in a long-term perspective, thus requires more investigation.

On the contrary, if we try to allocate more available resources to children, it does not have any dramatic effect on the development of children's PTSD. Furthermore, it could only aggravate the situation with parental PTSD, as far as children have no such impact on parents as parents have on their kids, and having less resources being allocated for parents, it becomes insufficient to treat them and reduce PTSD symptoms.

Graphical Functions

Effect of Parents' Mental Health on Family Distress

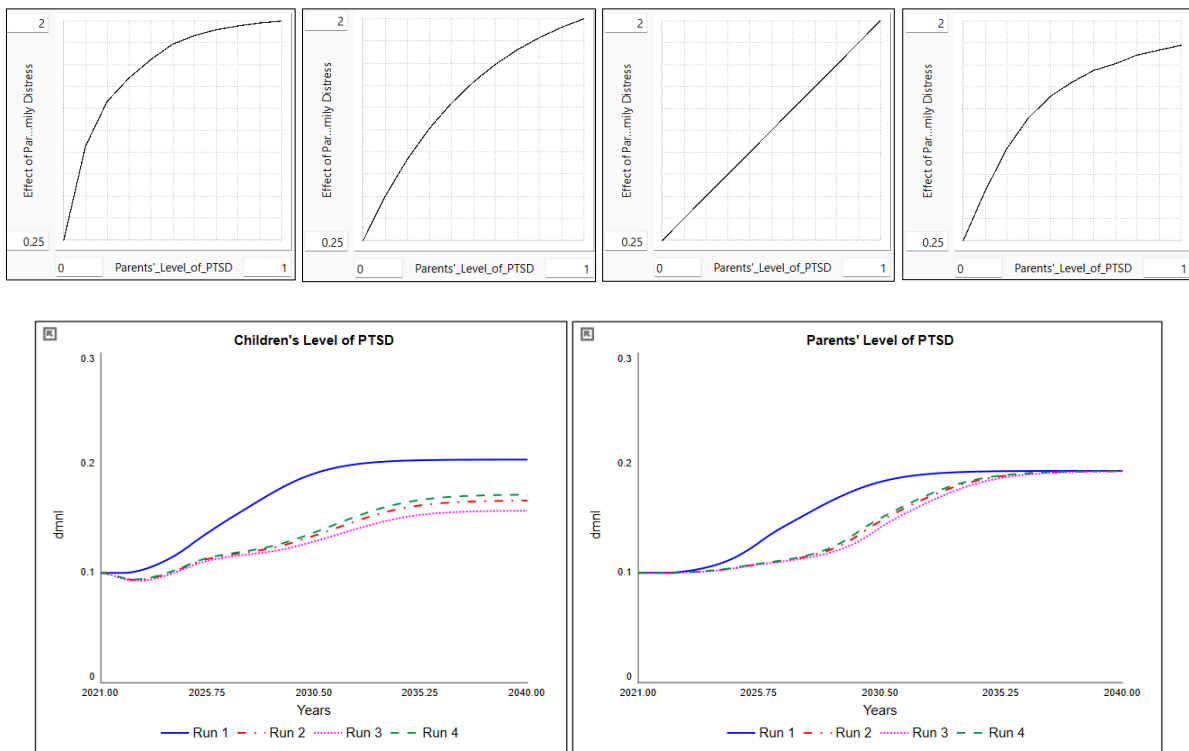
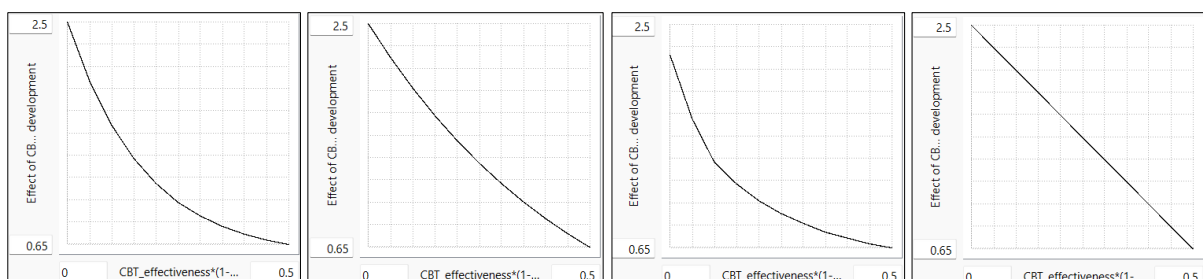


Fig. 35 Sensitivity Runs of children's and parents' PTSD levels for variation in effect of Parents' Mental Health on Family Distress

From the results we receive confirmation that parent's mental health has significant impact on family distress. When the effect is less steep or linear, signifying that parent's mental health has a lower impact on family members, and children are more resistant to any stressors within the family. Thus, their resilience level could increase, which can cause less growth of children's PTSD. Although it still does not have such a profound impact on parental PTSD reduction, but only delays its increase.

Effect of CBT on Children's PTSD development



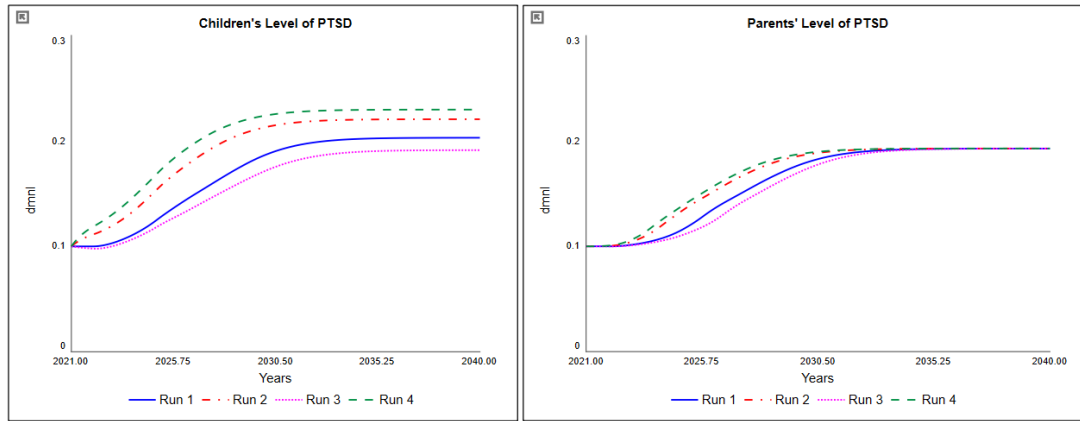


Fig. 36 Sensitivity Runs of children's and parents' PTSD levels for variation in effect of CBT on children's PTSD development

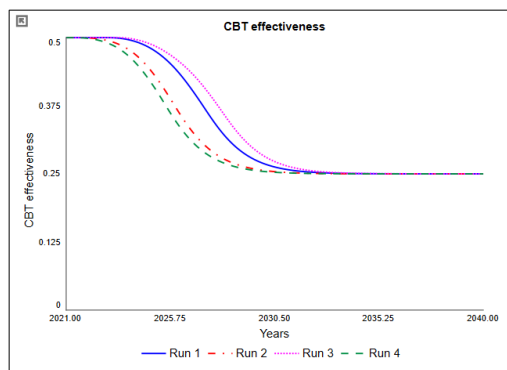
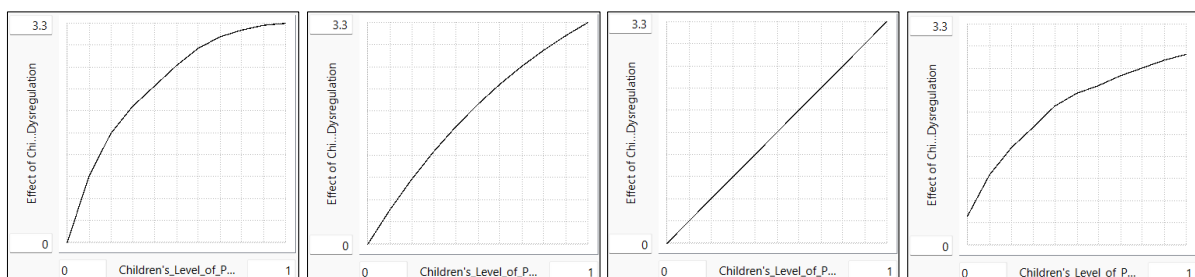


Fig. 37 Sensitivity Runs of CBT effectiveness for variation in effect of CBT on children's PTSD development

As it was expected, children's level of PTSD is sensitive even to the slightest changes in CBT effectiveness. Current non-linear relation controls the exponential decay curve in the CBT/PTSD relation. A lower sensitivity leads to higher growth of PTSD among younger population, which can be observed on the graph. Nonetheless, despite this change in children's PTSD, the overall model behavior, including parental PTSD and CBT effectiveness remains almost the same (excluding slight numerical sensitivity), this variable can be a leverage point of the model, as far as it indicates the importance of therapy in the development of PTSD.

Effect of Children's Mental Health on Child's Emotional Dysregulation



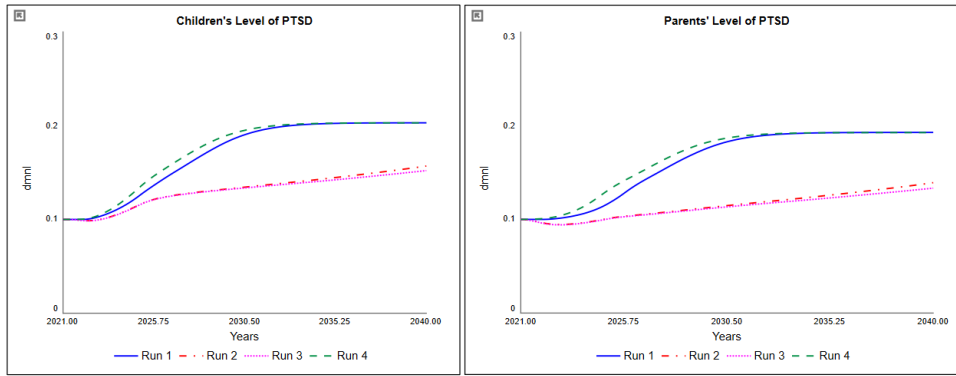


Fig. 38 Sensitivity Runs of children's and parents' PTSD levels for variation in effect of Children's Mental Health on Child's Emotional Dysregulation

The steepness of this non-linear function regulates the extent of influence of child's mental health on child's difficulties recognizing emotions. Less steep effect indicates lower impact on parental stress level, and thus on parent's PTSD development. As a consequence, it can lead to the reduction of children's PTSD level as well. The sensitivity test revealed the uncertainty in this parameter; hence this correlation requires further investigation and better quantification.

Effect of CBT on Parents' PTSD development

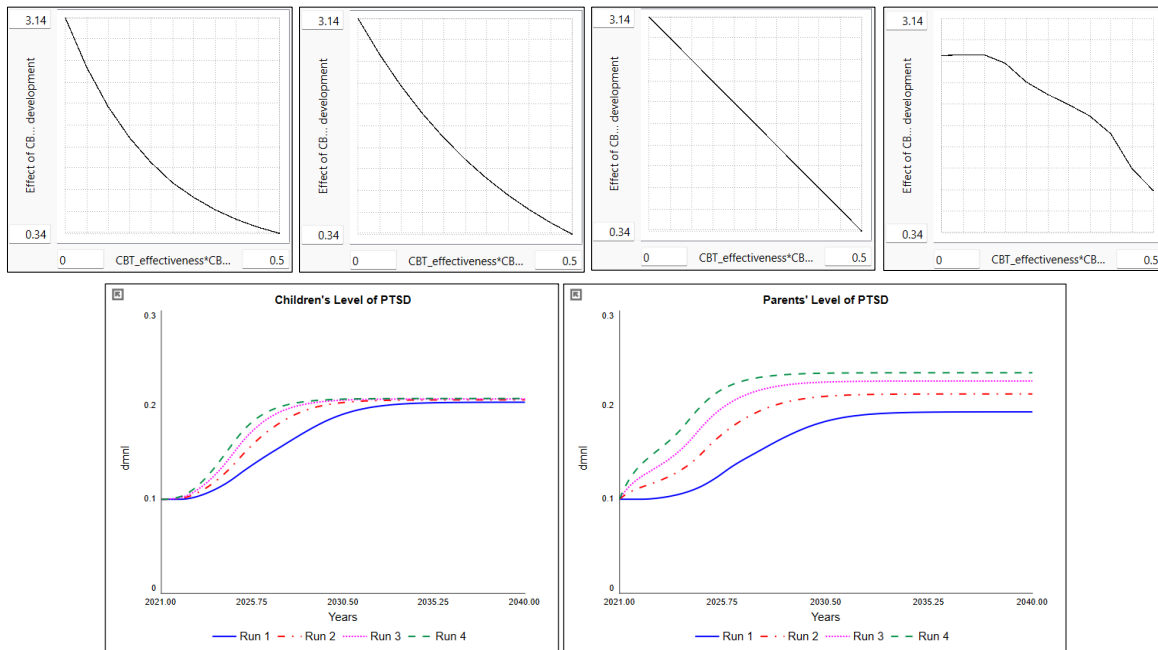


Fig. 39 Sensitivity Runs of children's and parents' PTSD levels for variation in effect of CBT on Parents' PTSD development

As anticipated, the outcomes of this sensitivity test appeared to be similar to the sensitivity of effect of CBT on children's PTSD development. However, comparing these results, model is far more sensitive to CBT effectiveness addressed to parents, thus this variable can be a leverage point of the model, as far as it indicates vital importance of therapy for parents.

