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Modeling the Changes in the Prevalence of Complex PTSD in Undergraduate Males and Females

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ABSTRACT

In the last decade, there has been a great increase in interest surrounding mental health services, which has resulted in university counseling departments becoming overwhelmed with interested clients. The purpose of this study was to project the changes in undergraduate male and female student populations who have complex PTSD and common comorbid mental illnesses in order to provide guidance to counseling departments, since different therapeutic techniques have varying levels of effectiveness for different mental illnesses. Functions of best fit of data from previous studies were calculated and derived using Mathematica and Desmos Graphing Calculator in order to have differential equations for the flows of the systems dynamics STELLA model. The initial values in the stocks in the STELLA model were found by evaluating the non-derived function of best fit at time zero. It was concluded that the number and percentage of undergraduates living with PTSD will be fluctuating from 2022 to 2032, but the number of males and females seeking recovery will be increasing, resulting in a decrease in comorbid eating disorders and/or PTSD-related suicides. The results are likely linked to the decrease in the stigma surrounding mental health and therapy, especially in young populations and will help university counseling departments prepare to better meet the needs of future students.

Introduction

An Overview of PTSD

Post-Traumatic Stress Disorder (PTSD) is a mental illness formally recognized in the Diagnostic and Statistical Manual of Mental Disorders (DSM-V). It is diagnosed by a prolonged response to traumatic events, and symptoms include repeated dreams and flashbacks of the experience, uncontrollable thoughts about the event, avoidance of certain situations, persistent severe distress, and hyperarousal. Symptoms must occur for more than one month in order to meet the criteria for a medical diagnosis (World Health Organization 1992). Undergraduate university students have the highest rate of occurrence of PTSD of any population in the United States. It was estimated by the Eastern Colorado Healthcare System in 2019 that approximately 17% of undergraduate students exhibit symptoms commonly associated with PTSD, while the estimate for the general population was around 10% (Cusack 2019). PTSD can majorly disrupt people's lives and increase the risk of developing depression, anxiety, eating disorders, and substance use disorders, as well as suicidal thoughts (Mayo Clinic 2018).

PTSD can be divided into two categories - acute PTSD and complex PTSD. The symptoms in acute PTSD last for less than three months and naturally improve over time, while the symptoms last for more than three months in the case of complex PTSD. Complex PTSD is generally caused by a series of traumatic events occurring over a longer period of time. People experiencing complex PTSD are generally unable to recover without professional help and are at high risk for self-harm and suicide (Clemans 2018). According to clinical psychologists from the Karolinska Institutet of Sweden and University College London, approximately 23% cases of complex PTSD where professional

help was not received within the first six months following the traumatic event resulted in a suicide attempt (Fox 2021).

Causes of Complex PTSD

Sexual Violence

Sexual violence is the leading cause of complex PTSD in student populations. In the United States, 30% of all cases of PTSD can be linked to sexual violence, and 35% of sexual violence victims are between the ages of 18 and 24 (Meyer 2019). 26% of female and 7% of male undergraduate students are victims of sexual violence. Despite efforts of colleges and universities to increase campus safety, results from anonymous annual surveys on campus climate conducted by the Association of American Universities have indicated that sexual violence statistics have not significantly changed on college campuses between 2015 and 2019 (Cantor 2019).

Natural recovery is often prevented in victims of sexual violence due to the massive stigma surrounding the topic. Many people avoid talking about sexual trauma for fear of judgment or criticism, while others are in denial or place the blame on themselves. Males and females respond to sexual trauma differently, with men more commonly feeling angry and resort to aggression, and women more commonly developing mental illnesses. 27% of males and 47% of females who have been sexually assaulted meet the criteria for a diagnosis of complex PTSD (Rogers 1997).

