Spring 5-15-2016

Suicide Attempts from Adolescence into Young Adulthood: A System Dynamics Perspective for Intervention and Prevention

Saras Yu Chung
Washington University in St. Louis

WASHINGTON UNIVERSITY IN ST. LOUIS

Brown School of Social Work

Dissertation Examination Committee:
Amanda Moore McBride, Chair
Patrick J. Fowler
Peter S. Hovmand
Joshua J. Jackson
Sean Joe
Patricia L. Kohl

Suicide Attempts from Adolescence into Young Adulthood: A System Dynamics Perspective for Intervention and Prevention

by
Saras Y. Chung

A dissertation presented to the
Graduate School of Arts & Sciences
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

May 2016
St. Louis, Missouri

Table of Contents

List of Figures

List of Tables

ACKNOWLEDGMENTS

This dissertation is generously supported by fellowships from Washington University's Social System Design Lab, and the Asian American and Pacific Islanders Council on Social Work Education. I am grateful for the institutional and financial support from these organizations and the people who support them.

This work would not be possible without the time and cognitive investments of my dissertation committee: Amanda Moore McBride, Peter Hovmand, Sean Joe, Patrick Fowler, Joshua Jackson, and Trish Kohl. Thank you for devoting effort to hear my ideas and inspire me in my academic pursuits. Amanda Moore McBride, you walked with me before I started the doctoral program. You always made sure I was pursuing that which mattered most. I'll miss our catch-up sessions dearly. Peter Hovmand, thank you for providing incredible mentorship. I am grateful for your thoughtful instruction, support, and insights. I hope to pay your investment forward for other future system dynamicists.

To my professors and colleagues at the Brown School, I am grateful for your instruction and support. Dean Renee Cunningham Williams, Lucinda Cobb, and Marissa Hardwrict, you have kept me on track for the past four years. To my previous professors, you have challenged me to grow in my methods and mindset towards research. To all the staff the Social System Design Lab, especially Nancy Zoellner, Diane Wittling, Ellis Ballard, and Megan Odenthal, thanks for sharing your lives through workshops, lab meeting icebreakers and support. Jill Kuhlberg, thanks for persuading me to take the Intro to SD class! To my fellow doctoral students and colleagues, your idea-bouncing, internet-cat distractions, and comradery will never be forgotten. Donny Gerke, my first-year buddy, thank you for being a friend.

For my youth development mentors in the field, Dave and Tina Hilliard, Claire Wyneken and Allison Williams, thank you for the many years of encouragement. Dave, your 50+ years of work for the nation through Wyman has left a deep impression on my vision for youth. I admire your sacrifice and hope to carry your work forward. To the many youth in my life, past and present, thank you for sharing personal stories of difficulty and healing. I have been challenged by your bravery and honesty.

Deepest thanks to my family: Sam, Song, and Jane Chung, and Larissa and Justin Johnson. Thanks for the no-questions-asked babysitting and loving on the kids during the past four years. To my bold and incredible children, Karis and Jaron, you have spent over 50 percent of your lives cheering me on in this program. Thank you for your pep-talks and career advice. Mommy is finally finishing the 22nd grade! To my husband, John Chung, thank you for supporting me with words of encouragement and chocolate. What seemed like a far-fetched idea, is now a reality, and I have you to thank for encouraging me to pursue this path.

Finally and most importantly, thank you to my parents, Yu Keun Kim and Hae Suk Kim. After immigrating to the U.S. with empty pockets and limited language skills, you worked back-breaking jobs for decades so I could have opportunities in life. You never quit. Through your sacrifice, you taught me what it means to passionately invest in others and to find God in the process. Though I cannot repay the lives you forfeited on my behalf, I hope you are honored through this work.

Saras Chung

Washington University in St. Louis
May 2016

Dedicated to my parents. Your sacrifices are not forgotten.

저를 위해 항상 수고해주셔서 감사합니다.

ABSTRACT OF THE DISSERTATION

Suicide Attempts from Adolescence into Young Adulthood: A System Dynamics Perspective for Intervention and Prevention

by

Saras Y. Chung

Doctor of Philosophy in Social Work

Washington University in St. Louis, 2016

Professor Amanda Moore McBride, Chair

Though the reduction of suicide-related deaths has been a national priority for over a decade (U.S. Department of Health and Human Services, 2001) and over $22 million per year (National Institutes of Health, 2015) have been invested to prevent suicide, rates of suicide have not declined (CDC, 2012). In fact, these rates have risen for adolescents (Wasserman, Cheng, & Jiang, 2005). The ineffectiveness in reducing deaths by suicide despite increased funding and coordinated efforts suggests the need for a new perspective on examining why and how adolescents begin to desire and attempt suicide and how to stop new attempts from occurring. Using an individual-level system dynamics model (Forrester, 1994; Sterman, 2000), this study answers the following research questions:

1. Is there a feedback relationship governing the experience of suicide attempts for adolescents into adulthood?
2. What types of interventions can be used to decrease suicidality across the lifespan?

Specifically, the goal of this study was to understand whether Thomas Joiner's interpersonal theory of suicide (IPTS) (Joiner, 2005; Van Orden et al., 2010), when

mathematically defined as a system dynamics model, could accurately simulate and predict suicide attempts across time. The model was specified with nationally representative data from the National Longitudinal Survey for Adolescent and Adult Health (Add Health) and tested for applicability in understanding differences in suicide attempts by gender and racial subgroups. Modifications to the structure of the model were made leading to a modified theory, the developmental systems model of the interpersonal theory of suicide. Results from experiments on the developmental systems model of IPTS suggest that reducing the duration of depression or increasing the time it takes to build capability to attempt suicide for adolescents can minimize attempts across adolescence and adulthood. Implications for research, policy, and practice are outlined, with an emphasis on future directions for suicide research.

Chapter 1: Introduction

This dissertation examines the developmental trends upon which young people attempt to die by suicide from adolescence and into adulthood. Each year in the United States, approximately two million adolescents attempt suicide, of which 4,600 die and another 157,000 require medical attention as a result (Centers for Disease Control [CDC], 2015). The magnitude of this phenomenon could be considered an epidemic, one which we have not been effective at preventing or treating.

Why would a young person try to die by taking their own lives? This question has been asked by surviving parents, friends, and concerned community members. It has spurned on research, the development of foundations, books, and interventions. Historical research on suicide has identified an extensive array of psychological, psychiatric, sociological, and behavioral correlates of suicide (Rogers, 2003). Despite descriptive information, we know "very little about how those characteristics are interconnected and coalesce at the individual level to lead a decision to suicide" (Rogers, 2001, p.17). Additionally, there is a dearth of information when it comes to predicting and disaggregating differences between various marginalized groups. Research shows that some racial, ethnic, age, and gender groups are at higher risk than others and it unclear why (CDC, 2015; Joe, Canetto, & Romer, 2008; Leong & Leach, 2008).

Though there are aspects of suicide that are unclear, we do know that death by suicide is often the result of extensive planning. Therefore, suicide is considered predictable and preventable (Smith et al., 2008). If suicides are preventable, why do they continue? Where are

places in the process of growing in suicidality where an intervention could prevent an attempt to take one's own life? Are there factors that should be considered for adolescents from various cultural backgrounds? Answering these questions can differentiate life or death for adolescents.