Appendix B: Model Documentation

Total	Count	Including Array Elements
Variables	157	157
Sectors	5	
Stocks	8	8
Flows	10	10
Converters	139	139
Constants	47	47
Equations	102	102
Graphicals	24	24
Macro Variables	6	

Children's PTSD development Sector

<p>Amount_of_children_in_Ukraine = 7898121</p> <p>UNITS: person</p> <p>DOCUMENT: This variable represents the number of children in Ukraine as of 2021, and this number is not changing over the time. According to UNICEF, total population under age 18 in Ukraine as of 2021 was 7,898,121. https://data.unicef.org/how-many/how-many-children-under-18-are-there-in-ukraine/ [Accessed May 27, 2023].</p>
<p>Chance_of_developing_Children's_PTSD_after_experiencing_trauma = Normal_chance_of_developing_Children's_PTSD_after_experiencing_trauma*Effect_of_Relative_Change_in_Resilience_on_chance_of_developing_PTSD</p> <p>UNITS: dmdl</p> <p>DOCUMENT: This variable represents the chance of developing children's PTSD after experiencing trauma. It is increased due to the decreased effect in relative change in resilience.</p>
<p>Chance_of_developing_Children's_PTSD_relative_to_normal = Chance_of_developing_Children's_PTSD_after_experiencing_trauma/Normal_chance_of_developing_Children's_PTSD_after_experiencing_trauma</p> <p>UNITS: dmdl</p> <p>DOCUMENT: This converter shows the chance of developing children's PTSD compared to the normal.</p>
<p>Children's_Level_of_PTSD(t) = Children's_Level_of_PTSD(t - dt) + (Children's_PTSD_development) * dt INIT Children's_Level_of_PTSD = Normal_Level_of_PTSD_for_children_and_parents</p>

UNITS: dmn1

DOCUMENT: This key variable represents the percentage of PTSD among children in Ukraine. The stock varies between 0 (no child has PTSD) and 1 (all children suffer from PTSD). Nevertheless, in order to avert unreasonable behavior in extreme conditions, with the help of limits in graphical functions it was assumed that in term of peaceful times:

1. even in case of minimum possible resilience and minimum possible CBT effectiveness, PTSD cannot rise above 20%;
2. even when resilience and CBT effectiveness are on their maximum, PTSD cannot drop under 5.75%, because there is always some percentage of PTSD among population.

The initial value of the stock is set at its normal level.

Children's_Normal_Resilience = .6

UNITS: resiliency

DOCUMENT: This variable represents a normal level of children's resilience. It is assumed to be slightly higher than medium value, i.e., 0.6.

Children's_PTSD_development = (Indicated_level_of_Children's_PTSD - Children's_Level_of_PTSD)/PTSD_AT

UNITS: Per Year

DOCUMENT: This inflow indicates the rate of change in the children's PTSD level. It operates as a first order adjustment, where children's level of PTSD adjusts to its indicated level with an adjustment time of 1 year.

Children's_Resilience(t) = Children's_Resilience(t - dt) + (Resiliency_Development) * dt
INIT Children's_Resilience = Children's_Normal_Resilience

UNITS: resiliency

DOCUMENT: This stock represents the level of children's resiliency. In other words it is child's ability to withstand stressors and successful adapt to tough or difficult life situations. The stock ranges from 0 to 1, where 0 indicates the total absence of resilience, and 1 - maximum resilience. However, as far as the model does not include extended formation of children's resilience (meaning that it is not accounted child's interactions with peers, at school, and/or another extraneous relations beside family), it is assumed, that children's resilience cannot drop under 0.1; even if there is no therapy and support from parents, but family distress and violence are at maximum. The initial value of the stock is set at its normal level.

Current_Children's_Resilience_effect_relative_to_normal = Children's_Resilience/Children's_Normal_Resilience

UNITS: dmn1

DOCUMENT: This variable shows the ratio of current child's resilience relative to normal.

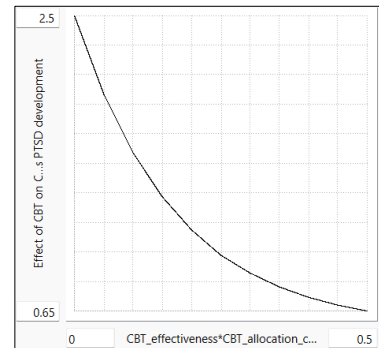
Effect_of_CBT_and_Responsive_Parenting_on_Children's_Resilience = Weighted_effect_of_Responsive_Parenting_on_Children's_Resilience+Weighted_effect_of_CBT_on_Children's_Resilience

UNITS: dmn1

DOCUMENT: This converter represents the cumulative effect of responsive parenting and CBT effectiveness on children's resilience development. It is formulated as an additive relation, due to the separability of the effects. Meaning that even if, for instance, there is no access to treatment, there will still be an individual effect on children's resilience from parenting, thus the total effect on resilience development will not be 0.

$$\begin{aligned} \text{Effect_of_CBT_on_Children's_PTSD_development} = & \\ \text{GRAPH}(\text{CBT_effectiveness} * \text{CBT_allocation_coefficient} * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + & \\ \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} - & \\ 0.15) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + & \\ \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} + 0.1) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) & \\ * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + & \\ \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} - & \\ 0.1) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} - & \\ 0.15) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - & \\ \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) & \end{aligned}$$

Points: (0.0000, 2.500), (0.0500, 2.010), (0.1000, 1.642), (0.1500, 1.366), (0.2000, 1.159), (0.2500, 1.000), (0.3000, 0.8882), (0.3500, 0.801), (0.4000, 0.7357), (0.4500, 0.6867), (0.5000, 0.650)



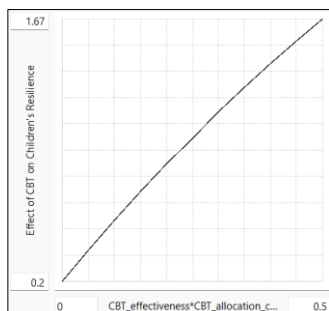
UNITS: dmnl

DOCUMENT: This converter represents the effect of CBT effectiveness on children's PTSD development. In other words, this graphical function shows how PTSD will be developing, depending on the quality of CBT. So, the fundamental assumption here is that when CBT effectiveness is at its maximum (i.e., = 0.5), then the effect is 1, meaning that PTSD develops at its normal pace. However, if CBT effectiveness began to decrease below 0.5 (effect of therapy is lower than anticipated) effect on PTSD could increase increasingly before it could reach the point of 1.67. It is assumed that the maximum level till which CBT can decrease level of PTSD among children = 5.75% at maximum effectiveness along with maximum resilience. The upper bound is placed here to prevent the PTSD stock from behaving irrationally (to ensure that PTSD cannot rise above 20% in terms of peaceful times). This variable can vary depending on the policy SWITCH.

If policy SWITCHES are turned off, we allocate for parents and children equal amount of therapy resources, thus CBT allocation coefficient = 0.5. On the contrary, if one of policy SWITCHES is turned on, we are allocating 60 and 65% out of total resources for children or for parents (indicating that children or parents will be a priority), depending on the policy scenario.

Effect_of_CBT_on_Children's_Resilience =
 GRAPH(CBT_effectiveness*CBT_allocation_coefficient*(1-
 "policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#1)")*(1-
 "policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient-
 0.15)*"policy_#1+_2+_3_status_(scenario_#4)"*(1-
 "policy_#1+_2+_3_status_(scenario_#1)"*(1-"policy_#1+_2+_3_status_(scenario_#2)"*(1-
 "policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient+0.1)*"policy_#1+_2+_3_status_(scenario_#1)"
 (1-"policy_#1+_2+_3_status_(scenario_#4)")(1-
 "policy_#1+_2+_3_status_(scenario_#2)"*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient-
 0.1)*"policy_#1+_2+_3_status_(scenario_#2)"*(1-
 "policy_#1+_2+_3_status_(scenario_#1)"*(1-"policy_#1+_2+_3_status_(scenario_#4)"*(1-
 "policy_#1+_2+_3_status_(scenario_#3)") + CBT_effectiveness*(CBT_allocation_coefficient-
 0.15)*"policy_#1+_2+_3_status_(scenario_#3)"*(1-
 "policy_#1+_2+_3_status_(scenario_#1)"*(1-"policy_#1+_2+_3_status_(scenario_#2)"*(1-
 "policy_#1+_2+_3_status_(scenario_#4)"))

Points: (0.0000, 0.200), (0.0500, 0.3741), (0.1000, 0.5416), (0.1500, 0.7026), (0.2000, 0.8575),
 (0.2500, 1.000), (0.3000, 1.150), (0.3500, 1.287), (0.4000, 1.420), (0.4500, 1.547), (0.5000, 1.670)



UNITS: dmn1

DOCUMENT: This converter represents the effect of CBT effectiveness on children's resilience. In other words, this graphical function shows how resilience will be developing, depending on the quality of CBT.

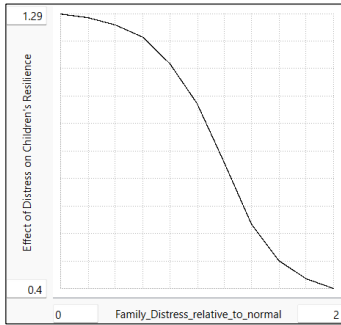
So, the fundamental assumption here is that when CBT effectiveness is at its maximum (i.e., = 0.5), then the effect is 1, meaning that resilience develops in its normal pace. However, if CBT effectiveness began to decrease below 0.5 (effect of therapy is lower than anticipated) effect on resilience could be decreasing before it could reach the point of 0.2.

The lower bound is placed here to prevent the resilience stock from behaving irrationally (to ensure that resilience cannot fall below 0.1).

This variable can vary depending on the policy SWITCH.

If policy SWITCHES are turned off, we allocate for parents and children equal amount of therapy resources, thus CBT allocation coefficient = 0.5. On the contrary, if one of policy SWITCHES is turned on, we are allocating 60 and 65% out of total resources for children or for parents (indicating that children or parents will be a priority), depending on the policy scenario.

Effect_of_Distress_on_Children's_Resilience = GRAPH(Family_Distress_relative_to_normal)
 Points: (0.000, 1.2900), (0.200, 1.2782), (0.400, 1.2547), (0.600, 1.2155), (0.800, 1.1293), (1.000, 1.0000), (1.200, 0.8078), (1.400, 0.6078), (1.600, 0.4902), (1.800, 0.4314), (2.000, 0.4000)

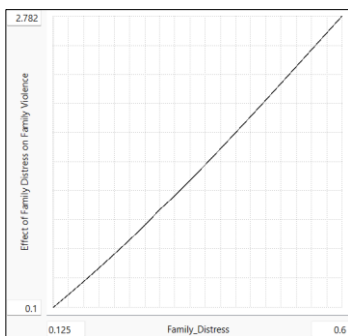


UNITS: dmdl

DOCUMENT: This variable represents the effect of family distress on children's resilience. The fundamental assumption here is that when family distress is on its normal level, then the effect equals 1, meaning that resiliency remains on its normal level. Nonetheless, as level of family distress decreases from the normal value towards zero, the influence on resilience become more and more efficient, indicating that the absence of stress within the family facilitates the child's resilience improvements, and increase decreasingly prior to the effect hits the point of 1.29. On the contrary, when family distress increase to the doubled normal value, the effect on resilience becomes less and less efficient, and decrease decreasingly prior to the effect drops to the point of 0.2, indicating that the higher level of family stressors inevitably leads to the child's resilience reduction. Upper and lower bounds are placed here to prevent the resilience stock from behaving irrationally (to ensure that resilience cannot rise beyond 1 and fall below 0.1).

Effect_of_Family_Distress_on_Family_Violence = GRAPH(Family_Distress)

Points: (0.1250, 0.100), (0.1500, 0.2173), (0.1750, 0.3378), (0.2000, 0.4616), (0.2250, 0.5885), (0.2500, 0.7187), (0.2750, 0.8519), (0.3000, 1.000), (0.3250, 1.127), (0.3500, 1.269), (0.3750, 1.413), (0.4000, 1.560), (0.4250, 1.709), (0.4500, 1.859), (0.4750, 2.011), (0.5000, 2.164), (0.5250, 2.318), (0.5500, 2.473), (0.5750, 2.627), (0.6000, 2.782)



UNITS: dmdl

DOCUMENT: This variable represents the effect of family distress on family violence. The fundamental assumption here is that when family distress is on its normal level, then the effect equals 1, meaning that family violence remains on its normal level. Nonetheless, as the level of family distress become even less the normal value, the influence on family violence become less and less significant, and decrease decreasingly prior to the effect drops to the point of 0.1.

On the contrary, when family distress increases to the doubled normal value, the effect on family violence becomes more and more efficient, and it is expected to reach nearly three times the normal level.