Childhood Maltreatment

Childhood maltreatment is another notable source of complex PTSD in undergraduate students. Childhood maltreatment incidents heavily fluctuate in response to the economy but remain consistent over multiple years. It is estimated that around half of the total childhood maltreatment victims are male, but different types of maltreatment are disproportionate between the sexes. It is estimated that 62% of childhood physical abuse (CPA) victims are males, while 38% are female (May-Chahal 2006). Only 18% of male CPA victims develop complex PTSD, while 50% of female victims do. Male victims commonly exhibit symptoms of PTSD but have sub-threshold cases and therefore cannot receive a formal PTSD diagnosis. Additionally, depression and suicidal thoughts more commonly develop in male victims (Ackerman 1998).

Adversely, childhood sexual abuse (CSA) is much more prevalent in female populations. According to a meta-analysis of CSA reports from the US in the early 2000's, 73% of CSA victims are female and 26% are male (Ackerman 1998). 35% of female victims and 22% of male victims develop complex PTSD. The rate of development of PTSD from CSA is significantly lower for females than for other types of maltreatment since the vast majority of CSA occurs in female infants or toddlers who will not be able to recall the experience, although other mental illnesses may result from this "hidden" traumatic experience (Walker 2004).

Neglect is the only type of child maltreatment that is estimated to be equally common in males and females. It is the most common type of child maltreatment with 519500 reported cases in the US in 2020. The rate of development of complex PTSD is also believed to be the same for males and females, with meta-analyses suggesting the rate of development to be around 30.6% (May-Chahal 2006).

Survivors of Suicide Attempts

Often overlooked is complex PTSD in people who have survived suicide attempts. The National Youth Risk Behavior Survey has anonymously surveyed high school and college students since 1991 on mental health topics such as suicidal ideation, nonfatal suicide attempts, and fatal suicides within school communities. It was concluded that suicidal ideation and fatal suicide attempts have elevated rates in male adolescent populations, however, nonfatal suicides are almost twice as common in adolescent female populations. Males and females often use different methods when

attempting suicide, which has resulted in the higher fatality rate of suicide in males (Xiao 2021). It has been determined that sex has no impact on complex PTSD resulting from nonfatal suicide attempts, with 27.5% of young adults who attempt suicide developing complex PTSD (Stanley 2019).

Comorbid Mental Illnesses

Additionally, it has become apparent that eating disorders, specifically Bulimia Nervosa and Binge Eating Disorder, have elevated rates in patients with complex PTSD. Highly stressed populations may develop eating disorders as a coping mechanism, as they can provide people with a perceived sense of control (Hewett 2014). Mitchell and colleagues concluded that approximately 50% of men and 39% of women living with PTSD also develop Bulimia Nervosa, while 24% of women and 26% of women living with PTSD develop Binge-Eating Disorder. The link between Anorexia and PTSD has only been studied in women, where the rate of comorbidity is 16% (Mitchell 2012)}.

In addition to eating disorders, substance use disorders commonly co-occur with complex PTSD, also as coping mechanisms. People often attempt to "self-medicate" or use substances to alleviate their symptoms shortly after the event. The substance use provides a short relief of the symptoms but can prevent the natural healing process and ultimately worsen the case (Gong 2019). A study conducted at Boston University in the early 2000's concluded that 34% of men and 26% of women diagnosed with complex PTSD resort to alcohol or drug abuse for a temporary relief of symptoms (Gradus 2017).

The Current Study

The aim of this study was to create a systems dynamics model that would predict the changes in cases of complex Post-Traumatic Stress Disorder, along with comorbid mental illnesses, in undergraduate male and female students from 2022 to 2032. It is highly unlikely that students with complex PTSD will be able to recover without professional help, and university counseling departments need to be aware of the predicted changes in the prevalence of complex PTSD in student populations in order to meet the needs of future students. This is a continuation study, and the previous study explored cases of complex PTSD in undergraduate students overall, but the increased specificity of this new model by separating by sex will likely result in more accurate predictions.

Stella Architect, a systems dynamics software, was used to create the model (ISEE Systems 2010). Inputs for the model, such as differential equations, initial values, and constant values, were calculated using data and results from previous studies using Wolfram Mathematica (Wolfram Research, Inc. 2022) and Desmos Graphing Calculator (Desmos 2018). The STELLA model connects and visually represents multiple factors that could potentially contribute to the changes in the prevalence of complex PTSD and comorbid eating disorders over time.