This dissertation examines how adolescents experience suicidal thoughts and behaviors by using data from a nationally representative longitudinal dataset and system dynamics modeling. In this chapter, the topic of study and the specific goals of the project will be outlined. Subsequent chapters will explore the empirical background and theories that have been used to explain this phenomenon. Next, methods that outline this study will be detailed. Results of analyses are reported and a discussion of the findings will conclude this dissertation.

1.1 Overview of the Dissertation Study

This dissertation tests a predominant theory of suicide, the interpersonal theory of suicide or IPTS (Joiner, 2005; Van Orden et al., 2010), using a feedback perspective for individuals, ages 12 to 30. Using nationally representative longitudinal data from the National Longitudinal Survey of Adolescent and Adult Health (Add Health), IPTS is tested and modified for its ability to explain the causal mechanisms that lead a person to attempt suicide. Four waves of Add Health data ask questions in regards to the participant's experience of suicidal thoughts and behaviors, depression, problem-solving/coping behaviors, exposure to violence and trauma, family characteristics, and peer relationships.

The ITPS model is tested and then modified using extant literature and related theories to accurately predict suicide attempts for the general sample of adolescents from Add Health. Racial subgroups of Latino, Asian, Black, White, and Native American adolescents are also examined to determine whether the modified theory can explain differences in attempts. The

model is then calibrated and two interventions are tested for their ability to prevent suicide attempts during adolescence. Findings and implications are discussed.

1.2 Statement of the Problem

The prevention of suicide-related deaths has been a national priority for decades (U.S. Department of Health and Human Services [HHS], 2001). Yet, despite the monetary and marketing investments to reduce suicide, the rates of suicide have remained relatively the same, if not worse, over time *(*HHS, 2012). The inability to reduce the rate of suicides throughout the past few decades may be attributable to the utilization of research methodologies that are unable to account for the dynamic nature of suicidal processes across the life course (Schiepek et al., 2011). The ineffectiveness of prevention and intervention efforts could also be attributable to cultural differences in the phenomenology of suicidal thoughts and behaviors amongst adolescents (Joe et al., 2008).

Cultural and racial variations in rates of suicide may result from the contexts in which these behaviors occur and differences in patterns of help-seeking (Cash & Bridge, 2009; Goldston et al., 2009; Joe & Niedermeier, 2008). For instance, *familism*, the value that an individual's needs are second to that of the family's (Burgess & Locke, 1945), is a pervasive value in many families of Asian or Latino background and is postulated to be both a risk and protective factor in predicting their mental health (Campos, Ullman, Aguilera, & Dunkel Schetter, 2014; Han, 2007; Perez & Cruess, 2011). The concept of familism combined with cultural values of collectivism and shame, as present in some Asian immigrant families (Jang, Chiriboga, & Okazaki, 2009; Le & Kato, 2006), may lead adolescents to feel conflicted about

receiving help for any mental problems they may be experiencing. The influence of an individual's values or beliefs, however, has been given little attention in current suicide theories.

Despite this lack of emphasis, there is evidence of strong associations between clinical depression and suicide during adolescence (Cash & Bridge, 2009). Psychological autopsy studies show that up to 60% of adolescent suicide victims had a depressive disorder at the time of death and between 40-80% of adolescents met the diagnostic criteria for depression at the time of death, making depression the main predictor of suicidal ideation (Cash & Bridge, 2009). These type of predictions have been noted in studies using various popular theories of suicide, time and time again (e.g., Barzilay et al., 2015; Fergusson, Horwood, Ridder, & Beautrais, 2005).

Though depression is highly correlated with deaths by suicide, a vast majority of people who are depressed do not try to kill themselves (Rogers, 2003). Confirming these associations will not add to what we currently know about suicide. Though correlation is an important component in determining the presence of causation, it is only the first step. In addition to correlation, time ordering and randomization are needed to determine causality. According to Rogers (2003), the real questions are, "What is it about depression that provides the link to suicide? And what is it about the experience of depression that links it to suicide for some individuals and not for others?" (p. 17).

Researchers, child development experts, and practitioners assert that problems of suicide, in particular regarding its relationship with depression, may be interconnected, feeding off each other in reinforcing cycles (e.g., Ford & Lerner, 1992; McArdle, Hamagami, Chang, & Hishinuma, 2014). The methods used in most empirical studies on suicide, however, are limited by assumptions of linearity in the suicidal process (Schiepek et al., 2011). A nonlinear view of

suicide suggests that the feelings of suicidal thoughts and behaviors may not follow a straight path over time. Nonlinearity in suicidal thoughts and behaviors would indicate that slight changes in one's environment or feelings may cause substantial changes in one's actions or behaviors across time. Linear models, such as regression, "are not able to explain such processes because they transform external input onto a system (e.g., life events or changes in the environment of an individual) or internal changes of a system into a proportionally related output." (Schiepek et al., 2011, p. 662). The explanatory power of using methods that account for nonlinearities in the phenomenon of suicide is suggested by Rogers (2003). He states, "It is time to move complexity theory from metaphors to mathematical models and apply them directly to the study of suicide if their promise is to be fulfilled." (Roger, 2003, p. 13).

At present, only three known research studies examine suicide with consideration of the nonlinear effect of "vicious cycles" or feedback loops. Feedback loops refer to circular causal relationships between variables where increases or decreases in one variable have self-reinforcing or self-correcting effects on the other and then itself (Richardson, 1999; Sterman, 2000). The interaction of these loops, combined with time delays, and nonlinearities can create complex dynamics of suicide across time. Klieman, Liu, and Riskind (2014) published a study that attempted to account for the presence of feedback loops in the relationship between depression and suicide using structural equation modeling. Yip et al. (2014) recently published a population-based model using Markov chains to examine the dynamics of suicide across a population. Mishara (1996) modeled the dynamics of suicide using methods borrowed from physics. These first studies are important, but exclude factors that may explain cultural issues related to individual reasons for adolescent suicide.

In addition the lack of research explaining why suicide outcomes vary for adolescents, are gaps in identifying the most effective interventions for diverse groups of adolescents (Joe et al., 2008; Joe & Niedermeier, 2006, 2008). A one-size-fits-all approach to suicide prevention and intervention may not be appropriate or effective. This is especially true as the nation's minority population are projected to become the new majority within the next decade (Frey, 2011).

As presented above, there are a number of issues related to suicide research during adolescence that must be addressed. Disentangling the problems with intervention effectiveness must begin with an understanding of how suicide works and how processes may differ for subgroups of adolescents. The next section examines the purpose and aims of this study which will address these gaps.

1.3 Purpose of the Study

Using secondary data from the National Longitudinal Study of Adolescent and Adult Health (Add Health), this dissertation used feedback loops to determine whether the interpersonal theory of suicide (IPTS) (Joiner, 2005; Van Orden et al., 2010) can predict how suicidality increases through adolescence and into young adulthood for all adolescents and by subgroups of race and gender. Additionally, ways to prevent suicide attempts were examined.

1.3.1 Specific Aims

This dissertation study aimed to accomplish the following:

1. Explore the usefulness of the interpersonal theory of suicide (ITPS) by Joiner (2005) and Van Orden et al. (2010), when specified as a system dynamics model,

to explain patterns of suicidal behaviors for adolescents in the Add Health dataset from ages 12 to 30.