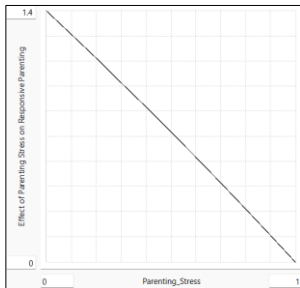
$$\text{Effect_of_Family_Relations_on_Children's_Resilience} = \text{Effect_of_Violence_on_Children's_Resilience} * \text{Effect_of_Distress_on_Children's_Resilience}$$

UNITS: dmn1

DOCUMENT: This converter represents the total effect of family relations on children's resilience. It is formulated as an multiplicative relation, due to the strong connection of the effects.

$$\text{Effect_of_Parenting_Stress_on_Responsive_Parenting} = \text{GRAPH}(\text{Parenting_Stress})$$

Points: (0.000, 1.400), (0.100, 1.269), (0.200, 1.137), (0.300, 1.000), (0.400, 0.8651), (0.500, 0.7262), (0.600, 0.5853), (0.700, 0.4423), (0.800, 0.297), (0.900, 0.1496), (1.000, 0.000)

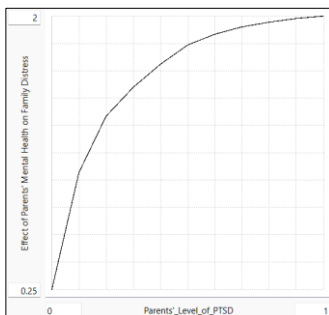


UNITS: dmn1

DOCUMENT: This variable represents the effect of parenting stress on responsive parenting. Parenting stress has a negative impact on family quality of life, including family interactions, well-being and parenting (Zeng et al., 2020). When there is no parenting stress, the ability of parents to be responsive to the children would be on its maximum, which is almost one and a half enhanced normal. With the increasing of parenting stress, it becomes more and more difficult for parents to provide the children emotional and physical needs, thus the ability to be responsive parents linearly decrease towards 0 (indicating the 100% level of parenting stress). Point (0.3, 1) on the graph ensures that normal level of parenting stress corresponds to the normal level of responsive parenting.

$$\text{Effect_of_Parents' Mental Health on Family Distress} = \text{GRAPH}(\text{Parents' Level of PTSD})$$

Points: (0.000, 0.250), (0.100, 1.000), (0.200, 1.360), (0.300, 1.545), (0.400, 1.692), (0.500, 1.815), (0.600, 1.884), (0.700, 1.931), (0.800, 1.961), (0.900, 1.985), (1.000, 2.000)

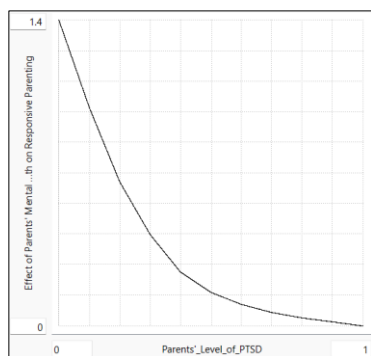


UNITS: dmn1

DOCUMENT: This variable represents the effect of parents' mental health on family distress. If there were no parents suffering from PTSD, family distress would be four times less common. However, with the increasing of PTSD level, it becomes more and more difficult for parents to restrain their emotions and anger, thus the ability to protect children from any kind of stressors decreases decreasingly. If the PTSD reaches its normal level, then the effect on family distress will be at the target value (which is ensured by (0.1,1) point on the graph). Finally, if the level of PTSD was 100%, the level of family distress could potentially exceed twice the normal value.

Effect_of_Parents'_Mental_Health_on_Responsive_Parenting = GRAPH(Parents'_Level_of_PTSD)

Points: (0.000, 1.400), (0.100, 1.000), (0.200, 0.660), (0.300, 0.419), (0.400, 0.247), (0.500, 0.154), (0.600, 0.099), (0.700, 0.062), (0.800, 0.037), (0.900, 0.019), (1.000, 0.000)

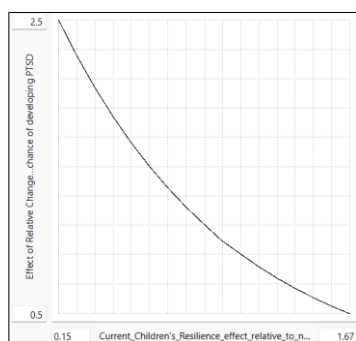


UNITS: dmnl

DOCUMENT: This variable represents the effect of parents' mental health on responsive parenting. If there were no parents with PTSD, then the ability of parents to be responsive to the children would be on its maximum, which is almost one and a half enhanced normal. With the increasing of PTSD level in a society, it becomes more and more difficult for parents to provide for the children emotional and physical needs, thus the ability to be responsive parents decrease decreasingly. If the PTSD reaches its normal level, then the effect on responsive parenting will be at the target value (which is ensured by (0.1,1) point on the graph). Finally, if the level of PTSD was 100%, there would not be any possibility of being responsive parents, thus effect would be 0.

Effect_of_Relative_Change_in_Resilience_on_chance_of_developing_PTSD = GRAPH(Current_Children's_Resilience_effect_relative_to_normal)

Points: (0.150, 2.500), (0.245, 2.257), (0.340, 2.039), (0.435, 1.841), (0.530, 1.663), (0.625, 1.503), (0.720, 1.358), (0.815, 1.227), (0.910, 1.109), (1.000, 1.000), (1.100, 0.9072), (1.195, 0.8207), (1.290, 0.7427), (1.385, 0.6724), (1.480, 0.6089), (1.575, 0.5516), (1.670, 0.500)



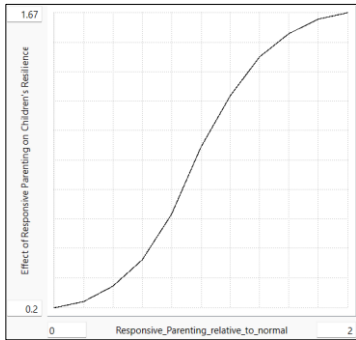
UNITS: dmn1

DOCUMENT: This variable represents the effect of relative change in resilience on chance of developing PTSD.

When current child's resilience relative to normal is on its minimum value slightly higher than 0.15 (considering that minimum possible level of resilience is 0.1 and normal of 0.6), then the chance of developing PTSD for children is twice and a half enhanced normal. When child's resilience begins to grow, it becomes more persistent to external stimuli, thus the chance of getting PTSD decrease decreasingly. If the resilience reaches its normal levels, then the effect on chance of developing PTSD will be at the target value (which is ensured by (1,1) point on the graph). Finally, when resilience attains its maximum, the possibility of having PTSD for a child would be half smaller than the normal (i.e., only 5%).

Effect_of_Responsive_Parenting_on_Children's_Resilience=GRAPH(Responsive_Parenting_relative_to_normal)

Points: (0.000, 0.200), (0.200, 0.231), (0.400, 0.308), (0.600, 0.439), (0.800, 0.666), (1.000, 1.000), (1.200, 1.256), (1.400, 1.450), (1.600, 1.566), (1.800, 1.638), (2.000, 1.670)



UNITS: dmn1

DOCUMENT: This variable represents the effect of responsive parenting on children's resilience. The fundamental assumption here is that when responsive parenting is on its normal level, then the effect equals 1, meaning that resiliency remains on its normal level. Nonetheless, as level of responsive parenting decreases from the normal value towards zero, the influence on resilience becomes less and less efficient, and decreases decreasingly prior to the effect drops to the point of 0.2.

On the contrary, when responsive parenting increases to the doubled normal value, the effect on resilience becomes more and more efficient, and increases decreasingly prior to the effect hits the point of 1.67.

Upper and lower bounds are placed here to prevent the resilience stock from behaving irrationally (to ensure that resilience cannot rise beyond 1 and fall below 0.1).

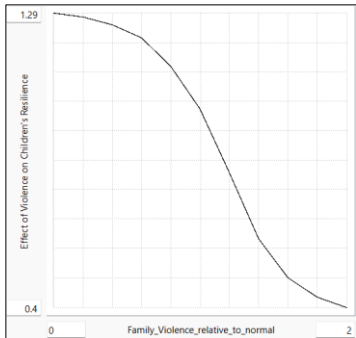
Effect_of_TRAUMA_on_children's_PTSD_development =
WAR_TRAUMA+Chance_of_developing_Children's_PTSD_relative_to_normal

UNITS: dmn1

DOCUMENT: This variable represents the effect of trauma on children's PTSD development. It is defined by the current chance of developing children's PTSD relative to normal (previously based on the resiliency level) and trauma, occurred because the war.

Effect_of_Violence_on_Children's_Resilience = GRAPH(Family_Violence_relative_to_normal)

Points: (0.000, 1.2900), (0.200, 1.2782), (0.400, 1.2547), (0.600, 1.2155), (0.800, 1.1293), (1.000, 1.0000), (1.200, 0.8078), (1.400, 0.6078), (1.600, 0.4902), (1.800, 0.4314), (2.000, 0.4000)



UNITS: dmn1

DOCUMENT: This variable represents the effect of family violence on children's resilience. The fundamental assumption here is that when family violence is on its normal level, then the effect equals 1, meaning that resiliency remains on its normal level. Nonetheless, as level of family violence decreases from the normal value towards zero, the influence on resilience become more and more efficient, indicating that the absence of violence in the family facilitates the child's resilience improvements, and increase decreasingly prior to the effect hits the point of 1.29. On the contrary, when family violence increases to the doubled normal value, the effect on resilience becomes less and less efficient, and decrease decreasingly prior to the effect drops to the point of 0.2, indicating that the higher level of family violence inevitably leads to the child's resilience reduction.

Upper and lower bounds are placed here to prevent the resilience stock from behaving irrationally (to ensure that resilience cannot rise beyond 1 and fall below 0.1).

Family_Distress =
Effect_of_Parents'_Mental_Health_on_Family_Distress*Normal_Family_Distress

UNITS: Distress

DOCUMENT: This converter shows the level of family distress, which is defined as any sort of stressor that affects one or a few family members and has an influence on the emotional connection between relatives, their mood and well-being.

Family_Distress_relative_to_normal = Family_Distress/Normal_Family_Distress

UNITS: dmn1

DOCUMENT: This variable shows the ratio of current level of family distress relative to normal.

Family_Violence = Normal_Family_Violence*Effect_of_Family_Distress_on_Family_Violence

UNITS: Violence

DOCUMENT: This converter shows the level of family violence, which is defined as any harmful, forceful, domineering, or abusive behavior between family members that produces fear in the individual experiencing the behavior.

<p>Family_Violence_relative_to_normal = Family_Violence/Normal_Family_Violence</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable shows the ratio of current level of family violence relative to normal.</p>
<p>Indicated_level_of_Children's_PTSD = Normal_Level_of_PTSD_for_children_and_parents*Total_effect_on_Children's_PTSD_development</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable represents the indicated level of Children's PTSD, which changes the actual level of PTSD by multiplying normal level of PTSD by the total effect of trauma and CBT effectiveness.</p>
<p>Indicated_Level_of_Children's_Resilience = Children's_Normal_Resilience*Total_effect_on_Children's_Resilience</p> <p>UNITS: resiliency</p> <p>DOCUMENT: This variable represents the indicated level of children's resiliency before information delay adjustment. The indicated value is determined by the total effect on children's resilience and normal level of resiliency.</p>
<p>Normal_chance_of_developing_Children's_PTSD_after_experiencing_trauma = 0.1</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable represent a risk of developing Children's PTSD after experiencing trauma. This number can vary depending on several factors such as the type and severity of trauma, the child's age, support system, and any pre-existing mental health conditions. According to the US department of veterans affairs, 8% of women and 4% of men have a possibility to develop PTSD at some point in their life (which is 6% in average). But during a war or pandemic this chance might be even higher. Thus, due to the fact that the model represents people who live in War zone and their mental health condition are worse compared with the people who live in a peaceful places. Thus, it can be assumed that this risk is higher than the average number and equal to 10%. In addition, for simplicity, it is assumed, that this percentage is equal for both children and parents. https://www.ptsd.va.gov/understand/common/common_adults.asp [Accessed May 28, 2023].</p>
<p>Normal_Family_Distress = 0.3</p> <p>UNITS: Distress</p> <p>DOCUMENT: This variable represents normal level of family distress. It is assumed to be almost twice less than medium value, i.e., 0.3.</p>
<p>Normal_Family_Violence = 0.1</p> <p>UNITS: Violence</p> <p>DOCUMENT: This variable represents normal level of family violence. It is assumed to be 0.1, considering yelling and slight outburst of anger as violent attitude to the child.</p>

Normal_Level_of_PTSD_for_children_and_parents = 0.1

UNITS: dmnl

DOCUMENT: This variable represents normal level of PTSD among Ukrainian population. As long as there was no available data, it was assumed that this number is the same for both children and parents. As far as model start time is 2021 year, it is presumed, that the percentage of PTSD was 10%, which is slightly higher than the average percentage of PTSD, because of the earlier occupation of the eastern part of Ukraine.

Normal_Responsive_Parenting = 0.5

UNITS: Responsive Parenting

DOCUMENT: This variable represents normal level of responsive parenting. It is assumed to be at the medium level, i.e., 0.5.

PTSD_AT = 1

UNITS: Years

DOCUMENT: This variable represents the amount of time by which the PTSD is formed. As far as PTSD is a serious disease, it takes a lot of time to be developed. Thus, it is assumed to be 1 year.

Resiliency_AD = 6/12

UNITS: Years

DOCUMENT: This variable shows the amount of time it takes for children and parents to develop resilience. It is assumed that it takes 6 months to build resilience, which is less than the time it takes to acquire PTSD.

Resiliency_Development = (Indicated_Level_of_Children's_Resilience - Children's_Resilience)/Resiliency_AD

UNITS: resiliency/Years

DOCUMENT: This biflow demonstrates the rate at which children's resilience is developed. This process depicts information delay with the goal of indicated level of children's resilience.