Methods

Stella Architect (ISEE Systems 2010) is a software that uses the STELLA visual programming language to create systems dynamics models using mathematical integrations. The models are made up of flows, which represent the differential equations; stocks, whose values are affected by the integration of the differential equations; and converters, which remain constant. The RK4 method of integration was used for this model, and the model was run over a ten-year period. Since no previous relevant systems dynamics models were found, functions of best fit for almost all factors considered in this study were solved for using Desmos or Mathematica and then derived to have differential equations for the flows of the STELLA model. Additionally, the initial values for the stocks of the STELLA model were calculated using Mathematica by evaluating the functions of best fit at time zero. The changes in the values of the foundational stocks of the model were confirmed with graphs before proceeding (Desmos 2018), (Wolfram Research, Inc.

2022). The model has four main components - common causes, overall change in the prevalence of PTSD, populations receiving treatment for PTSD, and common outcomes in populations where successful treatment was not received.

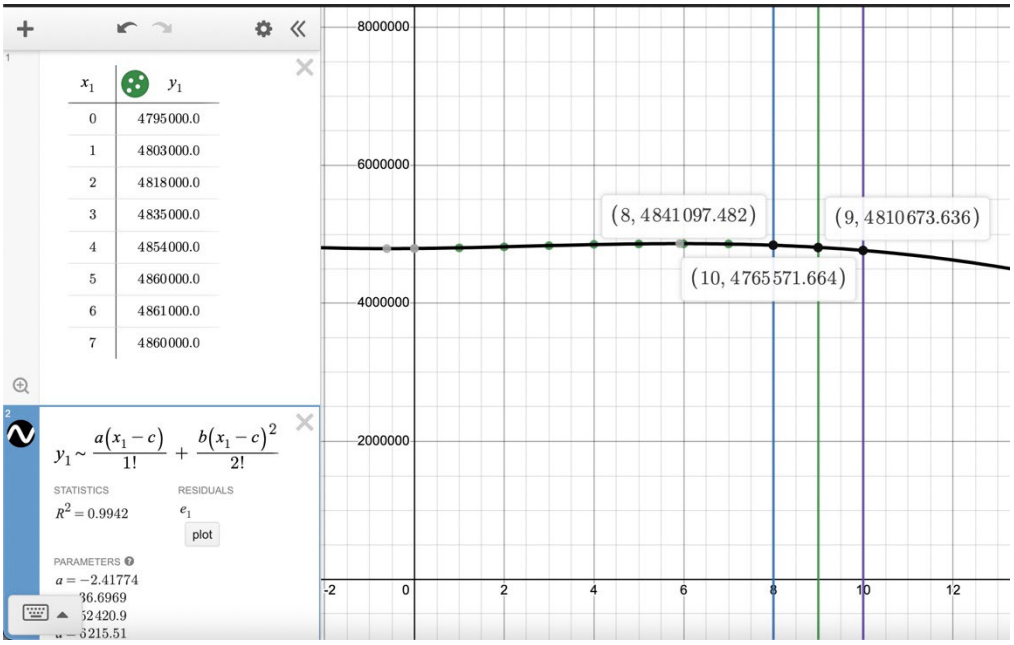

Figure 1. A Taylor Polynomial was used to estimate the male undergraduate population in the US from 2030 to 2032 using Desmos Graphing Calculator.

Figure 1 is shown above demonstrating how a Taylor Polynomial was used to predict male undergraduate populations with a very high R-squared value while continuing in a reasonable manner beyond time 7, which represents the year 2029.

Sexual Violence Victims

Sexual violence is the most common cause of complex PTSD, especially in undergraduate students, who have the highest rates of sexual violence. To determine the changes in complex PTSD from sexual violence in male and female undergraduate students over time, Taylor polynomials were created to predict enrollment numbers through 2032 using the National Center for Education Statistics' numbers and predictions for the number of male and female undergraduate students through 2030 (Debrey 2021). The Taylor polynomials were derived in Mathematica in order to serve as the differential equation representing the changing male or female undergraduate population. The derived polynomials were then multiplied by the rate of sexual violence for each sex (7% for males and 26% for females (Cantor 2017)) and the rate of development of complex PTSD from sexual violence for each sex (27% for males and 47% for females) (Snipes 2017). Male victims of sexual violence are seen in the center of the left side of Figure 2.