2. Create a modified theory of IPTS using system dynamics to explain individual patterns of suicidal thoughts and behaviors from adolescence into adulthood.
3. Identify whether the modified theory can explain variances in suicidal behaviors for subgroups by race and gender.
4. Identify "leverage points" or intervenable areas where small changes in the system can prevent suicide attempts from adolescence into adulthood.

1.3.2 Research Questions and Dynamic Hypotheses

The structure of any given system generates dynamic behaviors and outcomes. A dynamic hypothesis, in system dynamics, is an inquiry or conjecturing of the relationship between the structure and behavior of a dynamic system over time. Similar to general hypotheses, dynamic hypotheses are used to compare expectations against reality using experiments. Unlike a general hypothesis, however, dynamic hypotheses suggest that a proposed feedback structure can generate the dynamic behaviors that are depicted in reference modes. A reference mode is a tool in system dynamics that explicitly identifies and graphically depicts a given behavior over time usually using historical trends from actual data. Therefore, a dynamic hypothesis should entail a set of propositions that can be tested about a change over time that is endogenous, or within the boundaries of a given system. For the purpose of this dissertation, the following research questions and their corresponding hypotheses are listed.

RESEARCH QUESTION 1

How do adolescents experience suicidal thoughts and attempts from adolescence into adulthood?

- **Hypothesis 1**: Adolescents who desire to die by suicide may increase their capability to attempt suicide through practice, creating a greater determination to die by suicide in the absence of effective responses to one's attempt.

RESEARCH QUESTION 2

What types of initiatives are most effective at preventing or reducing suicide attempts across adolescence and into adulthood?

- **Hypothesis 2**: Initiatives that are aimed at reducing depression across the life span are more likely to reduce attempts than initiatives aimed at targeting suicide post attempt.

1.3.3 The Reference Mode

In system dynamics, the reference mode is used as a way for formally describe and define a dynamic problem. The reference mode depicts the dynamic nature of a problem across time and demonstrates a trend of the actual conditions and those that are "desired" by the project's aims/objectives either verbally or graphically. Figure 1.1 depicts the reference mode for this study using data on the mean number of suicide attempts for Add Health participants, ages 12 to 30. The solid line demonstrates actual data on mean attempts for adolescents who attempted suicide during Wave 1 or 2 of Add Health by age with shading to demonstrate 95% confidence intervals. The dashed line depicts the number of suicide attempts for adolescents who did not attempt during adolescence (Waves 1 and 2) from ages 12 to 30. Though it is possible that adolescents who attempted also completed their suicides and therefore were not available for future waves to document their attempts, this is not the case for the Add Health sample. In this particular weighted subset of data, no adolescents died by suicide.

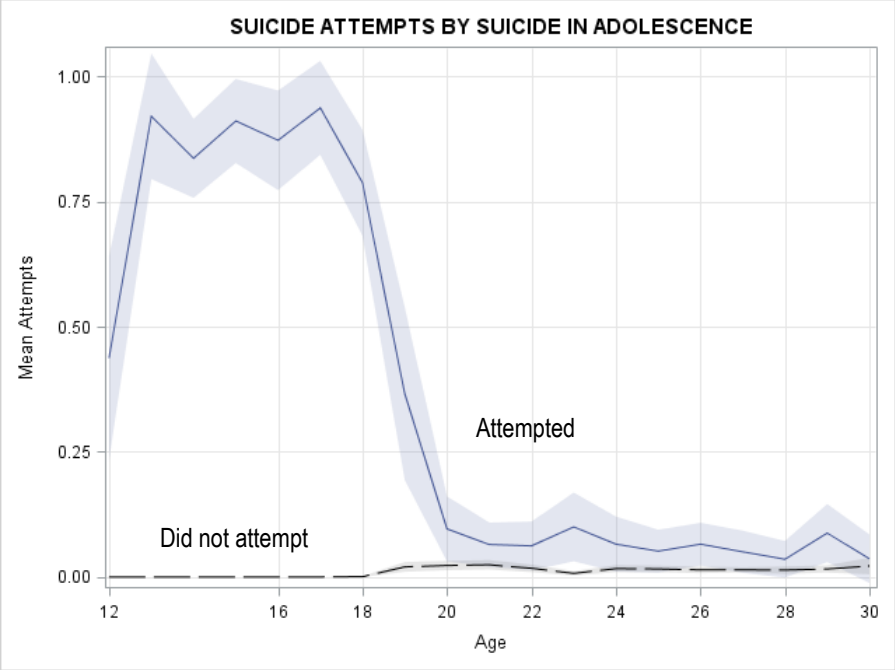


Figure 1.1 Reference Mode: Mean Suicide Attempts for Attempted Suicide by Age

Dynamic behaviors, such as those depicted in the reference mode in Figure 1.1, can be understood better by breaking down phases of behavior. By examining phases of behavior over time of suicide attempts, some possibilities about the structure that creates these behaviors can be inferred. These phases are characterized by balancing and reinforcing loops and are demonstrated in Figure 1.2.

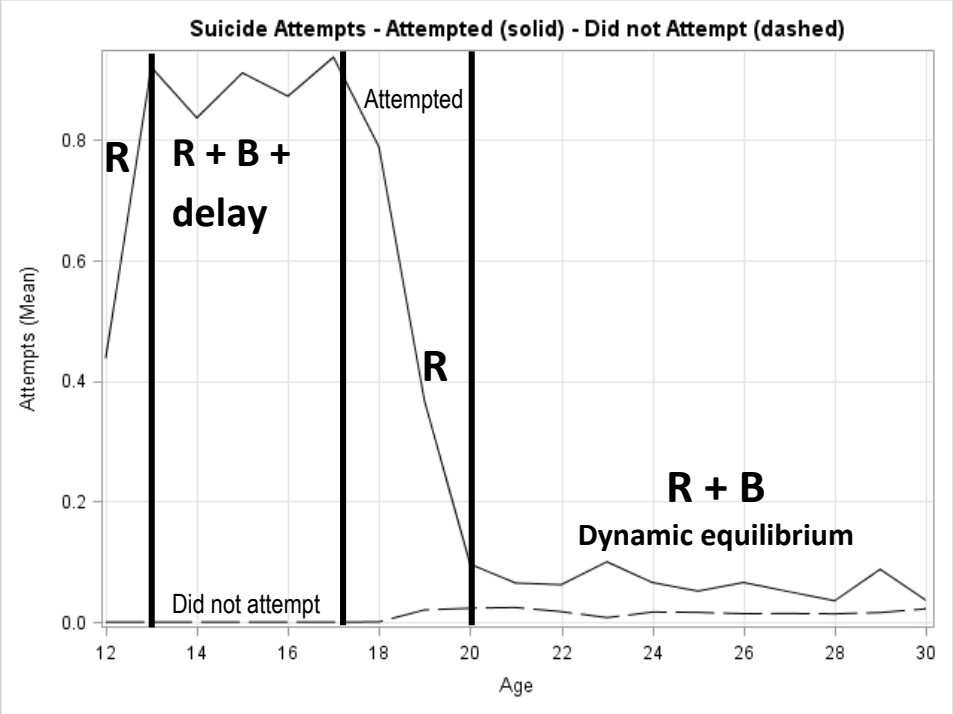


Figure 1.2 Reference Mode Depicted with Balancing and Feedback Loops

The reference mode depicted in Figure 1.2 takes the data from Add Health (Figure 1.1) and overlays the graph with the plausible phases of feedback behavior. Figure 1.2 suggests that there are reinforcing mechanisms driving suicide attempts sharply from 0.4 to 1 attempt from ages 12 to 13. There also seem to be a combination of reinforcing and balancing mechanisms with delays occurring from ages 13 to 17, demonstrated by the sustained number of attempts oscillating during that time period. Around ages 17 to 20, there's a sharp decline or reinforcing loop responsible for the drop in attempts. From ages 20 to 30, there is a combination of reinforcing and balancing loops that are creating a dynamic equilibrium in suicide attempts. Analyzing these reference modes in phases can help in future iterations of modeling to examine which structures are driving outcomes.