Responsive_Parenting = Normal_Responsive_Parenting*Total_Effect_on_responsive_parenting

UNITS: Responsive Parenting

DOCUMENT: This converter shows the level of responsive parenting, that is the parental awareness of their children's needs (both emotional and physical), including emotional warmth, support, and respect, while avoiding needless involvement. The parameter ranges from 0 to 1, where 0 indicates the total lack of parents' ability to be responsive parents, and 1 - maximum ability.

Responsive_Parenting_relative_to_normal = Responsive_Parenting/Normal_Responsive_Parenting

UNITS: dmnl

DOCUMENT: This variable shows the ratio of current level of responsive parenting relative to normal.

Total_effect_on_Children's_PTSD_development =
Weighted_effect_of_CBT_on_Children's_PTSD_development+Weighted_effect_of_TRAUMA_on
_children's_PTSD_development

UNITS: dmn1

DOCUMENT: This converter represents the total effect of Trauma and CBT effectiveness on children's PTSD development. It is formulated as an additive relation, due to the separability of the effects. "The impact of a change in any one input is the same no matter what values the other inputs have. Strong separability is clearly incorrect in extreme conditions" (Serman, 2000). Meaning that even if, for instance, the effect of CBT effectiveness = 0, the total effect of CBT and resilience will not be 0.

Total_effect_on_Children's_Resilience =
Weighted_Effect_of_Family_Relations_on_Children's_Resilience+Weighted_effect_of_Therapy_a
nd_Responsive_Parenting_on_Children's_Resilience

UNITS: dmn1

DOCUMENT: This converter represents the cumulative effect of responsive parenting, CBT effectiveness and family relations on children's resilience development. It is formulated as an additive relation, due to the separability of the effects.

Total_Effect_on_responsive_parenting =
Effect_of_Parents'_Mental_Health_on_Responsive_Parenting*Effect_of_Parenting_Stress_on_Res
ponsive_Parenting

UNITS: dmn1

DOCUMENT: This converter represents the total effect of parents' PTSD and parenting stress on responsive parenting. It is formulated as a multiplicative relation, due to the strong connection of the effects.

Unhealthy_Children = Children's_Level_of_PTSD*Amount_of_children_in_Ukraine

UNITS: person

DOCUMENT: The amount of children with PTSD in Ukraine.

War_Switch = 0

UNITS: dmn1

DOCUMENT: This variable represents the experimental switch for changing the state of the system from relatively peaceful times to full-scale war scenario (which is considered as a baseline).

WAR_TRAUMA = (RAMP(0.2, 2022, 2025))*War_Switch

UNITS: dmn1

DOCUMENT: This parameter represents the linear increase of war trauma over time, with a slope of 0.2 during 2022-2025 years (indicating the beginning and assumed end of the war in Ukraine). In other words it shows that people are daily suffering from russian aggression (experiencing rocket and shell fire, psychological pressure, and unprovoked tortures in the occupied territories), and it

without stopping increases the the chance of developing PTSD. War trauma is assumed to have influenced parents and children equally.

Weight_on_CBT_effectiveness_and_responsive_parenting_effects = 0.5

UNITS: dmn1

DOCUMENT: Therapy along with responsive parenting may not contribute identically to the development of the resilience. However, having lack evidence of their relative contributions, it is assumed to be an equal weight on both effects.

Weight_on_CBT_effectiveness_and_TRAUMA_effects = 0.5

UNITS: dmn1

DOCUMENT: Therapy and Trauma may not contribute identically to the development of PTSD. However, having lack evidence of their relative contributions, it is assumed to be an equal weight on both effects.

"Weight_on_CBT_effectiveness,_responsive_parenting_and_family_relations_effects" = 0.5

UNITS: dmn1

DOCUMENT: Therapy along with responsive parenting and violent family relations may not contribute identically to the development of the resilience. However, having lack evidence of their relative contributions, it is assumed to be an equal weight on both effects.

Weighted_effect_of_CBT_on_Children's_PTSD_development =
Effect_of_CBT_on_Children's_PTSD_development*(1-
Weight_on_CBT_effectiveness_and_TRAUMA_effects)

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of CBT effectiveness on children's PTSD development. Its weight is assumed to be 0.5 with equal weight between CBT effectiveness and Trauma.

Weighted_effect_of_CBT_on_Children's_Resilience =
Effect_of_CBT_on_Children's_Resilience*Weight_on_CBT_effectiveness_and_responsive_parenti
ng_effects

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of CBT effectiveness on children's resilience development. Its weight is assumed to be 0.5 with equal weight between CBT effectiveness and responsive parenting.

Weighted_Effect_of_Family_Relations_on_Children's_Resilience =
Effect_of_Family_Relations_on_Children's_Resilience*"Weight_on_CBT_effectiveness,_responsi
ve_parenting_and_family_relations_effects"

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of family relations on children's resilience development. Its weight is assumed to be 0.5 with equal weight between therapy, responsive parenting and family relations.

Weighted_effect_of_Responsive_Parenting_on_Children's_Resilience = (1-Weight_on_CBT_effectiveness_and_responsive_parenting_effects)*Effect_of_Responsive_Parenting_on_Children's_Resilience

UNITS: dmnl

DOCUMENT: This variable represents the weighted effect of responsive parenting on children's resilience development. Its weight is assumed to be 0.5 with equal weight between CBT effectiveness and responsive parenting.

Weighted_effect_of_Therapy_and_Responsive_Parenting_on_Children's_Resilience = (1-"Weight_on_CBT_effectiveness, responsive_parenting_and_family_relations_effects")*Effect_of_CBT_and_Responsive_Parenting_on_Children's_Resilience

UNITS: dmnl

DOCUMENT: This variable represents the weighted effect of therapy and responsive parenting on children's resilience development. Its weight is assumed to be 0.5 with equal weight between therapy, responsive parenting and family relations.

Weighted_effect_of_TRAUMA_on_children's_PTSD_development = Effect_of_TRAUMA_on_children's_PTSD_development*Weight_on_CBT_effectiveness_and_TRAUMA_effects

UNITS: dmnl

DOCUMENT: This variable represents the weighted effect of Trauma on children's PTSD development. Its weight is assumed to be 0.5 with equal weight between CBT effectiveness and Trauma.

Health Personnel Sector

Attrition_rate = Therapists/Average_employment_time

UNITS: Therapists/Years

DOCUMENT: This outflow indicates the rate of quitting or retiring of therapists. The unit is therapists per year.

Average_employment_time = 10

UNITS: Years

DOCUMENT: This variable represents the average employment time in Ukraine for the cognitive behavioral therapists. As far as we are considering the health personnel in the public healthcare institutions, thus their average employment time is higher and estimated to be 10 years.

Desired_Engaging_Rate =

((Gap_of_therapists*Fraction_of_desired_number_of_therapists_hired)/Engaging_Time)+Attrition_rate*(1-"policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2_status_(scenario_#1)")*(1-"policy_#1_status_(scenario_#1)")*(1-"policy_#1_status_(scenario_#2)")*(1-"policy_#1_status_(scenario_#3)")*(1-

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"policy_#1_+_2_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#3)") +
(((Gap_of_therapists*(0.2+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time)+Attrition_rate)*"policy_#1_+_2_+_3_status_(scenario_#4))* (1-
"policy_#1_+_2_status_(scenario_#1))* (1-"policy_#1_status_(scenario_#1))* (1-
"policy_#1_status_(scenario_#2))* (1-"policy_#1_status_(scenario_#3))* (1-
"policy_#1_+_2_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#3)") +
(((Gap_of_therapists*(0.05+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time+Attrition_rate)*"policy_#1_+_2_status_(scenario_#1))* (1-
"policy_#1_+_2_+_3_status_(scenario_#4))* (1-"policy_#1_status_(scenario_#1))* (1-
"policy_#1_status_(scenario_#2))* (1-"policy_#1_status_(scenario_#3))* (1-
"policy_#1_+_2_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#3)") +
(((Gap_of_therapists*(0.1+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time+Attrition_rate)*"policy_#1_+_2_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#1))* (1-
"policy_#1_+_2_+_3_status_(scenario_#4))* (1-"policy_#1_status_(scenario_#1))* (1-
"policy_#1_status_(scenario_#2))* (1-"policy_#1_status_(scenario_#3))* (1-
"policy_#1_+_2_status_(scenario_#3)") +
(((Gap_of_therapists*(0.2+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time+Attrition_rate)*"policy_#1_+_2_status_(scenario_#3))* (1-
"policy_#1_+_2_+_3_status_(scenario_#4))* (1-"policy_#1_status_(scenario_#1))* (1-
"policy_#1_status_(scenario_#2))* (1-"policy_#1_status_(scenario_#3))* (1-
"policy_#1_+_2_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#1)") +
(((Gap_of_therapists*(0.05+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time)+Attrition_rate)*"policy_#1_status_(scenario_#1))* (1-"policy_#1_+_2_status_(scenario_#1))* (1-
"policy_#1_+_2_+_3_status_(scenario_#4))* (1-"policy_#1_status_(scenario_#2))* (1-
"policy_#1_status_(scenario_#3))* (1-"policy_#1_+_2_status_(scenario_#2))* (1-
"policy_#1_+_2_status_(scenario_#3)") +
(((Gap_of_therapists*(0.1+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time)+Attrition_rate)*"policy_#1_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#1))* (1-
"policy_#1_+_2_+_3_status_(scenario_#4))* (1-"policy_#1_status_(scenario_#1))* (1-
"policy_#1_status_(scenario_#3))* (1-"policy_#1_+_2_status_(scenario_#2))* (1-
"policy_#1_+_2_status_(scenario_#3)") +
(((Gap_of_therapists*(0.2+Fraction_of_desired_number_of_therapists_hired))/Engaging_Time)+Attrition_rate)*"policy_#1_status_(scenario_#3))* (1-"policy_#1_+_2_status_(scenario_#1))* (1-
"policy_#1_+_2_+_3_status_(scenario_#4))* (1-"policy_#1_status_(scenario_#1))* (1-
"policy_#1_status_(scenario_#2))* (1-"policy_#1_+_2_status_(scenario_#2))* (1-
"policy_#1_+_2_status_(scenario_#3)")

```

UNITS: Therapists/Years

DOCUMENT: This parameter determines the desired rate of therapists, who needed to be engaged per year, based on the gap and fraction of therapists, which can be actually hired. This variable can vary depending on the policy SWITCH. If policy SWITCHES are turned off, then healthcare system does not have a shortage of therapists, thus engaging rate, along with fraction of therapists hired = 0. On the contrary, if one of policy SWITCHES is turned on, we are engaging 5, 10 or 20% out of desired number of therapists, depending on the policy scenario.

Desired_Number_of_therapists =
Actual_demand_for_CBT//Amount_of_people_treated_per_therapist_per_year

UNITS: Therapists

DOCUMENT: This converter shows the desired number of therapists, who need to be hired in order to meet people's demand for PTSD treatment

<p>$\text{Engaging_rate} = \text{Desired_Engaging_Rate}$</p> <p>UNITS: Therapists/Years</p> <p>DOCUMENT: This inflow indicates the rate of engaging new therapists. The unit is therapists per year.</p>
<p>$\text{Engaging_Time} = 3/12$</p> <p>UNITS: Years</p> <p>DOCUMENT: This parameter represents the time it takes to engage new therapists. It is assumed to be 3 months.</p>
<p>$\text{Fraction_of_desired_number_of_therapists_hired} = 0$</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the fraction of desired therapists hired. As far as it is assumed, that before war there were enough CB therapists to treat 10% of population with PTSD and the population is considered to be constant, there was no necessity to hire new therapists, thus this parameter initially equals 0.</p>
<p>$\text{Gap_of_therapists} = \text{Desired_Number_of_therapists} - \text{Therapists}$</p> <p>UNITS: Therapists</p> <p>DOCUMENT: This converter represents the gap of therapists, indicating a shortage of therapists in the healthcare system, depending on people's demand and actual number of therapists.</p>
<p>$\text{Therapists}(t) = \text{Therapists}(t - dt) + (\text{Engaging_rate} - \text{Attrition_rate}) * dt$ INIT Therapists = 1299</p> <p>UNITS: Therapists</p> <p>DOCUMENT: This stock represents the amount of Cognitive Behavioral Therapists (CBT) in Ukraine. According to National Health Service of Ukraine, number of all health personnel in Ukraine as of 2021 = 105 649. It is assumed, that the number of CB therapists is approximately 1.23% = 1289 and this number covered the demand for CBT before the war. https://edata.e-health.gov.ua/storage/files/book-ua.pdf?1683796029 (page 76)</p>

Parents' PTSD development Sector

<p>$\text{Amount_of_parents_in_Ukraine} = 29507625$</p> <p>UNITS: person</p> <p>DOCUMENT: This variable represents the amount of parents in Ukraine as of 2021. It is assumed, that amount of adults equal to the amount of parents, and this number is not changing over the time.</p>
--

According to the World Bank, total population in Ukraine in 2021 was 43 792 855. Among them 67.38% of adults (Statista. 2023), which is equal to 29 507 625.
<https://data.worldbank.org/indicator/SP.POP.TOTL?locations=UA>
<https://www.statista.com/statistics/296573/age-structure-in-ukraine/> [Accessed May 27, 2023].

CBT_allocation_coefficient = 0.5

UNITS: dmn1

DOCUMENT: This parameter determines the prioritization of therapy for parents and children. In other words which percentage of resources (in terms of available health personnel) we allocate for parents and for children. Initially, it is assumed, that there is no prioritization, thus the equal percentage of parents and children are treated, and the allocation coefficient equal to 0.5.

Chance_of_developing_Parents'_PTSD_after_experiencing_trauma =
 Normal_chance_of_developing_Parents'_PTSD_after_experiencing_trauma*Effect_of_Relative_C
 hange_in_Parents'_Resilience_on_chance_of_developing_PTSD

UNITS: dmn1

DOCUMENT: This variable represents the chance of developing parents' PTSD after experiencing trauma. It is increased due to the decreased effect in relative change in resilience.

Chance_of_developing_Parents'_PTSD_relative_to_normal =
 Chance_of_developing_Parents'_PTSD_after_experiencing_trauma/Normal_chance_of_developing
 _Parents'_PTSD_after_experiencing_trauma

UNITS: dmn1

DOCUMENT: This converter shows the chance of developing parents' PTSD compared to the normal.

Change_in_Social_Support = (Indicated_Level_of_Social_Support-
 Social_Support)/Time_to_Gain_Social_Support

UNITS: Social Support/Years

DOCUMENT: This biflow demonstrates the rate at which social support is formed. This process depicts information delay with the goal of indicated level of social support.

Child's_Emoional_Dysregulation =
 Normal_Child's_Emoional_Dysregulation*Effect_of_Children's'_Mental_Health_on_Child's_Emot
 ional_Dysregulation

UNITS: Emotional Dysregulation

DOCUMENT: This converter shows the level of child's emotional dysregulation, that is child's difficulties recognizing emotions, reacting with sufficient emotions in social circumstances, and controlling emotional reactions.

Child's_Emoional_Dysregulation_Relative_to_Normal =
 Child's_Emoional_Dysregulation/Normal_Child's_Emoional_Dysregulation

UNITS: dmn1

DOCUMENT: This variable shows the ratio of current level of child's emotional dysregulation relative to normal.

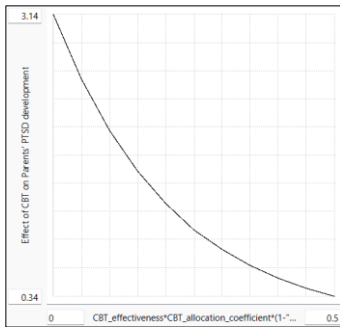
$$\text{Current_Parents_Resilience_effect_relative_to_normal} = \frac{\text{Parents_Resilience}}{\text{Parents_Normal_Resilience}}$$

UNITS: dmn1

DOCUMENT: This variable shows the ratio of current parents' resilience relative to normal.

$$\begin{aligned} \text{Effect_of_CBT_on_Parents_PTSD_development} = & \\ & \text{GRAPH}(\text{CBT_effectiveness} * \text{CBT_allocation_coefficient} * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + \\ & \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} + 0.15) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"} \\ & * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + \\ & \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} - \\ & 0.1) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"} * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + \\ & \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} + 0.1) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"} \\ & * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"}) + \\ & \text{CBT_effectiveness} * (\text{CBT_allocation_coefficient} + 0.15) * \text{"policy_#1_+_2_+_3_status_(\text{scenario_#3})"} \\ & * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#1})"}) * (1 - \\ & \text{"policy_#1_+_2_+_3_status_(\text{scenario_#2})"}) * (1 - \text{"policy_#1_+_2_+_3_status_(\text{scenario_#4})"})) \end{aligned}$$

Points: (0.0000, 3.140), (0.0500, 2.497), (0.1000, 1.987), (0.1500, 1.583), (0.2000, 1.262), (0.2500, 1.000), (0.3000, 0.8067), (0.3500, 0.6469), (0.4000, 0.5202), (0.4500, 0.4197), (0.5000, 0.340)



UNITS: dmn1

DOCUMENT: This converter represents the effect of CBT effectiveness on parents' PTSD development. In other words, this graphical function shows how PTSD will be developing, depending on the quality of CBT.

So, the fundamental assumption here is that when CBT effectiveness is on its maximum (i.e., = 0.5), then the effect is 1, meaning that PTSD develops in its normal pace. However, if CBT effectiveness began to decrease below 0.5 (effect of therapy is lower than anticipated) effect on PTSD could increase increasingly before it could reach the point of 3.14.

It is assumed that the maximum level til which CBT can decrease level of PTSD among parents = 4% at maximum effectiveness along with maximum resilience and minimum parenting stress.

The upper bound is placed here to prevent the PTSD stock from behaving irrationally (to ensure that PTSD cannot rise above 20% in term of peaceful times).

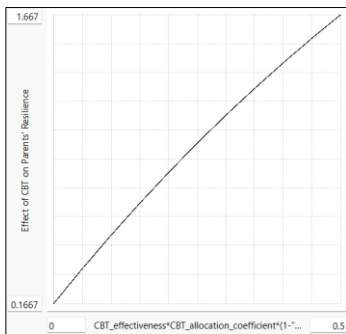
This variable can vary depending on the policy SWITCH.

If policy SWITCHES are turned off, we allocate for parents and children equal amount of therapy resources, thus CBT allocation coefficient = 0.5. On the contrary, if one of policy SWITCHES is turned on, we are allocating 60 and 65% out of total resources for children or for parents (indicating that children or parents will be a priority), depending on the policy scenario.

Effect_of_CBT_on_Parents'_Resilience =