Childhood Maltreatment Survivors

For the portion of the model dedicated to victims of childhood maltreatment, calculations of the changes in the American youth male and female populations were first performed using data from the US Census Bureau and population projections through 2030 (US Census Bureau 2021). Functions of best fit were then made to represent the changing number of cases of neglect, CSA, and CPA in males and females using data from the annual Child Maltreatment

Reports (ACF 2009-2020). Both functions were derived before being divided into a separate flow that represented the changing percentage of children affected by each type of maltreatment. The changing percentages were multiplied by the differential equations for undergraduate populations before being multiplied by the prevalence of complex PTSD in males or females with a history of the maltreatment type (Ackerman 1998), (Mitchell 2012). The bottom part of Figure 2 is dedicated to childhood maltreatment in males.

Survivors of Suicide Attempts

The undergraduate flows for male and female undergraduate populations were multiplied by the changing percentage of males and females who have survived suicide attempts and the percentage of people who develop complex PTSD following the attempt. Taylor polynomials were used to predict the changing percentage of young men and women who have survived attempts using statistics from the Youth Risk Behavior Survey from 1991 to 2019 (Xiao 2021). A graphical converter was used to represent the estimated changes in nonfatal suicide attempts for both sexes. Male survivors of suicide attempts are represented in the top right corner of Figure 2.

Overall Change of Complex PTSD for Males and Females

To determine the overall expected changes in cases of Complex PTSD in undergraduate males or females, the differential equations representing the changes in complex PTSD in male or female sexual violence victims, victims of each of the three types of child maltreatment, and suicide attempt survivors were combined into one inflow. As shown in Figure 2, the model had one outflow representing students with PTSD whose lives were lost to suicide. The majority of fatal suicide attempts occur before people are able to access treatments or professional intervention, so recovering populations were not considered in this equation. The percentage of young men and women with PTSD who are lost to suicide has remained fairly consistent, with the rates averaging 1.72% in men and 2.65% in women (Fox 2021).

Outcomes of the Populations with PTSD

A variety of equations and flows stemmed from the flow that represented the overall population with complex PTSD, including recovering populations and populations that develop comorbid eating disorders or substance use disorders.

For the recovering male and female populations, the total male or female undergraduate populations with PTSD flows were multiplied by the changing percentages of males and females seeking treatment and professional help for PTSD. Results from the Substance Abuse and Mental Health Administration (SAMHSA) Annual Reports regarding the percentage of men and women between the ages of 18 and 25 receiving professional services to aid with the recovery any mental illness (AMI) from 2015 to 2020 were used to calculate the changing percentage of males and females in recovery a Taylor polynomial. The value of the polynomial was calculated from time 0 to time 10 with a step size of 1.0 to find the values that would be used in the graphical converter at each time. While males receive treatment for AMI at much lower frequencies than females, the projected numbers of both males and females in recovery are expected to increase over the next ten years. The recovery inflow is in the center of Figure 2.

The sections of the model regarding comorbid eating disorders were also linked to the overall changes in complex PTSD stocks. To evaluate for these values, the recovery population flows for males and females were subtracted from the overall changes in complex PTSD flows for both males and females to find the size of the vulnerable populations for eating disorders. The vulnerable population was then multiplied by the male or female rate of Bulimia Nervosa or Binge-Eating Disorder, as well as Anorexia Nervosa in females. It has estimated that approximately 80% of females who do not seek treatment for complex PTSD will develop an eating disorder (Brewerton 2007), and the rates used in this model totaled to 82% for females.