Figure 1.3 depicts a reference mode for the number of attempts made by gender. The general shape of the line follows that of the entire sample of adolescents who attempted suicide,

with a reinforcing mechanism driving suicide attempts from ages 12 to 13. For females (solid line), there are balancing and reinforcing loops that sustain suicide attempts at a mean of .9 to 1 from ages 13 to 18, with sharp decreases from 18 to 21 to near zero and balancing behaviors across ages 21 to 30. For males (dashed line), suicide attempts increase sharply to age 13 with decreases, yet relatively high levels of attempts from ages 14 to 16 with another sharp increase from age 16 to 17. From ages 17 to 20, there is a general decrease in attempts back to zero, however many perturbations from ages 22 to 24 and again from 29 to 30, though relatively lower.

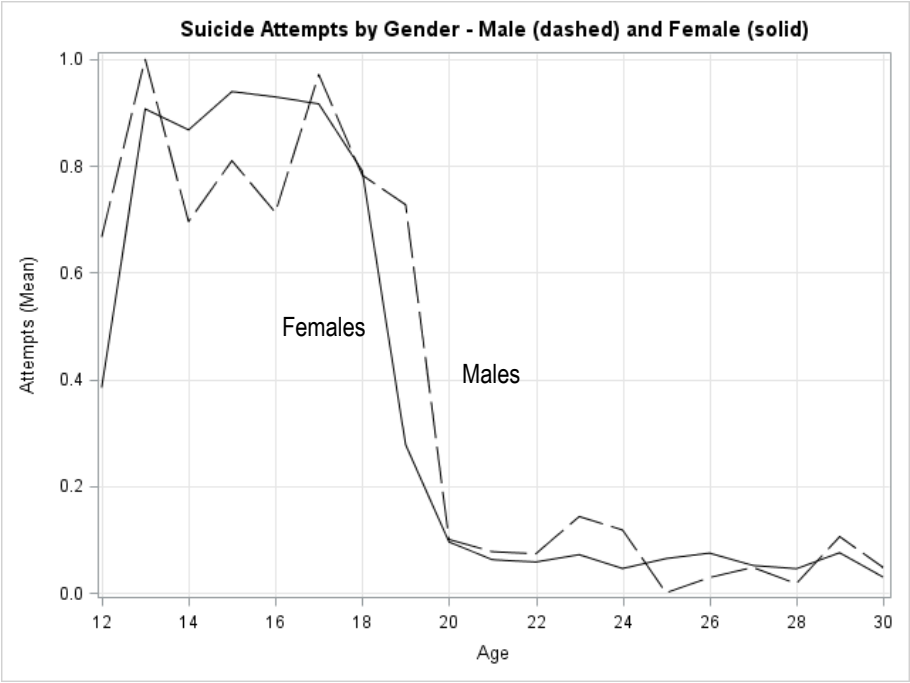


Figure 1.3 Suicide Attempts by Gender for Adolescents who Attempted Suicide

Figure 1.4 demonstrates suicide attempts when disaggregated by race. Though important to see the differences, here we are examining the general pattern of suicide attempts for adolescents from each racial group who attempted during adolescence. The general pattern of behavior is similar to attempts shown in Figure 1.1 and 1.3, however the differences vary in

regards to peaks and timing by race. For instance, for Asian adolescents, there seems to be peaks