```
GRAPH(CBT_effectiveness*CBT_allocation_coefficient*(1-
"policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#1)")*(1-
"policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
CBT_effectiveness*(CBT_allocation_coefficient+0.15)*"policy_#1+_2+_3_status_(scenario_#4)
"*(1-"policy_#1+_2+_3_status_(scenario_#1)")*(1-
"policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
CBT_effectiveness*(CBT_allocation_coefficient-
0.1)*"policy_#1+_2+_3_status_(scenario_#1)"*(1-
"policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#2)")*(1-
"policy_#1+_2+_3_status_(scenario_#3)") +
CBT_effectiveness*(CBT_allocation_coefficient+0.1)*"policy_#1+_2+_3_status_(scenario_#2)"
*(1-"policy_#1+_2+_3_status_(scenario_#1)")*(1-
"policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
CBT_effectiveness*(CBT_allocation_coefficient+0.15)*"policy_#1+_2+_3_status_(scenario_#3)
"*(1-"policy_#1+_2+_3_status_(scenario_#1)")*(1-
"policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#4)")
```

Points: (0.0000, 0.1667), (0.0500, 0.3481), (0.1000, 0.5217), (0.1500, 0.6879), (0.2000, 0.8469), (0.2500, 1.000), (0.3000, 1.145), (0.3500, 1.284), (0.4000, 1.417), (0.4500, 1.545), (0.5000, 1.667)



UNITS: dmdl

DOCUMENT: This converter represents the effect of CBT effectiveness on parents' resilience. In other words, this graphical function shows how resilience will be developing, depending on the quality of CBT.

So, the fundamental assumption here is that when CBT effectiveness is on its maximum (i.e., = 0.5), then the effect is 1, meaning that resilience develops in its normal pace. However, if CBT effectiveness began to decrease below 0.5 (effect of therapy is lower than anticipated) effect on resilience could be decreasing before it could reach the point of 0.1667.

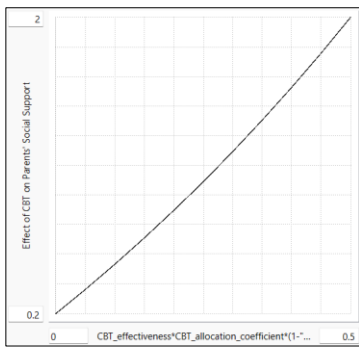
The lower bound is placed here to prevent the resilience stock from behaving irrationally (to ensure that resilience cannot fall below 0.1).

This variable can vary depending on the policy SWITCH.

If policy SWITCHES are turned off, we allocate for parents and children equal amount of therapy resources, thus CBT allocation coefficient = 0.5. On the contrary, if one of policy SWITCHES is turned on, we are allocating 60 and 65% out of total resources for children or for parents (indicating that children or parents will be a priority), depending on the policy scenario.

Effect_of_CBT_on_Parents'_Social_Support =
 GRAPH(CBT_effectiveness*CBT_allocation_coefficient*(1-
 "policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#1)")*(1-
 "policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient+0.20)*"policy_#1+_2+_3_status_(scenario_#4)"
 (1-"policy_#1+_2+_3_status_(scenario_#1)")(1-
 "policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient-
 0.1)*"policy_#1+_2+_3_status_(scenario_#1)"*(1-
 "policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#2)")*(1-
 "policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient+0.1)*"policy_#1+_2+_3_status_(scenario_#2)"
 (1-"policy_#1+_2+_3_status_(scenario_#1)")(1-
 "policy_#1+_2+_3_status_(scenario_#4)")*(1-"policy_#1+_2+_3_status_(scenario_#3)") +
 CBT_effectiveness*(CBT_allocation_coefficient+0.15)*"policy_#1+_2+_3_status_(scenario_#3)"
 (1-"policy_#1+_2+_3_status_(scenario_#1)")(1-
 "policy_#1+_2+_3_status_(scenario_#2)")*(1-"policy_#1+_2+_3_status_(scenario_#4)"))

Points: (0.0000, 0.200), (0.0500, 0.3465), (0.1000, 0.4996), (0.1500, 0.6595), (0.2000, 0.8267),
 (0.2500, 1.000), (0.3000, 1.184), (0.3500, 1.375), (0.4000, 1.574), (0.4500, 1.782), (0.5000, 2.000)



UNITS: dmdl

DOCUMENT: This converter represents the effect of CBT effectiveness on social support. In other words, this graphical function shows how social support will be developing, depending on the quality of CBT.

So, the fundamental assumption here is that when CBT effectiveness is on its maximum (i.e., = 0.5), then the effect is 1, meaning that social support develops in its normal pace. However, if CBT effectiveness began to decrease below 0.5 (effect of therapy is lower than anticipated) effect on social support could be decreasing before it could reach the point of 0.2.

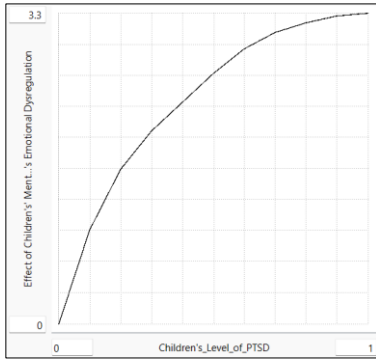
The lower bound is placed here to prevent the social support stock from behaving irrationally (to ensure that social support cannot fall below 0.1).

This variable can vary depending on the policy SWITCH.

If policy SWITCHES are turned off, we allocate for parents and children equal amount of therapy resources, thus CBT allocation coefficient = 0.5. On the contrary, if one of policy SWITCHES is turned on, we are allocating 60 and 65% out of total resources for children or for parents (indicating that children or parents will be a priority), depending on the policy scenario.

Effect_of_Children's'_Mental_Health_on_Child's_Emotional_Dysregulation =
 GRAPH(Children's_Level_of_PTSD)

Points: (0.000, 0.000), (0.100, 1.000), (0.200, 1.643), (0.300, 2.050), (0.400, 2.355), (0.500, 2.660),
 (0.600, 2.922), (0.700, 3.096), (0.800, 3.198), (0.900, 3.271), (1.000, 3.300)



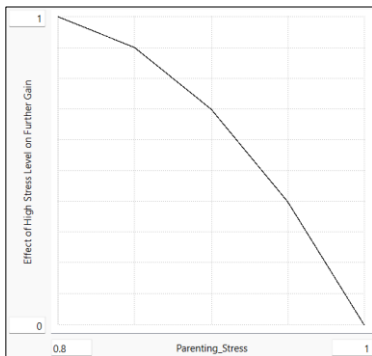
UNITS: dmn1

DOCUMENT: This variable represents the effect of children's mental health on child's emotional dysregulations.

If there were no children suffering from PTSD, children are assumed to have no emotional dysregulations. However, with the increasing of PTSD level, children become unable to control their emotions and anger, thus emotional dysregulations become more common and increase decreasingly. If the PTSD reaches its normal level, then the effect on emotional dysregulations will be at the target value (which is ensured by (0.1,1) point on the graph). Finally, if level of PTSD was 100%, the level of child's emotional dysregulations could potentially exceed more than three times the normal value.

Effect_of_High_Stress_Level_on_Further_Gain = GRAPH(Parenting_Stress)

Points: (0.8000, 1.000), (0.8500, 0.900), (0.9000, 0.700), (0.9500, 0.400), (1.0000, 0.000)



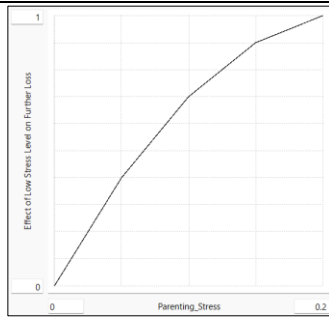
UNITS: dmn1

DOCUMENT: This variable shows the effect of high stress level on further gain. When level of parenting stress exceeds 0.8 (the point of high stress), the effect operates to suppress a bit the stress gain, considering that the maximum level is assumed to be 100%. The effect is strengthened and decrease increasingly when parenting stress approaches 1.

This formulation is adapted from Homer's (1985) burnout model.

Effect_of_Low_Stress_Level_on_Further_Loss = GRAPH(Parenting_Stress)

Points: (0.0000, 0.000), (0.0500, 0.400), (0.1000, 0.700), (0.1500, 0.900), (0.2000, 1.000)



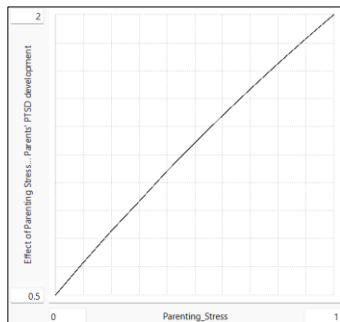
UNITS: dmdl

DOCUMENT: This variable shows the effect of low stress level on further loss. If parenting stress falls below the point of low stress (i.e. 0.2), the effect operates to suppress a bit the stress loss, in order to prevent the stock falling below 0. This effect becomes stronger and decreases increasingly as parenting stress declines towards zero.

Adapted from Homer's (1985) burnout model.

Effect_of_Parenting_Stress_on_Parents'_PTSD_development = GRAPH(Parenting_Stress)

Points: (0.000, 0.500), (0.100, 0.674), (0.200, 0.8421), (0.300, 1.000), (0.400, 1.162), (0.500, 1.314), (0.600, 1.460), (0.700, 1.602), (0.800, 1.739), (0.900, 1.872), (1.000, 2.000)



UNITS: dmdl

DOCUMENT: This variable represents the effect of parenting stress on parents' PTSD development.

The fundamental assumption here is that when parenting stress is on its normal level, then the effect equals 1, meaning that PTSD develops in its normal pace.

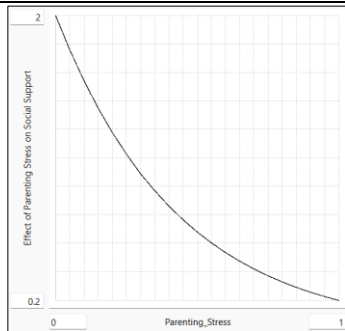
However, if parenting stress begins to grow up, parents have a higher possibility to develop PTSD, hence the effect increase prior it reaches the point of 2.

On the contrary, if parenting stress declines from the normal value, the chance of developing PTSD becomes lower, thus the effect decrease before it hits the point of 0.5.

Upper and lower bounds are placed here to prevent the PTSD stock from behaving irrationally.

Effect_of_Parenting_Stress_on_Social_Support = GRAPH(Parenting_Stress)

Points: (0.000, 2.000), (0.050, 1.783), (0.100, 1.589), (0.150, 1.416), (0.200, 1.262), (0.250, 1.125), (0.300, 1.000), (0.350, 0.8939), (0.400, 0.7967), (0.450, 0.7101), (0.500, 0.6329), (0.550, 0.5641), (0.600, 0.5027), (0.650, 0.4481), (0.700, 0.3993), (0.750, 0.3559), (0.800, 0.3172), (0.850, 0.2826), (0.900, 0.2519), (0.950, 0.2244), (1.000, 0.200)

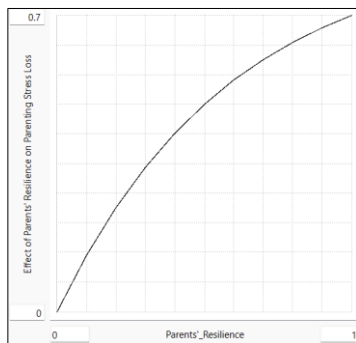


UNITS: dmn1

DOCUMENT: This variable represents the effect of parenting stress on social support. The fundamental assumption here is that when parenting stress is on its normal level, then the effect equals 1, meaning that social support remains on its normal level. However, if parenting stress begin to grow up, parents become more reluctant to receiving the desired support and help from spouse, relatives, friends or coworkers (Park et al., 2022), hence the effect decrease decreasingly prior it drops to the point of 0.2. On contrary, if parenting stress declines from the normal value, parents are more eager to receive external help and support, thus the effect is increase increasingly before it hits the point of 2. Upper and lower bounds are placed here to prevent the social support stock from behaving irrationally.

Effect_of_Parents'_Resilience_on_Parenting_Stress_Loss = GRAPH(Parents'_Resilience)

Points: (0.000, 0.0000), (0.100, 0.1335), (0.200, 0.2462), (0.300, 0.3414), (0.400, 0.4218), (0.500, 0.4897), (0.600, 0.547722557505), (0.700, 0.5954), (0.800, 0.6363), (0.900, 0.6708), (1.000, 0.7000)

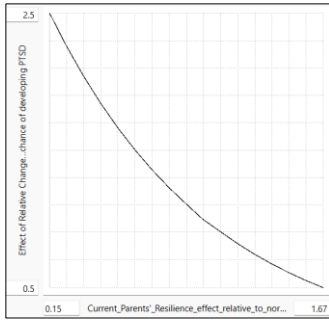


UNITS: dmn1

DOCUMENT: This variable represents the amount of parenting stress loss, which can be perceived from their own resilience. The key assumption here is that parenting stress cannot be reduced in the absence of resilience. However, with the grow of resilience, parenting stress loss begins to increase decreasingly towards the assumed maximum of 0.7.

Effect_of_Relative_Change_in_Parents'_Resilience_on_chance_of_developing_PTSD = GRAPH(Current_Parents'_Resilience_effect_relative_to_normal)

Points: (0.150, 2.500), (0.245, 2.257), (0.340, 2.039), (0.435, 1.841), (0.530, 1.663), (0.625, 1.503), (0.720, 1.358), (0.815, 1.227), (0.910, 1.109), (1.000, 1.000), (1.100, 0.9072), (1.195, 0.8207), (1.290, 0.7427), (1.385, 0.6724), (1.480, 0.6089), (1.575, 0.5516), (1.670, 0.500)



UNITS: dmn1

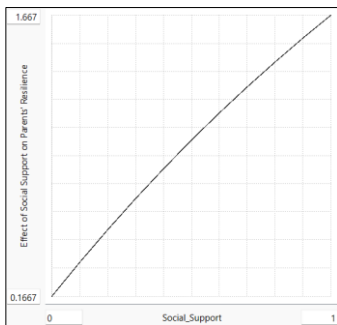
DOCUMENT: This variable represents the effect of relative change in resilience on chance of developing PTSD.

It as assumed to be same as for children.

When current parents' resilience relative to normal is on its minimum value slightly higher than 0.15 (considering that minimum possible level of resilience is 0.1 and normal of 0.6), then the chance of developing PTSD for parents is twice and a half enhanced normal. When resilience begins to grow, person becomes more persistent to external stimuli, thus the chance of getting PTSD decrease decreasingly. If the resilience reaches its normal levels, then the effect on chance of developing PTSD will be at the target value (which is ensured by (1,1) point on the graph). Finally, when resilience attains its maximum, the possibility of having PTSD for parents would be half smaller than the normal (i.e. only 5%).

Effect_of_Social_Support_on_Parents'_Resilience = GRAPH(Social_Support)