Lastly, the number of comorbid cases of substance use disorders (SUDs) were calculated by multiplying the vulnerable male and female populations by the rate of onset of SUDs for each sex. 33.9% of men who did not seek treatment for PTSD within the first six months developed an alcohol or drug dependence, while 26.3% of women developed SUD.

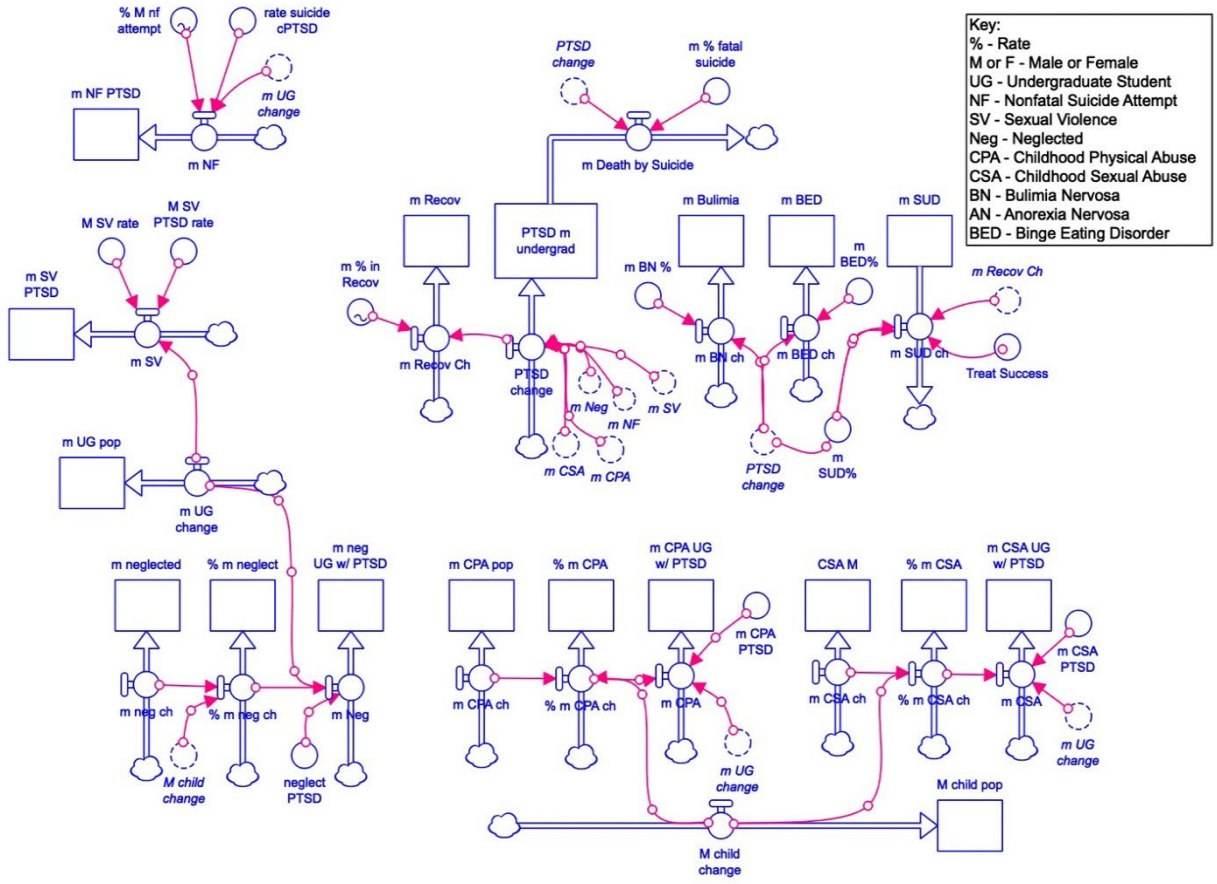

Figure 2. STELLA model of the male undergraduate students with complex PTSD.