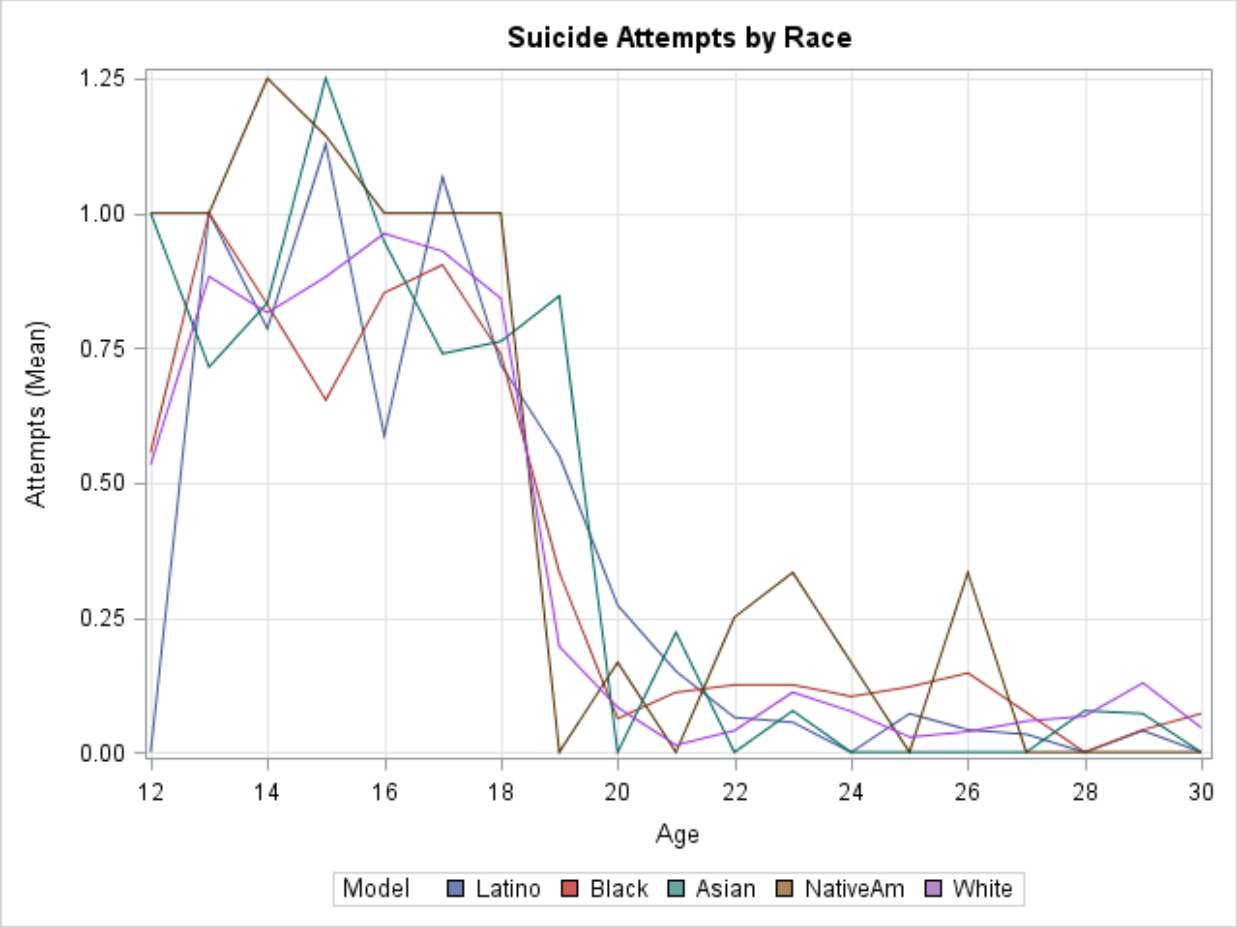


Figure 1.4 Attempts by Race for Adolescents who Attempted Suicide

of suicide attempts that increase from ages 14 to 15, with sharp decreases into age 18 and then increases again from ages 18 to 19 and ages 20 to 21. Native Americans also demonstrate sharp increases in attempts from ages 12 to 13, sustained attempts into age 17, sharp decreases from age 17 to 18 and then peaking attempts from ages 18 to 19, 20 to 22 and 23 to 24.

The purpose of using these reference modes is to compare results from the system dynamics simulation model fitted with parameters from Add Health data for model calibration and to examine whether the proposed theoretical structure of attempts is accurate. The model

will also be examined for its usefulness in predicting suicide attempts by race. Once the model can accurately simulate the reference mode, ways to reduce suicide attempts will be tested and documented.

1.4 Definitions and Terms

1.4.1 Suicide and Suicidal Thoughts and Behaviors

According to the APA, suicide is defined as the act of killing oneself, most often as a result of depression or other mental illness ("Suicide," 2015). "Suicidal behavior" is classified as ideations (i.e., thoughts), communications, and behaviors that are self-initiated and have some degree of intent to die (Van Orden et al., 2010). This behavior may also be referred to as "suicidal thoughts and behaviors" (STB).

"Suicide attempt" refers to a non-fatal self-directed potentially injurious behavior with any intent to die as a result of the behavior. The attempt may or may not result in injury. Related to suicide attempts, but not necessarily similar by the intent is "non-suicidal self-injury" or NSSI. NSSI refers to deliberate direct destruction or alterations of body tissue without a conscious suicidal intent (Erbacher, Singer, & Poland, 2015). These terms are important in depicting various behaviors that are highly associated with STB.

One form of suicide that will not be included in this conceptualization of suicide is killing oneself as a strategic act of defiance or martyrdom for a said cause. This type of suicide, called "altruistic suicide" by suicidologist, Emile Durkheim, corresponds more precisely with the construct of martyrdom (Lewis, 2012). This term, though important and may pertain to a small number of adolescents, is beyond the scope and interest of this dissertation.

1.4.2 Race, Ethnicity, and Culture

This study, which is rooted in the perspective of social work, uses the social construction of race as a proxy for difficulties that accompany experiences as a racial minority, such as discrimination, prejudice, or marginalization (Allen-Meares, Colarossi, Oyserman, & Deroos, 2003).

Race. Race, as a biological construction, is a highly contested and greatly debated topic (APA, 2002; Dunham & Wilson, 2007; Schiele & Hopps, 2009). The biological construction of race or ethnicity used as predictors is a form of racial reasoning (Zuberi, 2000), however, race can be used as a proxy variable for experiences *associated* with membership in a racial group, such as discrimination (Allen-Meares et al., 2003). Issues with race are apparent in the disproportionate experience of social problems by racial/ethnic grouping, from poverty to criminal incarceration rates, differential treatment in schools, to health disparities (Schiele & Hopps, 2009).

In other academic disciplines, race has been utilized as a biological construct to study causal inferences (Zuberi, 2000). For instance, medical research has used the biological concept of race as a proxy for underlying genetic structures (Root, 2003). However, using race or gender, unalterable characteristics of individuals, to make causal claims are inappropriate variables for inferential statistical analysis (Zuberi, 2000). Treating models that use race as an explanatory or predictor variable is a form of racial reasoning (Zuberi, 2000). For the purpose of this dissertation, race will be defined as a social construction, a category to which others assign individuals or themselves on the basis of physical characteristics, such as the color of one's skin

or hair type. Perceptions based on these factors may lead to overgeneralizations and stereotypes resulting in treatment or discrimination (APA, 2002).

Culture. According to the APA (2002), *culture* is defined as "the belief systems and value orientations that influence customs, norms, and practices" (p. 8). Culture is the embodiment of a worldview through learned and shared beliefs, values, and practices, including religious and spiritual traditions. It is fluid and dynamic, including both cultural universal phenomena as well as culturally specific constructs. Culture may transcend issues, such as race.

Ethnicity. Ethnicity refers to one's acceptance of the group mores and practices of one's culture of origin and the concomitant sense of belonging (APA, 2002). This definition of ethnicity aligns with the American Psychological Associations guidelines for multicultural research. This construct may be multidimensional, as one may prescribe to various ethnic backgrounds (e.g., "Mexican-American").

1.4.3 Depression

Depression, as defined in this dissertation by the World Health Organization (WHO)'s International Classification of Diseases-10 (ICD-10), is a cluster of specific symptoms with associated impairment (Thapar et al. 2012). This definition is chosen over the American Psychological Association's Diagnostic and Statistical Manual of Mental Disorders (DSM) due to its utilization of national and international health statistics in defining disorders (Regier, Kuhl, & Kupfer, 2013). The international perspective on depression may be more appropriate in this study of racial and ethnic minority groups. According to the ICD-10 definition (World Health Organization [WHO], 2015), depression in adolescents includes at least two of the three core symptoms:

- Depressed mood present for most of the day and almost every day;
- Loss of interest or pleasure in activities;
- Decreased energy or increased susceptibility to fatigue.

Additionally, associated symptoms include:

- Loss of confidence or self-esteem;
- Unreasonable feelings of self-reproach or excessive inappropriate guilt;
- Recurrent thoughts of death or suicide, or any suicidal behavior;
- Diminished ability to think or concentrate;
- Change in psychomotor activity, agitation, or retardation;
- Sleep disturbance;
- Change in appetite with corresponding change in weight.

At least two or three of the above symptoms must be present for at least two weeks to diagnose a mild depressive episode. Someone with a *mild* depressive disorder is usually distressed by their symptoms but will probably be able to continue most activities. *Moderate* depressive episodes include four or more of the above symptoms and the individual is likely to have great difficulty in continuing ordinary activities. *Severe* depressive episodes without psychotic symptoms describe episodes of depression in which several of the above symptoms are marked and distressing, typically loss of self-esteem and ideas of worthlessness or guilt. Suicidal thoughts and acts are common and a number of somatic symptoms are also present. Episodes of severe depression with psychotic symptoms may include severe depression, as previously described, accompanied with hallucinations, delusions, psychomotor retardation, or stupor so severe that ordinary social activities are impossible. Severe depression with psychotic symptoms may also be a danger to life from suicide, dehydration, or starving.

1.5 Significance of the Study

This project offers contributions to existing research on the relationship between depressive symptoms and suicidal thoughts and behaviors for diverse groups of adolescents into adulthood. Moving beyond descriptive or correlational outcomes associated with suicide, this dissertation will examine the development of suicide attempts over adolescence. At present, the longitudinal relationship between depressive levels, suicide, and prevention and intervention has not been explored using systems thinking or the feedback perspective.