Points: (0.000, 0.1667), (0.100, 0.3481), (0.200, 0.5217), (0.300, 0.6879), (0.400, 0.8469), (0.500, 1.000), (0.600, 1.145), (0.700, 1.284), (0.800, 1.417), (0.900, 1.545), (1.000, 1.667)



UNITS: dmn1

DOCUMENT: This variable represents the effect of social support on parents' resilience.

The fundamental assumption here is that when social support is on its normal level, then the effect equals 1, meaning that resilience develops in its normal pace.

However, if social support was higher than the normal value, it could improve parents' resilience to withstand stressors, hence the effect increases prior it hits the point of 1.667.

On contrary, if social support declined from the normal value, parents' resilience could be undermined, thus the effect is decrease before it drops to the point of 0.1667.

Upper and lower bounds are placed here to prevent the resilience stock from behaving irrationally.

Effect_of_TRAUMA_on_Parents'_PTSD_development =
WAR_TRAUMA+Chance_of_developing_Parents'_PTSD_relative_to_normal

UNITS: dmnl

DOCUMENT: This variable represents the effect of trauma on parents' PTSD development. It is defined by the current chance of developing parents' PTSD relative to normal (previously based on the resiliency level) and trauma, occurred because the war.

Indicated_level_of_Parents'_PTSD =
Normal_Level_of_PTSD_for_children_and_parents*Total_effect_on_Parents'_PTSD_development

UNITS: dmnl

DOCUMENT: This variable represents the indicated level of Children's PTSD, which changes the actual level of PTSD by multiplying normal level of PTSD by the total effect on parent's PTSD development.

Indicated_Level_of_Parents'_Resilience =
Total_effect_on_Parents'_Resilience*Parents'_Normal_Resilience

UNITS: resiliency

DOCUMENT: This variable represents the indicated level of parents' resiliency before information delay adjustment. The indicated value is determined by the total effect on parents' resiliency and normal level of resiliency.

Indicated_Level_of_Social_Support =
Normal_Level_of_Social_Support*Total_Effect_on_Parents'_Social_Support

UNITS: Social Support

DOCUMENT: This variable represents the indicated level of social support before information delay adjustment. The indicated value is determined by the total effect on social support and normal level of social support.

Normal_chance_of_developing_Parents'_PTSD_after_experiencing_trauma = 0.1

UNITS: dmnl

DOCUMENT: This variable represents a risk of developing parents' PTSD after experiencing trauma. This number can vary depending on several factors such as the type and severity of trauma, support system, and any pre-existing mental health conditions. According to the US department of veterans affairs, 8% of women and 4% of men have a possibility to develop PTSD at some point in their life (which is 6% in average). But during a war or pandemic this chance might be even higher. Thus, due to the fact that the model represents people who live in War zone and their mental health condition are worse compared with the people who live in a peaceful places. Thus, it can be assumed that this risk is higher than the average number and equal to 10%. In addition, for simplicity, it is assumed, that this percentage is equal for both children and parents. https://www.ptsd.va.gov/understand/common/common_adults.asp [Accessed May 28, 2023].

Normal_Child's_Emotional_Dysregulation = 0.3

UNITS: Emotional Dysregulation

DOCUMENT: This variable represents normal level of child's emotional dysregulation. It is assumed to be 0.3.

Normal_Level_of_Social_Support = 0.5

UNITS: Social Support

DOCUMENT: This variable represents normal level of social support. It is assumed to be at the medium level, i.e. 0.5.

Normal_Parenting_Stress = 0.3

UNITS: dmn1

DOCUMENT: This variable represents normal level of parenting stress. It is assumed to be almost twice less than medium value, i.e. 0.3.

Parenting_Stress(t) = Parenting_Stress(t - dt) + (Parenting_Stress_Gain - Parenting_Stress_Loss) * dt

INIT Parenting_Stress = Normal_Parenting_Stress

UNITS: dmn1

DOCUMENT: This stock represents the level of parenting stress. In other words it is a type of stress, which parents experience, when they are unable to cope as a parent, especially, when they have children with mental health problems. The stock ranges from 0 to 1, where 0 indicates the total absence of parenting stress, and 1 - maximum stress. However, in order to avert unreasonable behavior in extreme conditions, with the help of limits in graphical functions it was assumed that parenting stress cannot drop under 10%, justifying that even in case of absolute absence of child's emotional dysregulation, it is impossible to exclude completely parenting stress. The initial value of the stock is set at its normal level.

Parenting_Stress_Gain =

((Parenting_Stress_Gain_Adjustment_from_Child's_Emotional_Dysregulation)/Time_to_Adjust_Parenting_Stress)* Effect_of_High_Stress_Level_on_Further_Gain

UNITS: Per Year

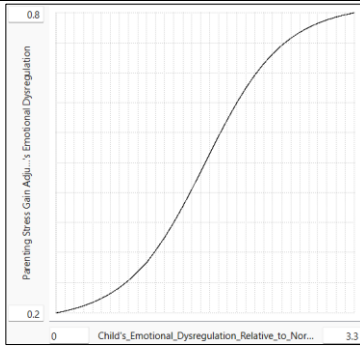
DOCUMENT: This inflow depicts the rate at which parenting stress rises. It represents the parenting stress gain adjustment from child's emotional dysregulation over the time to adjust stress, multiplied by the limit to keep the stock from rising above 100%.

This formulation is adapted from Homer's (1985) burnout model.

Parenting_Stress_Gain_Adjustment_from_Child's_Emotional_Dysregulation =

GRAPH(Child's_Emotional_Dysregulation_Relative_to_Normal)

Points: (0.000, 0.2000), (0.100, 0.2038), (0.200, 0.2084), (0.300, 0.2140), (0.400, 0.2207), (0.500, 0.2288), (0.600, 0.2387), (0.700, 0.2506), (0.800, 0.2648), (0.900, 0.2817), (1.000, 0.3000), (1.100, 0.3245), (1.200, 0.3507), (1.300, 0.3800), (1.400, 0.4121), (1.500, 0.4463), (1.600, 0.4819), (1.700, 0.5181), (1.800, 0.5537), (1.900, 0.5879), (2.000, 0.6200), (2.100, 0.6493), (2.200, 0.6755), (2.300, 0.6985), (2.400, 0.7183), (2.500, 0.7352), (2.600, 0.7494), (2.700, 0.7613), (2.800, 0.7712), (2.900, 0.7793), (3.000, 0.7860), (3.100, 0.7916), (3.200, 0.7962), (3.300, 0.8000)



UNITS: dmn1

DOCUMENT: This variable indicates the amount of parenting stress gained depending on the level of a child's emotional dysregulation.

The fundamental assumption here is that when child's emotional dysregulation is on its normal level, then the effect equals 1, meaning that parenting stress remains on its normal level.

Nonetheless, as level of child's emotional dysregulation decreases from the normal value towards zero, the influence on parenting stress becomes less and less efficient, and decrease decreasingly prior to the effect drops to the point of 0.2.

On the contrary, if child's emotional dysregulation increases three times the normal value, parenting stress gain from child's emotional dysregulation increases rapidly and then slows down to a maximum of 0.8 (assuming that the maximum gain in parenting stress from child's emotional dysregulation is 80%).

Parenting_Stress_Loss =

$((\text{Effect_of_Parents_Resilience_on_Parenting_Stress_Loss} * \text{Parenting_Stress_Loss_Adjustment_from_Social_Support}) / \text{Time_to_Adjust_Parenting_Stress}) * \text{Effect_of_Low_Stress_Level_on_Further_Loss}$

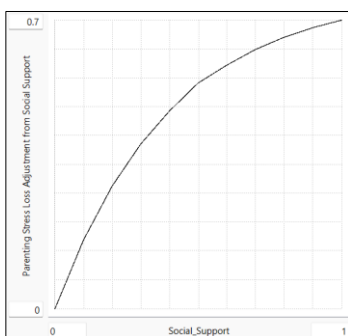
UNITS: Per Year

DOCUMENT: This outflow depicts the rate at which parenting stress decreases. It represents the parenting stress loss adjustment from parents' resilience and social support over the time to adjust stress, multiplied by the limit to keep the stock from going below zero.

Adapted from Homer's (1985) burnout model.

Parenting_Stress_Loss_Adjustment_from_Social_Support = GRAPH(Social_Support)

Points: (0.000, 0.0000), (0.100, 0.1674), (0.200, 0.2981), (0.300, 0.4002), (0.400, 0.4800), (0.500, 0.547722557505), (0.600, 0.5910), (0.700, 0.6290), (0.800, 0.6587), (0.900, 0.6819), (1.000, 0.7000)



UNITS: dmn1

DOCUMENT: This variable represents the amount of parenting stress loss, which can be perceived from social support.

The key assumption here is that parenting stress cannot be reduced in the absence of social support. However, with the grow of social support, parenting stress loss begins to increase decreasingly towards the assumed maximum of 0.7.

Parents'_Level_of_PTSD(t) = Parents'_Level_of_PTSD(t - dt) + (Parents'_PTSD_development) * dt
{NON-NEGATIVE}

INIT Parents'_Level_of_PTSD = Normal_Level_of_PTSD_for_children_and_parents

UNITS: dmn1

DOCUMENT: This key variable represents the percentage of PTSD among parents in Ukraine. The stock varies between 0 (no parents have PTSD) and 1 (all parents suffer from PTSD). Nevertheless, in order to avert unreasonable behavior in extreme conditions, with the help of limits in graphical functions it was assumed that in term of peaceful times:

1. even in case of minimum possible resilience, minimum possible CBT effectiveness and maximum parenting stress, PTSD cannot rise above 20%;
2. even when resilience and CBT effectiveness are on their maximum, and parenting stress on the minimum, PTSD cannot drop under 4%, because there is always be some percentage of PTSD among population.

The initial value of the stock is set at its normal level.

Parents'_Normal_Resilience = 0.6

UNITS: resiliency

DOCUMENT: This variable represents normal level of parents' resiliency. It is assumed to be slightly higher than medium value, i.e. 0.6, the same as for children.

Parents'_PTSD_development = (Indicated_level_of_Parents'_PTSD - Parents'_Level_of_PTSD)/PTSD_AT

UNITS: Per Year

DOCUMENT: This inflow indicates the rate of change in the parents' PTSD level. It operates as a first order adjustment, where parents' level of PTSD adjusts to its indicated level with an adjustment time of 1 year.

Parents'_Resilience(t) = Parents'_Resilience(t - dt) + (Parents'_Resiliency_Development) * dt
INIT Parents'_Resilience = Parents'_Normal_Resilience

UNITS: resiliency

DOCUMENT: This stock represents the level of parents' resiliency. In other words it is parents' ability to withstand stressors and successful adapt to tough or difficult life situations. The stock ranges from 0 to 1, where 0 indicates the total absence of resilience, and 1 - maximum resilience. However, as far as the model does not include extended formation of parents' resilience (meaning that parents' interactions with spouse, at work, during community events (e.g. marathon, fundraising, charity events), and/or another extraneous relations beyond family are not accounted), it is assumed, that parents' resilience cannot:

1. rise above 0.75, even if therapy effectiveness and social support can be 100%;
2. fall below 0.1; even if there is no therapy and support;

The initial value of the stock is set at its normal level.

Parents'_Resiliency_Development = (Indicated_Level_of_Parents'_Resilience - Parents'_Resilience)/Resiliency_AD

UNITS: resiliency/Years

DOCUMENT: This biflow demonstrates the rate at which parents' resilience is developed. This process depicts information delay with the goal of indicated level of parents' resilience.

Social_Support(t) = Social_Support(t - dt) + (Change_in_Social_Support) * dt
INIT Social_Support = Normal_Level_of_Social_Support

UNITS: Social Support