Results

To evaluate the values and differential equations included in the STELLA model, the Mathematica software and Desmos Graphing Calculator were used to calculate functions of best fit that represented the changes in the stocks of the systems dynamics model. Stella Architect is an integration software, so the Taylor polynomials of best fit were derived in order to have the desired effect. The model was run over the course of ten years, representing the years 2022 to 2032. Equations representing changes in complex PTSD in male and female victims of sexual violence, survivors of childhood maltreatment, and survivors of suicide attempts were used to solve for the overall change in complex PTSD in the US undergraduate student populations over the next ten years.

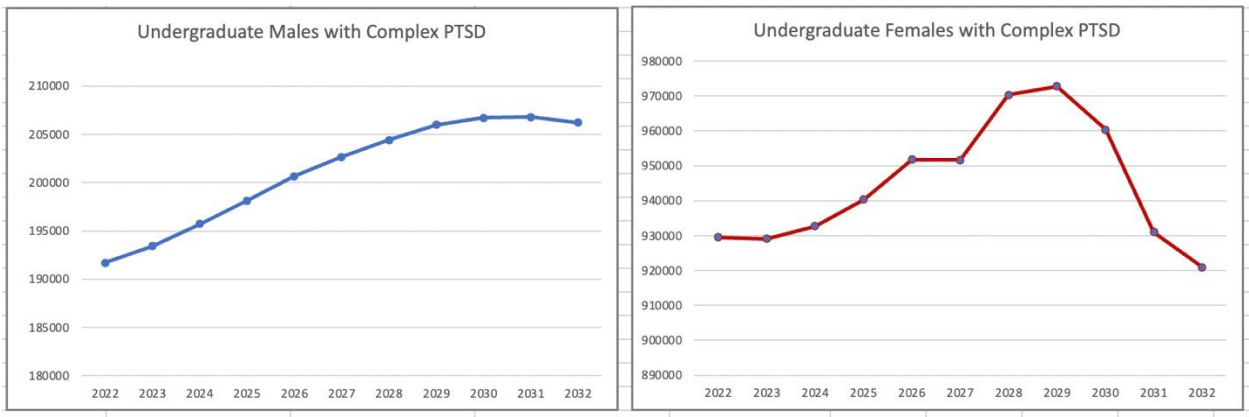

Figure 3. Projected numbers of male (left) and female (right) undergraduates experiencing complex PTSD.

As can be seen in Figure 3 diagnoses for complex PTSD are predominantly in females. The estimate for 2032 for undergraduate males was 206218 and 920892 in females. Additionally, the rate of complex PTSD in undergraduate females was about 3 times greater than the rate for males. The rate of complex PTSD in undergraduate females is projected to be between 15 and 16% each year, while the rate in males is projected to be between 3.9 and 4.4%.

No clear patterns or trends can be seen in this figure, as the number of students with complex PTSD is fluctuating in both males and females. However, this is likely a result of the number of undergraduate students fluctuating in recent years and has been projected by the National Center for Education Statistics to continue to do so Debrey 2021).

Figures 4 and 5 shown below show the projected changes in the number of vulnerable males and females within the PTSD population. The vulnerable population refers to those that have a high likelihood of developing an eating disorder or suicidal thoughts and is the population that was not able to receive successful treatment.

Year	Vulnerable Males	Recovering Males	Males Lost to Suicide
2022	120567	71113	2068
2023	120388	73037	2065
2024	120252	75470	2062
2025	126171	71972	2164
2026	121587	79084	2085
2027	120967	81692	2075
2028	120072	84341	2059
2029	117202	88776	2010
2030	114908	91799	1971
2031	112605	94199	1931
2032	109811	96407	1883

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Figure 4. Projected vulnerable male PTSD population, number of males in recovery, and those who are lost to suicide.

Year	Vulnerable Females	Recovering Females	Females Lost to Suicide
2022	460303	469227	12198
2023	446611	482474	11835
2024	435668	497040	11545
2025	427279	513036	11323
2026	421265	530530	11164
2027	410819	540811	10887
2028	409184	561135	10843
2029	401347	571379	10636
2030	388383	572011	10292
2031	369704	561305	9797
2032	359793	561099	9535

Figure 5. Projected vulnerable female PTSD population, number of females in recovery, and those who are lost to suicide.