Additionally, the proposed study works directly towards two of four strategic objectives set by the National Institutes of Mental Health (NIMH). Specifically, this research targets NIMH Strategic Objective 2: to chart mental illness trajectories to determine when, where, and how to intervene; and NIMH Strategic Objective 3: to develop new and better interventions that incorporate the diverse needs and circumstances of people with mental illness (National Institute of Mental Health [NIMH], 2015).

By addressing these objectives, this study has the potential to influence the way practitioners intervene with adolescents who have attempted suicide. Using computer simulation to test a model of suicide attempts, increased specification in interventions can be manipulated in an increasingly ethical manner. This study moves beyond the general period of 'follow-up' (usually one and a half times the intervention's duration) to expand understand across the lifespan. Where most studies are limited by the financial, logistical, and ethical constraints of research, this study provides an example of using computer simulation to predict outcomes beyond what has been previously feasible with actual participants. Similar types of computer simulations (e.g., agent-based modeling, system dynamics), have been used to predict consumer

behaviors (e.g., Amstutz, 1967), changes in the environment (e.g., Meadows & Meadows, n.d.), and the dispersion of diseases (e.g. Thompson & Tebbens, 2007).

This study also adds to the field of social work research by using a systems-focused method. Many social theories, such as those related to depression and suicide, discuss the presence of "vicious cycles." The term is proliferated in theoretical and practical language related to social work in various realms. Yet, few research studies utilize methods that account for these types of causal nonlinear relationships across time. Therefore, this study adds to a repository of newer emerging studies on social issues that utilize the power of computer simulation to increase our theoretical understanding (e.g., Hovmand, Ford, Kyriakakis, Brown, & Brown, 2009; Rahmandad & Sabounchi, 2011; Wittenborn, Rahmandad, Rick, & Hosseinichimeh, 2015).

1.6 Summary

Previous suicide research has identified numerous correlates of completed and nonfatal suicidal behaviors. Despite these descriptive efforts, there is little evidence that this type of research has effectively impacted the rates of suicide, reduced the occurrence of other suicidal behaviors, or informed understanding of the suicidal process (Rogers, 2003). There are also gaps in literature depicting suicide from a non-European American viewpoint. Up until this point, suicide processes have predominantly been studied using a linear frame of analysis, though theories suggest that there are dynamic processes that create complex patterns behind depressive symptoms and their link between suicidal thoughts and behaviors. Research questions answered by this dissertation will inform existing theories and how and why various interventions may or may not work to reduce the rates of suicide prevalence from adolescence into adulthood.

Chapter 2: Background

The purpose of this chapter is to describe the empirical evidence and theoretical conceptualizations of suicide during adolescence, with particular attention placed on research for subgroups of racially diverse adolescents. In particular, theoretical and empirical studies on the occurrence of suicide during adolescence using Joiner's (2005) interpersonal theory of suicide (IPTS), will be examined. A discussion of the research and theoretical basis for suicide during adolescence and young adulthood will lead to the next chapter, which describes the methods and conceptual framework for this study.

2.1 Background

Background of Research on Suicide in Adolescents

Emile Durkheim, a French sociologist and one of the first scholars in the late 1800s to theorize suicidality, greatly influenced today's research on suicide (Mcintosh, 2002). The publication of Durkheim's *Le Suicide*, spurred on numerous studies and alternative theories on the phenomenon (Mcintosh, 2002). Though research about suicide during adolescence has proliferated in the past thirty years, social work research on suicide and efforts to effectively reduce this nonreversible act is comparably dismal (Joe & Niedermeier, 2008).

Social work research on suicide has historically focused on clinical populations, with little disaggregation of intervention effects for specific racial/ethnic groups (Joe et al., 2008). A systematic review of social work research on suicide resulted in a small total of 45 social work studies (Joe & Niedermeier, 2008). There is clearly a space for increased understanding of the

role of social workers role in this area of research, especially as it pertains to recovery from attempts and prevention of recurring incidences into adulthood.

In the past 25 years, perhaps the most substantial development in this field has been the demystification of youth suicide (Erbacher et al., 2015; Goodyer, 2001). Many researchers now understand that youth considering suicide often have undertreated or untreated mental health problems (Erbacher et al., 2015; Fergusson et al., 2005). Additionally, there is an increased understanding of the etiology of suicidal behaviors for youth, and how these behaviors are affected by various issues with self-efficacy (e.g., Valois, Zullig, & Hunter, 2013), emotion regulation (e.g., Pisani et al. 2013), and social and interpersonal factors (e.g., King & Merchabnt, 2008).

It is also generally understood that to understand suicide, one must also study depression. The two phenomena are overlapping, but also distinct (Goodyer, 2001). One of the most prevalent characteristics of suicidal youth is intense depression (Cash & Bridge, 2009; Wodarski, Dulmus, & Wodarski, 2003). Depression may occur naturally during adolescence as part of the maturation process (Maughan, Collishaw, & Stringaris, 2013), and many cases of depression actually dissipate with time. However, the intensity and severity of these symptoms can affect an adolescent's psychological health well into adulthood (Wodarski et al., 2003).

A precursor to suicide in almost 50% of documented cases, major depression during adolescence affects at least approximately 4-5% of early teens (Costello, Erkanli, & Angold, 2006; Maughan et al., 2013). In 2013, an even larger percentage of adolescents (29.9%) indicated feeling hopeless or sad almost every day for the previous two weeks before being surveyed (Kann et al., 2014). Converging evidence of psychological autopsy studies,

community-based prospective studies, and clinical studies point to the importance mental disorders such as depression in the pathogenesis of suicidal behavior and suicide (King & Merchant, 2008a).

Empirical studies on depression seem prolific in scholarly research. However, research on depression was not extensive prior to the 19th century (Goodyer, 2001). Even less than three decades ago, depression was considered an adult disorder. Children were thought to be too immature to experience depression and adolescents who had symptoms of depression were told they were experiencing a "normal" part of puberty (Maughan et al., 2013).

In addition to the denial that children or adolescents could experience the moods associated with depression, were issues with terminology and concepts. For example, the terms "mania", "melancholia", the "vapours", and a range of alternatives were used to describe depressive states (Goodyer, 2001). These terms were further convoluted by inconsistent use and debatable definitions for "affect", "mood", "emotion", and "feeling" (Goodyer, 2001). Much has developed since those early years of study.

Currently, the study of depression during adolescence is a burgeoning field. Research indicates that experiences of depression actually peak during adolescence (Thapar, Collishaw, Pine, & Thapar, 2012), especially for girls. Furthermore, depression during adolescence can be viewed as an early-onset form for the equivalent adult disorder, taking on a chronic and recurring role in the course of an adult's life (Maughan et al., 2013; Thapar et al., 2012). Similar to the history of research on child and adolescent depression, research on suicide during adolescence has emerged in response to the increased awareness that suicide also affects children and youth.