DOCUMENT: This stock represents the level of social support, that is "the provision of assistance or comfort to others, typically to help them cope with biological, psychological, and social stressors" (APA dictionary of psychology, 2023). The stock ranges from 0 to 1, where 0 indicates the total absence of social support, and 1 - maximum level of social support. However, as far as the model does not include extended formation of social support (meaning that it is not accounted parent interactions with spouse, at work, during community events (e.g. marathon, fundraising, charity events), and/or another extraneous relations beyond family), it is assumed, that social support cannot be:

1. higher than 0.75, even if therapy effectiveness can be 100% and parenting stress is on its minimum;
2. lower than 0.1, even if there is no therapy available, but parenting stress is at maximum.

The initial value of the stock is set at its normal level.

Time_to_Adjust_Parenting_Stress = 3/12

UNITS: year

DOCUMENT: This variable shows the amount of time it takes to adjust parenting stress. It is assumed that it takes 3 months to develop parenting stress, which is less than the time it takes to acquire PTSD and build resilience.

Time_to_Gain_Social_Support = 6/12

UNITS: Years

DOCUMENT: This variable indicates how long it takes to build social support. It is expected that it will take 6 months, which is the same amount of time as it takes to build resilience.

Total_effect_on_Parents'_PTSD_development =
Weighted_effect_of_Parenting_Stress_on_Parents'_PTSD_development+Weighted_effect_of_TRAUMA_on_Parents'_PTSD_development+Weighted_effect_of_CBT_on_Parents'_PTSD_development

UNITS: dmnl

DOCUMENT: This converter represents the total effect of Trauma, parenting stress and CBT effectiveness on parents' PTSD development. It is formulated as an additive relation, due to the separability of the effects. Meaning that even if, for instance, the effect of CBT effectiveness = 0, the total effect of CBT, parenting stress and resilience will not be 0.

Total_effect_on_Parents'_Resilience =
Weighted_effect_of_CBT_on_Parents'_Resilience+Weighted_effect_of_Social_Support_on_Parents'_Resilience

UNITS: dmn1

DOCUMENT: This converter represents the cumulative effect of social support and CBT effectiveness on parent's resiliency formation. It is formulated as an additive relation, due to the separability of the effects. Meaning that even if, for instance, there is no access to treatment, there will be still an individual effect on resilience from social support, thus the total effect on resilience formation will not be 0.

Total_Effect_on_Parents'_Social_Support =
Weighted_effect_of_Parenting_Stress_on_Social_Support+Weighted_effect_of_Therapy_on_Parents'_Social_Support

UNITS: dmn1

DOCUMENT: This converter represents the cumulative effect of parenting stress and CBT effectiveness on the formation of social support. It is formulated as an additive relation, due to the separability of the effects. Meaning that even if, for instance, there is no access to treatment, there will be still an individual effect on social support from parenting stress, thus the total effect on social support formation will not be 0.

Unhealthy_Parents = Amount_of_parents_in_Ukraine*Parents'_Level_of_PTSD

UNITS: person

DOCUMENT: The amount of parents with PTSD in Ukraine.

Weight_on_Parenting_stress_and_CBT_effectiveness_effects = 0.5

UNITS: dmn1

DOCUMENT: Therapy along with parenting stress may not contribute identically to the development of social support. However, having lack evidence of their relative contributions, it is assumed to be an equal weight on both effects.

"Weight_on_Parenting_Stress,_CBT_effectiveness_and_TRAUMA_effects" = 0.25

UNITS: dmn1

DOCUMENT: This parameter shows the weight of parenting stress and trauma. Both of them are assumed to be 0.25, implying that parenting stress and trauma are given two times less weight than therapy effectiveness for the development of parents' PTSD.

Weight_on_Social_Support_and_CBT_effectiveness_effects = 0.7

UNITS: dmn1

DOCUMENT: This parameter shows the weight of CBT effectiveness. It is assumed to be 0.7, implying that social support is given nearly one and a half times less weight than therapy effectiveness for the development of parents' resilience.

Weighted_effect_of_CBT_on_Parents'_PTSD_development =
 Effect_of_CBT_on_Parents'_PTSD_development*(1-
 2*"Weight_on_Parenting_Stress,_CBT_effectiveness_and_TRAUMA_effects")
 UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of CBT effectiveness on parents' PTSD development. It is considered that its weight is 0.5, while parenting stress and trauma are given twice as much but have identical weights.

Weighted_effect_of_CBT_on_Parents'_Resilience =
 Effect_of_CBT_on_Parents'_Resilience*Weight_on_Social_Support_and_CBT_effectiveness_eff
 ects

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of CBT effectiveness on the formation of parent's resilience. It is considered that its weight is 0.7, with lower weight given to social support.

Weighted_effect_of_Parenting_Stress_on_Parents'_PTSD_development =
 "Weight_on_Parenting_Stress,_CBT_effectiveness_and_TRAUMA_effects"*Effect_of_Parenting_
 Stress_on_Parents'_PTSD_development

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of parenting stress on parents' PTSD development. It is considered that its weight is 0.25, with the same weight given to Trauma and higher weight given to CBT effectiveness.

Weighted_effect_of_Parenting_Stress_on_Social_Support =
 Effect_of_Parenting_Stress_on_Social_Support*Weight_on_Parenting_stress_and_CBT_effectiven
 ess_effects

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of parenting stress on the formation of social support. It is considered that its weight is 0.5, with equal weight given to CBT effectiveness and parenting stress.

Weighted_effect_of_Social_Support_on_Parents'_Resilience = (1-
 Weight_on_Social_Support_and_CBT_effectiveness_effects)*Effect_of_Social_Support_on_Paren
 ts'_Resilience

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of social support on the formation of parent's resilience. It is considered that its weight is 0.3, with higher weight given to CBT effectiveness.

Weighted_effect_of_Therapy_on_Parents'_Social_Support = (1-
 Weight_on_Parenting_stress_and_CBT_effectiveness_effects)*Effect_of_CBT_on_Parents'_Social_
 _Support

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of CBT effectiveness on the formation of social support. It is considered that its weight is 0.5, with equal weight given to CBT effectiveness and parenting stress.

Weighted_effect_of_TRAUMA_on_Parents'_PTSD_development =
Effect_of_TRAUMA_on_Parents'_PTSD_development*"Weight_on_Parenting_Stress,_CBT_effectiveness_and_TRAUMA_effects"

UNITS: dmn1

DOCUMENT: This variable represents the weighted effect of Trauma on parents' PTSD development. It is considered that its weight is 0.25, with the same weight given to parenting stress and higher weight given to CBT effectiveness.

Policy and Scenarios

"Expanding_people's_awareness_in_1.5_times_POLICY_SWITCH" = 0

UNITS: dmn1

DOCUMENT: This variable represents the experimental switch which initiates a mechanism that aids in increasing people's awareness in 1.5 times, implying that individuals become more educated and begin to recognize the significance of CBT. Thus the ratio of people seeing CBT per year rises from 0.25 to 0.375.

Initially, the current mechanism is turned off (the parameter has a value of 0). In order to activate the mechanism, the value should be switched to 1.

"Increasing_healthcare_system_capacity_by_10%_along_with_expanding_people's_awareness_in_1.5_times_POLICY_SWITCH" = 0

UNITS: dmn1

DOCUMENT: This variable represents the experimental switch for increasing healthcare system capacity by 10%, along with expanding people's awareness by 1.5 times.

"Increasing_healthcare_system_capacity_by_20%_along_with_expanding_people's_awareness_in_1.5_times_POLICY_SWITCH" = 0

UNITS: dmn1

DOCUMENT: This variable represents the experimental switch for increasing healthcare system capacity by 20%, along with expanding people's awareness by 1.5 times.

"Increasing_healthcare_system_capacity_by_5%_along_with_expanding_people's_awareness_in_1.5_times_POLICY_SWITCH" = 0

UNITS: dmn1

DOCUMENT: This variable represents the experimental switch for increasing healthcare system capacity by 5%, along with expanding people's awareness by 1.5 times

<p>Allocation_60%_of_resources_to_children_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the experimental switch for allocation 60% of resources to children, indicating that children will be a priority.</p>
<p>Allocation_60%_of_resources_to_parents_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the experimental switch for allocation 60% of resources to parents, indicating that parents will be a priority.</p>
<p>Allocation_65%_of_resources_to_parents_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable is the experimental switch for allocating 65% of resources to parents, suggesting that parents will be prioritized.</p>
<p>Combination_of_3_policies_POLICY_SWITCH = 0</p> <p>UNITS: Dimensionless</p> <p>DOCUMENT: This variable represents the experimental switch for three existing policies, thus for increasing healthcare system capacity by 20%, along with expanding people's awareness by 1.5 times and allocation of 65% resources to parents.</p>
<p>Expanding_people's_awareness_in_2_times_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the experimental switch which initiates a mechanism that aids in increasing people's awareness in 2 times, implying that individuals become more educated and begin to recognize the significance of CBT. Thus the ratio of people seeing CBT per year rises from 0.25 to 0.5. Initially, the current mechanism is turned off (the parameter has a value of 0). In order to activate the mechanism, the value should be switched to 1.</p>
<p>Increasing_healthcare_system_capacity_by_10%_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the experimental switch for increasing healthcare system capacity by 10%.</p>
<p>Increasing_healthcare_system_capacity_by_20%_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the experimental switch for increasing healthcare system capacity by 20%.</p>

<p>Increasing_healthcare_system_capacity_by_5%_POLICY_SWITCH = 0</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable represents the experimental switch for increasing healthcare system capacity by 5%.</p>
<p>"policy_#1+_2+_3_status_(scenario_#1)" = IF(Allocation_60%_of_resources_to_children_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: Dimensionless</p> <p>DOCUMENT: This variable implements the scenario #1 (policy #1 + 2 + 3) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1+_2+_3_status_(scenario_#2)" = IF(Allocation_60%_of_resources_to_parents_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: Dimensionless</p> <p>DOCUMENT: This variable implements the scenario #2 (policy #1 + 2 + 3) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1+_2+_3_status_(scenario_#3)" = IF(Allocation_65%_of_resources_to_parents_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: Dimensionless</p> <p>DOCUMENT: This variable implements the scenario #3 (policy #1 + 2 + 3) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1+_2+_3_status_(scenario_#4)" = IF(Combination_of_3_policies_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: Dimensionless</p> <p>DOCUMENT: This variable implements the scenario #4 (policy #1 + 2 + 3) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1+_2_status_(scenario_#1)" = IF("Increasing_healthcare_system_capacity_by_5%_along_with_expanding_people's_awareness_i n_1.5_times_POLICY_SWITCH "=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: dmn1</p> <p>DOCUMENT: This variable implements the scenario #1 (policy #1 + 2) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1+_2_status_(scenario_#2)" = IF("Increasing_healthcare_system_capacity_by_10%_along_with_expanding_people's_awareness_ in_1.5_times_POLICY_SWITCH "=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p>