Figure 5 shows the projections for the vulnerable female undergraduate PTSD population in the coming years. As shown in Figures 4 and 5, the vulnerable male and female populations are expected to significantly decrease over the next ten years. This is likely a result of the increasing percentage of young males and females seeking professional intervention. The Taylor Polynomial that was generated to predict the percentage of college-aged males seeking treatment for any mental illness predicted the percentage to change from 37.1% in 2022 to 46.8% in 2032. For females, it was calculated that the percentage of college-aged women with any mental illness who would receive treatment would increase from 50.5% in 2022 to 60.9% in 2032.

Fatal suicides were calculated solely in the vulnerable male and female populations, so PTSD-related suicides were naturally expected to decrease within this time period since the recovering population was expected to significantly increase for both sexes. Figures 6 and 7 demonstrate the projections for the number of males and females with comorbid mental illnesses.

Year	Males Developing Bulimia Nervosa	Males Developing Binge-Eating Disorder	Males Developing Substance Use Disorder
2022	95840	46042	64980
2023	96713	46461	65571
2024	97861	47012	66350
2025	99072	47594	67170
2026	100336	48201	68027
2027	101330	48679	68701
2028	102207	49100	69296
2029	102989	49476	69827
2030	103354	49651	70074
2031	103402	49674	70107
2032	103109	49534	69908

Figure 6. Projected numbers of undergraduate males with comorbid mental illnesses.

Year	Females Developing Bulimia Nervosa	Females Developing Binge-Eating Disorder	Females Developing Anorexia Nervosa	Females Developing Substance Use Disorder
2022	183247	239261	149561	244466
2023	177796	239146	149490	244349
2024	173439	240079	150073	245302
2025	170100	242037	151297	247303
2026	167706	244992	153144	250322
2027	163547	244949	153117	250279
2028	162896	249760	156124	255194
2029	159776	250379	156512	255827
2030	154615	247205	154527	252584
2031	147179	239642	149799	244855
2032	143234	237038	148172	242195

Figure 7. Projected numbers of undergraduate females with comorbid mental illnesses.

Surprisingly, the rates of prevalence of comorbid Bulimia or Binge-eating disorder were almost equivalent between the male and female populations, as both mental illnesses are almost twice as common in females in otherwise mentally healthy populations. Populations with comorbid Bulimia, Anorexia, or Binge-eating disorder were calculated directly from the recovering population. Although the number of complex PTSD cases are expected to fluctuate from year to year, the growing number of young men and women wanting to receive professional help for their mental illnesses has led to an overall decrease in comorbid eating disorders, which commonly arise as a coping mechanism after the initial three month "critical period."

Contrarily, Substance Use Disorders often arise as coping mechanisms after the initial PTSD symptoms arise in trauma survivors. This most commonly occurs before people are able to understand their symptoms or seek professional help, so the overall PTSD population was considered in this calculation, rather than the vulnerable population. As a result, the number of comorbid SUD cases are expected to fluctuate over the coming decade in both males and females.

Discussion

The goal of this study was to predict changes in complex PTSD and comorbid mental illnesses in US undergraduate male and female students over the next ten years using Mathematica (Wolfram Research, Inc. 2020) and Stella Architect (ISEE Systems 2010). The number of undergraduate students in the US is predicted to continue fluctuating, which has resulted in no clear direction in which the cases of complex PTSD are heading for either sex. Taylor Polynomials were used to predict the expected values for numbers that were expected to change due to the high accuracy and specificity of their nature. The Taylor polynomials were solved for in Desmos Graphing Calculator (Desmos 2018) before being derived in order to serve as the differential equations. The majority of the Taylor Polynomials also had no clear sense of direction, except for most notably the percentage of young males and females who are expected to receive treatment for mental illnesses in the coming years.