2.2 Suicide in Adolescence: Theory and Empirical Studies

Suicides are devastating to families, friends, and communities. It is irreversible and jolting. Recent estimates by the U.S. Centers for Disease Control indicate that the rates of suicide and suicide attempts increase dramatically from ages 14 to 20, from 2.64 to 12.93 per 100,000 people (National Center for Health Statistics, 2014). Suicide has been reported to be the third leading cause of death for young people, ages 10-24, approximately 4,600 lives are lost each year by suicide (U.S. Centers for Disease Control [CDC], 2014).

Death is not the only concern related to suicide for adolescents. The CDC recently reported that the number of adolescents having suicidal thoughts has risen over the years, from 13.8% in 2009 to 15.8% in 2011 (Kann et al., 2014). Though the rates of suicide are reported for all teens across the United States, there is great variation in rates of suicide by gender, geography (Wasserman et al., 2005), and culture (Van Orden et al., 2010). In most countries, male suicides outnumber the number of female suicides in every nation, however females outnumber males at three to one in regards to non-lethal attempts (Van Orden et al., 2010). According to data from the 2013 YRBS, the prevalence of having attempted suicide was higher among female (10.6%) than male (5.4%) students (Kann et al., 2014). This discrepancy in suicidal thoughts and attempts are often referred to as the gender paradox (Canetto & Sakinofsky, 1998).

2.2.1 Risk and Protective Factors

There are a diverse number of causes that have been postulated to understand the pathogenesis of depression and suicide, many of which are interrelated. For instance, depression during puberty is one of the biggest risk factors of suicide (Thapar et al., 2012). More than 50 percent of suicide victims reported to have a depressive disorder at time of death (Thapar et al.,

2012). This figure is considered conservative, however, due to the underdiagnoses of depression in adolescence (Costello et al., 2006).

The presence of other types of psychiatric disorders are also common risk factors for suicidal behaviors in teens, as 90% of adolescents who died by suicide also had a psychiatric illness (Wolfe, Foxwell, & Kennard, 2014). Though depression is most prevalently found to be associated with teen suicide, the risk is heightened when depression is also present with mood disorders, such as conduct disorder, anxiety, psychosis, anorexia nervosa, or PTSD (Wolfe et al., 2014). Other risk factors associated with suicide includes a previous history of non-suicidal self-injury (NSSI) (Prinstein, 2008; Tuisku et al., 2014) and multiple prior attempts to die by suicide (King & Merchant, 2008b).

In addition to psychiatric disorders, certain personality factors are associated with suicide. In a sample of children and youth, higher levels of impulsivity were associated with suicidal thoughts and behaviors, including higher novelty seeking, harm avoidance, lower scores on persistence, self-directedness, and cooperativeness (Ghanem et al., 2013). Other factors predicting the occurrence of suicide attempts in youth from this sample were the presence of psychiatric disorders, stressful life events, and high reward dependence. This data supported the hypothesis that impulsivity and personality traits play an important role in youth suicide, independently or in interaction with other factors (Ghanem et al., 2013).

Protective factors that are associated with depression, despite exposure to risk factors, include individual and social factors. Individual attributes that protect against the development of depression in adolescents who are at high-risk include inherited factors and high intelligence (Thapar et al., 2012). Most consistently, high quality interpersonal relationships, either with

peers or family members, are found to protect against depression, especially for those who are exposed to child maltreatment or parental depression (Thapar et al., 2012). Other protective factors that are potentially modifiable include emotion-regulation skills, coping mechanisms, and thinking styles (Siener & Kerns, 2012; Suveg, Hoffman, Zeman, & Thomassin, 2009; Thapar et al., 2012).

It is important to note that protective factors may also differ for various ethnic groups. English language proficiency, pride in ethnic identity, and social support from ethnic communities may provide a buffer against the effects of perceived discrimination in some ethnic groups (Goldston et al., 2009). The concept of *familism*, an orientation in Latino and Asian cultures that emphasizes the obligation to make the family a central part of their lives, can serve as both a protective and risk factor for depression and suicide depending on the acculturation level of some adolescents (Han, 2007). Other types of protective factors may vary widely based on the complex mix of interpersonal, social, and environmental qualities.

2.2.2 The Role of Culture, Ethnicity, and Race in Suicide

The role of culture, ethnicity, and race in the development of suicide for U.S.-based adolescents has not been fully explored (Goldston et al., 2009; Joe et al., 2008; Leong & Leach, 2008). Recent estimates suggest that depression during adolescence affects minorities at higher rates, with approximately 9% of Hispanic and 8% of blacks experiencing major depressive disorders when compared to 7% of their white peers (Avenevoli, Swendsen, He, Burstein, & Merikangas, 2015). Race may also interact with gender. According to 2013 data from the YRBS, rates of suicide attempts varied greatly by race and gender, with Hispanic females (15.6%) attempting suicide at four times the rate of white males (4.2%) and two times the rate of white

females (8.5%) (Kann et al., 2014). These discrepancies stress the need to examine how suicide theories may differ by the attitudes, values, and experiences of various racial subgroups.

Especially in a country, such as the United States, understanding issues with racial or ethnic self-identification may shed light on the experience of adolescent suicide. The search for ethnic identity is a major developmental task that has a strong role in predicting one's mental health and academic achievement during adolescence (Phinney & Ong, 2007; Wakefield & Hudley, 2007). Some theorists suggest that encounters with racism, prejudice, or discrimination marks the shift from an unexamined racial/ethnic status, to a search for ethnic identity (Wakefield & Hudley, 2007). Adolescents in multicultural societies (e.g., the U.S.) are increasingly aware of ethnic issues and often desire to explore these discrepancies based on their own identity (Wakefield & Hudley, 2007). This search may lead to an immersion in an adolescent's ethnic group's history, cultural practices, and beliefs, with frequent comparisons of these practices and beliefs to that of the greater multiethnic culture in which they reside (Wakefield & Hudley, 2007).

In addition to understanding the process of ethnic identity formation, it may be helpful to examine within-group differences of regarding attitudes and values towards suicide. Rather than only examining racial or ethnic group affiliation as a label, strong emphasis should also be placed determining an individual's level of acculturation; attitudes towards family; adhereance to collectivism vs. individualism; ascribed religion and spirituality; varying manifestations and interpretations of distress; and cultural mistrust, stigma, and help-seeking (Goldston et al., 2009). For instance, acculturative stress (Hovey & King, 1996), immigrant generation status (Peña et al., 2008), and reasons for immigration are risk factors for depression and suicide (Bhui, Dinos, & Mckenzie, 2012), however even these constructs vary within racial and ethnic groups. For

instance, Asian American adolescents whose families immigrated to attain economic advancement may have far different exposures to risk than others who immigrated seeking refuge from war-trauma (Bhui et al., 2012), or endured physically dangerous immigration journeys (Goldston et al., 2009). African American youth vary widely in their risk for suicidal behaviors whether they are from rural or urban areas, are recent immigrants, or whose ancestors were brought to the U.S. through slavery (Goldston et al., 2009).

It is apparent that the racial and ethnic factors influencing depression and suicidal thoughts and behaviors are more complex than they seem. To increase the efficacy of intervention efforts, is important to disentangle these differences by examining the underlying attitudes and experiences of individuals. The next section will discuss theories that have been proposed to explain suicidal thoughts and behaviors.