<p>UNITS: dmnl</p> <p>DOCUMENT: This variable implements the scenario #2 (policy #1 + 2) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1+_2_status_(scenario_#3)" = IF("Increasing_healthcare_system_capacity_by_20%_along_with_expanding_people's_awareness_in_1.5_times_POLICY_SWITCH "=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable implements the scenario #3 (policy #1 + 2) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1_status_(scenario_#1)" = IF(Increasing_healthcare_system_capacity_by_5%_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable implements the scenario #1 (policy #1) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1_status_(scenario_#2)" = IF(Increasing_healthcare_system_capacity_by_10%_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable implements the scenario #2 (policy #1) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#1_status_(scenario_#3)" = IF(Increasing_healthcare_system_capacity_by_20%_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable implements the scenario #3 (policy #1) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#2_status_(scenario_#1)" = IF("Expanding_people's_awareness_in_1.5_times_POLICY_SWITCH "=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p> <p>UNITS: dmnl</p> <p>DOCUMENT: This variable implements the scenario #1 (policy #2) from 2024 year, while specified switch is turned ON.</p>
<p>"policy_#2_status_(scenario_#2)" = IF(Expanding_people's_awareness_in_2_times_POLICY_SWITCH=1) AND (policy_start_time<TIME) THEN (1) ELSE (0)</p>

UNITS: dmn1

DOCUMENT: This variable implements the scenario #2 (policy #2) from 2024 year, while specified switch is turned ON.

policy_start_time = 2024

UNITS: Years

DOCUMENT: This parameter represents the year of policies implementation.

Therapy Sector

$$\begin{aligned} \text{Actual_demand_for_CBT} = & \text{Total_demand_for_CBT} * \text{Ratio_of_people_seeing_CBT_per_year} * (1 - \\ & \text{"policy_}\#1_+_2_+_3_status_(\text{scenario_}\#4)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#1)\text{"}) * (1 - \\ & \text{"policy_}\#2_status_(\text{scenario_}\#2)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#1)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#2)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#3)\text{"}) + \\ & \text{Total_demand_for_CBT} * (\text{Ratio_of_people_seeing_CBT_per_year} * 1.5) * \text{"policy_}\#1_+_2_+_3_stat \\ & \text{us_}(\text{scenario_}\#4)\text{"} * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#3)\text{"}) + \\ & \text{Total_demand_for_CBT} * (\text{Ratio_of_people_seeing_CBT_per_year} * 1.5) * \text{"policy_}\#2_status_(\text{scenar} \\ & \text{io_}\#1)\text{"} * (1 - \text{"policy_}\#1_+_2_+_3_status_(\text{scenario_}\#4)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#3)\text{"}) + \\ & \text{Total_demand_for_CBT} * (\text{Ratio_of_people_seeing_CBT_per_year} * 2) * \text{"policy_}\#2_status_(\text{scenario} \\ & \text{_}\#2)\text{"} * (1 - \text{"policy_}\#1_+_2_+_3_status_(\text{scenario_}\#4)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#1)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#3)\text{"}) + \\ & \text{Total_demand_for_CBT} * (\text{Ratio_of_people_seeing_CBT_per_year} * 1.5) * \text{"policy_}\#1_+_2_status_(\text{s} \\ & \text{cenario_}\#1)\text{"} * (1 - \text{"policy_}\#1_+_2_+_3_status_(\text{scenario_}\#4)\text{"}) * (1 - \\ & \text{"policy_}\#2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#2)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#3)\text{"}) + \\ & \text{Total_demand_for_CBT} * (\text{Ratio_of_people_seeing_CBT_per_year} * 1.5) * \text{"policy_}\#1_+_2_status_(\text{s} \\ & \text{cenario_}\#2)\text{"} * (1 - \text{"policy_}\#1_+_2_+_3_status_(\text{scenario_}\#4)\text{"}) * (1 - \\ & \text{"policy_}\#2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#3)\text{"}) + \\ & \text{Total_demand_for_CBT} * (\text{Ratio_of_people_seeing_CBT_per_year} * 1.5) * \text{"policy_}\#1_+_2_status_(\text{s} \\ & \text{cenario_}\#3)\text{"} * (1 - \text{"policy_}\#1_+_2_+_3_status_(\text{scenario_}\#4)\text{"}) * (1 - \\ & \text{"policy_}\#2_status_(\text{scenario_}\#1)\text{"}) * (1 - \text{"policy_}\#2_status_(\text{scenario_}\#2)\text{"}) * (1 - \\ & \text{"policy_}\#1_+_2_status_(\text{scenario_}\#2)\text{"}) * (1 - \text{"policy_}\#1_+_2_status_(\text{scenario_}\#1)\text{"}) \end{aligned}$$

UNITS: Person/Years

DOCUMENT: This variable shows the actual demand for therapy, depending on the ratio of people who actually seeks help from the total amount of individuals who require it.

This variable can vary depending on the policy SWITCH.

If policy SWITCHES are turned off, then ratio of people seeing CBT per year remains the same (i.e. 25%).

On the contrary, if one of policy SWITCHES is turned on, we activate a mechanism that aids in increasing the ratio by 1.5 or 2 times, depending on the policy scenario.

Amount_of_people_treated_per_therapist_per_year = 720

UNITS: Person/Therapists/year

DOCUMENT: This parameter represents the amount of people treated per therapist per year. It is assumed, that one therapist can see 3 patients per day in its normal pace. That is $3*5 = 15$ patients per week, $15*4 = 60$ patients per month, and $60*12 = 720$ patients per year.

Average_time_to_treat = 1

UNITS: year

DOCUMENT: This variable shows the time needed to treat PTSD. As far as PTSD is a serious mental disease, it takes a lot of time to be developed and treated. Thus, it is assumed to be 1 year.

Capacity_Utilisation = People_Treated_per_year//Total_people_can_be_treated

UNITS: dmnl

DOCUMENT: This converter represents therapists capacity utilization, that is the fraction, by which the therapists' normal capacity is exaggerated.

CBT_effectiveness(t) = CBT_effectiveness(t - dt) + (Change_in_CBT_effectiveness) * dt
INIT CBT_effectiveness = Normal_CBT_effectiveness

UNITS: CBT effectiveness

DOCUMENT: This stock represents the effectiveness of Cognitive Behavioral Therapy (CBT) for the treatment of PTSD. The stock varies between 0.25 and 0.5, where 0.5 indicates that the maximum possible CBT effectiveness is 50% (which is the same as normal), and 0.25 - minimum (CBT effectiveness is assumed to decrease 2 times in case when the healthcare system capacity in one and a half times higher than normal).
The initial value of the stock is set at its normal level.

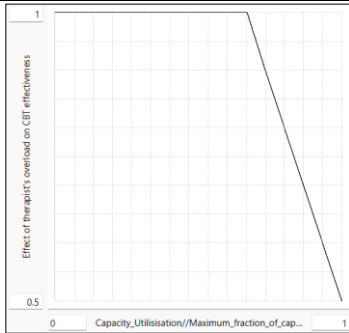
Change_in_CBT_effectiveness = (Indicated_level_of_CBT_effectiveness - CBT_effectiveness)/Time_to_adjust_CBT_effectiveness

UNITS: CBT effectiveness/Years

DOCUMENT: This biflow demonstrates the rate at which CBT effectiveness is formed. This process depicts information delay with the goal of indicated level of CBT effectiveness.

Effect_of_therapist's_overload_on_CBT_effectiveness =
GRAPH(Capacity_Utilisation//Maximum_fraction_of_capacity_utilization)

Points: (0.000, 1.0000), (0.0666666666667, 1.0000), (0.133333333333, 1.0000), (0.200, 1.0000), (0.266666666667, 1.0000), (0.333333333333, 1.0000), (0.400, 1.0000), (0.466666666667, 1.0000), (0.533333333333, 1.0000), (0.600, 1.0000), (0.670, 1.0000), (0.733333333333, 0.9000), (0.800, 0.8000), (0.866666666667, 0.7000), (0.933333333333, 0.6000), (1.000, 0.5000)



UNITS: dmn1

DOCUMENT: This variable represents the effect of therapist's overload on CBT effectiveness, that is its ability to provide high quality services based on its workload. The main assumption here is that, until the total amount of people treated do not exceed therapists' capacity to treat them in their normal pace (meaning that the demand does not exceed the supply), therapy effectiveness would be kept on its normal level. But as soon as capacity utilization begins to grow up, therapy effectiveness is sharply declining. And if capacity utilization reaches one and a half times over usual, CBT effectiveness become two times less normal

Indicated_level_of_CBT_effectiveness = IF Capacity_Utilisation = 0 THEN 0 ELSE Effect_of_therapist's_overload_on_CBT_effectiveness*Normal_CBT_effectiveness

UNITS: CBT effectiveness

DOCUMENT: This variable represents the indicated level of CBT effectiveness before information delay adjustment. The indicated value is determined by the effect on CBT effectiveness and its normal level.

Maximum_fraction_of_capacity_utilization = 1.5

UNITS: dmn1

DOCUMENT: This parameter represents the maximum fraction of capacity utilization, that is the maximum ratio, by which total number of people therapists treated can be increased without losing the effectiveness.

Maximum_people_treated = Total_people_can_be_treated*Maximum_fraction_of_capacity_utilization

UNITS: Person/Years

DOCUMENT: This variable represents the maximum number of people that can be treated (at maximum effectiveness).

Normal_CBT_effectiveness = 0.5

UNITS: CBT effectiveness

DOCUMENT: This parameter represents the normal level of CBT effectiveness. "[n]onresponse to CBT by PTSD can be as high as 50%, contributed to by various factors, including comorbidity and the nature of the study population" (Kar et al., 2011). Hence, normal CBT effectiveness is assumed to be 50%.

People_Treated_per_year = DELAY1(MIN(Maximum_people_treated, Actual_demand_for_CBT), Average_time_to_treat) {DELAY CONVERTER}

UNITS: Person/Years

DOCUMENT: This variable represents the annual amount of people receiving treatment, based on the assumption, that therapists are not able to exceed one and a half times their capacity in treating people, even if the demand exceeds their capacity.

Variable is represented in a form of a first-order material delay.

Ratio_of_people_seeing_CBT_per_year = 0.25

UNITS: Per Year

DOCUMENT: This variable represents the ratio of people seeing CBT per year. According to Roberts et al. (2019), among internally displaced persons, due to the Russian aggression in the eastern part of Ukraine, who has depression, anxiety or PTSD, there were revealed almost 75% treatment gap; meaning that only 25% of people who may require medical care actually receive it. Hence, based on this survey, this parameter is assumed to be 0.25.

"Supply/Demand_balance" = Total_people_can_be_treated//Actual_demand_for_CBT

UNITS: dmnl

DOCUMENT: This variable represents the supply/demand balance in order to keep track on the proportion of people, who can be treated, based on the capacity of healthcare system.

Time_to_adjust_CBT_effectiveness = 1

UNITS: year

DOCUMENT: This variable shows the time needed to adjust CBT effectiveness. It is assumed to be 1 year.

Total_demand_for_CBT = (Unhealthy_Children+Unhealthy_Parents)

UNITS: person

DOCUMENT: This variable shows the demand for therapy, that is total amount of individuals with PTSD in Ukraine who need CBT treatment.

Total_people_can_be_treated = Therapists*Amount_of_people_treated_per_therapist_per_year

UNITS: Person/Years

DOCUMENT: This variable represents the total number of people that can be treated, depending on the number of therapists and their capacity.