While there was no clear sense of direction for the individual model results, there did prove to be a significant difference between the numbers of males and females experiencing complex PTSD. The percentage of female students experiencing complex PTSD was about three times the percentage of male students experiencing complex PTSD. Within the individual factors, complex PTSD from childhood physical abuse was exhibited in 18% in males and 50% in females (Mitchell 2012). The significant difference between the sexes is currently unexplained, but some hypotheses state that deeper emotional connections may be a risk factor for PTSD, which is more commonly seen in women. Additionally, it is plausible that males have difficulty reporting PTSD symptoms or remain in denial about the

symptoms. Clinical psychology studies often rely on self-reporting, and toxic masculinity or a stigma surrounding men's mental health may have a significant impact on this result.

Conclusion

Overall, the number of males and females seeking recovery and professional services is expected to increase, which has resulted in a decrease in the projected number of cases of comorbid eating disorders or fatal suicides. The increased open conversations about mental health have led to a decrease in the stigma surrounding therapy, especially in young populations, which has resulted in a projected significant decrease in the vulnerable populations of both male and female undergraduates.

Limitations

With this model being one of the first of its kind, it has potential to help alleviate the stress faced by many university counseling departments. The problem is that 31.3 million adults sought mental health services in the US in 2010, and that number increased to 41.2 million by the end of 2019. Over that ten-year period, the number of people who sought mental health services increased by approximately 32%, while the number of mental health professionals in the US only increased by 10%. The interest in mental health services has grown very quickly, and university counseling departments in particular have become extremely overwhelmed. Almost all university counseling departments are not able to support their client base or have extremely long waiting lists, which could seriously mentally or physically harm clients who have time-sensitive matters, like PTSD symptoms. A systems dynamics model was created in this study to make projections for cases of complex PTSD and the common comorbid mental illnesses in an effort to guide university counseling departments as to where they should allocate funding in order to better serve future clients. Different mental illnesses have different therapeutic techniques that have higher rates of effectiveness, and it would be helpful to know which specialties will be needed in the future when hiring employees. If similar models are created for a variety of other mental illnesses, counseling departments will know what to expect from their future client base and will be able to plan to help future clients recover most quickly and effectively.

While this model can serve as a helpful resource for university counseling departments, it will not be completely accurate and effective. Additionally, it is important to note that serving in the sexual violence, childhood maltreatment, and nonfatal suicide attempts are not the only factors that can lead to the development of complex PTSD. Military veterans and refugees also have very high rates of prevalence of complex PTSD. A previous study conducted by the author in late 2021 included student veterans in the model, but the Russo-Ukrainian War is a recent event and therefore is extremely difficult to predict at this point. Including war veterans or refugees would certainly have decreased the future accuracy and usefulness of the model, so the factors were left out in this version of the model. A future version of the model may include military members or refugees.

Another drawback of this model is that it was assumed that the child maltreatment statistics used would be representative of the undergraduate male or female populations. It is likely that many children who have been maltreated do not have the means to pursue an undergraduate education. This would result in a decrease in the undergraduate populations whose PTSD can be stemmed to childhood maltreatment.

Lastly, it is necessary to note the numbers of male and female undergraduate students receiving services for complex PTSD were calculated without regards to America's currently overwhelmed mental healthcare system. The assumption was that each person who would like to receive mental health services was able to do so in a timely manner, which is unfortunately very unrealistic. The lack of access to appointments with mental health professionals is the most common reason many people with PTSD end up developing a substance use disorder. People often attempt to self-medicate because they are not able to get an appointment with a psychiatrist or mental health professional in a timely manner.

Future Studies

A major challenge of this study was finding statistics regarding PTSD, eating disorders, and substance abuse disorders in males with traumatic experiences, since the majority of studies focus on female populations. While it is critical that more work is done with male populations, it is very difficult to study in a computational setting. Therefore, in further studies, efforts will likely be focused on female populations, studying differences in females of different backgrounds and ethnic groups, such as white, black, Hispanic or Latinx, Asian or Pacific Islander, and American Indian or Alaska Native, as well as gender identity and sexual orientation. Different types of traumatic experiences have varying levels of prevalence in different populations in the US, and different groups are often more or less inclined to receive professional intervention. This expanded model will be more accurate and effective in providing projections for undergraduate females with complex PTSD.

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