2.3 Theoretical Framework

Many theories on suicide are salient to the development of adolescents into adulthood, though few specifically describe cultural influences that may affect this development. The main theory of interest that will be examined in this dissertation is Joiner & Van Orden's view of the interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010). This theory is chosen to examine over other theories, such as David Lester's Paradox Theory of Suicide (Lester, 1989) or Durkheim's Theory of Suicide (Durkheim, 1956), due to its proliferation and increasing support from empirical frameworks and studies (Gunn, 2014). Chu's cultural model of suicide (Chu, Goldblum, Floyd, & Bongar, 2010) will also be examined because it specifically accounts for cultural factors in suicide. Developmental systems theories will also be reviewed for its usefulness in accounting for iterative aspects of development during adolescence.

2.3.1 The Interpersonal Theory of Suicide

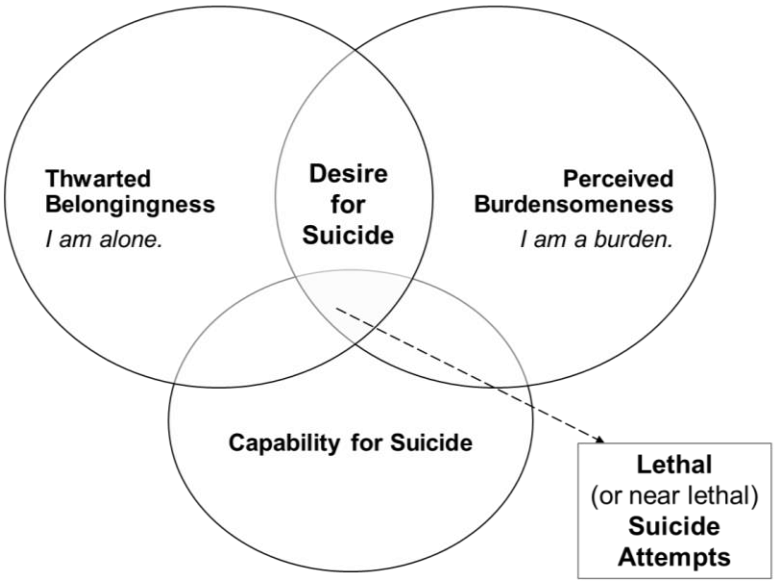
The interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010) is grounded on the assumption that people die by suicide because they can and because they want to. In this theory, three constructs are central to suicidal behavior: two constructs are primarily related to suicidal desire (thwarted belongingness and perceived burdensomeness) and one construct focuses on capability (the acquired capability for suicide). The theory also specifies the relationship between these constructs and includes a causal hypothesis for the development of the desire for suicide and capability to engage in serious suicidal behavior (i.e., lethal or near-lethal attempts).

Thwarted belongingness. The first construct included in the interpersonal theory of suicide is the idea of low social connection or integration (Van Orden et al., 2010). Social connection is associated with suicide because it is fundamental to human psychological needs (Van Orden et al., 2010). Thwarted belongingness is the perception that one is alienated from others or is not an integral part of one's family, circle of friends, or other valued group (Joiner et al., 2009). This construct is corresponds to Durkheim's theory of suicide, which places high importance on social relationships. When this emotional state is combined with a sense of perceived burdensomeness, Van Orden suggests that a desire for death develops. Durkheim (1897) suggests that the dysregulation of social forces, such as diminished social integration, can lead to an increase in suicide due to a lack of connection to something that transcends oneself (Van Orden et al., 2010). Thwarted belongingness is described as a dynamic cognitive-affect state, influenced by both interpersonal and intrapersonal factors which may vary across time.

Perceived burdensomeness. Perceptions of burdensomeness is a common threat between family conflict, unemployment, and physical illness that can account for associations with suicide. Though it may not seem applicable to adolescents, a perceived sense of burdensomeness on family is also a key factor in Sabbath's (1969) family systems theory of adolescent suicidal behavior (Van Orden, 2010). In Sabbath's theory, an adolescent may perceive oneself to be an expendable member of the family, a construct that relates to the idea of perceived burdensomeness. A child/adolescent may sense their expendability either consciously or unconsciously through spoken or unspoken actions or words from their family (Sabbath, 1969). According to this theory, there are pathogenic parental attitudes toward the adolescent that are interpreted by the individual that he or she is no needed and, perhaps, that the family would be better-off if the adolescent was dead (Lester & Rodgers, 2013).

Acquired capability for suicide. According to the interpersonal theory of suicide, in order to kill oneself, must lose some of the fear associated with suicidal behaviors (Van Orden et al., 2010). This aspect of IPTS draws upon evolutionary models of fear and anxiety. It builds upon the assumption that humans are biologically wired to fear suicide because it involves exposure to stimuli and cues that are associated with threats to survival. IPTS, however, suggests it is possible to acquire the capability for suicide by increasing physical pain tolerance and reducing one's fear of death through habituation and increased exposure to physically painful and/or fear-inducing experiences. These experiences may be repeated acts of self-harm, such as NSSI or repeated suicide attempts (Joiner et al., 2009) or family history of suicide, impulsivity, clustering/exposure to suicidality, combat exposure, suicide attempts, and childhood maltreatment (Van Orden et al., 2010). Therefore, one can 'build up' or reinforce one's own capacity to die by suicide by repeatedly being exposed to any of the described experiences.

Figure 3.1 depicts the interpersonal theory of suicide by Van Orden et al. (2010). In this theory, all components (a feeling of low social belonging, the perception of being a burden, and the capability for suicide) are necessary for lethal (or near lethal) suicide attempts.



**Joiner (2005); adapted by Van Orden et al. (2010)*

Figure 2.1 Interpersonal Theory of Suicide

The concepts included in this model are social and do not include any of the biological or physiological components that may predict suicide. Joiner (2009) says this in intentional. He indicates that of all the risk factors for suicidal behavior, ranging from the molecular to levels of culture, the most uniform support is related to indices of social isolation. Numerous research has demonstrated, however, that personality factors, such as impulsivity (e.g., Chen & Vazsonyi, 2011) or neuroticism (e.g. Fergusson, Beautrais, & Horwood, 2003) may exacerbate the feelings that Joiner (2005, 2009) believes are important to attempt or die by suicide.

Though this theory describes the capability for suicide as being enhanced through repeated practice with suicidal thoughts and attempts, it is not depicted as a feedback process. For instance, capability for suicide is dependent upon repeated exposures to death or self-injury. This aspect of IPTS suggests there is a reinforcing loop, where after an increasing number of exposures, there is a compounding effect leading to a diminished fear of attempting suicide. It is unclear, however, how much, for whom, and why these types of capabilities may occur. This leads us to theories that account for complexities in the relationship between depression and suicidal thoughts and behaviors during adolescence.

2.3.2 The Cultural Model of Suicide

The Cultural Model of Suicide (Chu et al., 2010) describes a theoretical framework to explain the role of cultural dissonance in suicidal thoughts and behaviors. A systematic review of the four major categories of culturally specific risk for minorities was conducted to create this model. The risks for minorities included cultural sanctions, or the acceptability of suicide as an option; idioms of distress, or one's likelihood to express suicidality; minority stress, such as experiences that minorities undergo due to social identity or position (acculturation, discrimination related strain, social disadvantages); and social discord, or conflict, lack of integration, or alienation from family, community, or friends (Chu et al., 2010). Figure 3.2 displays the model and the following narrative describes it.

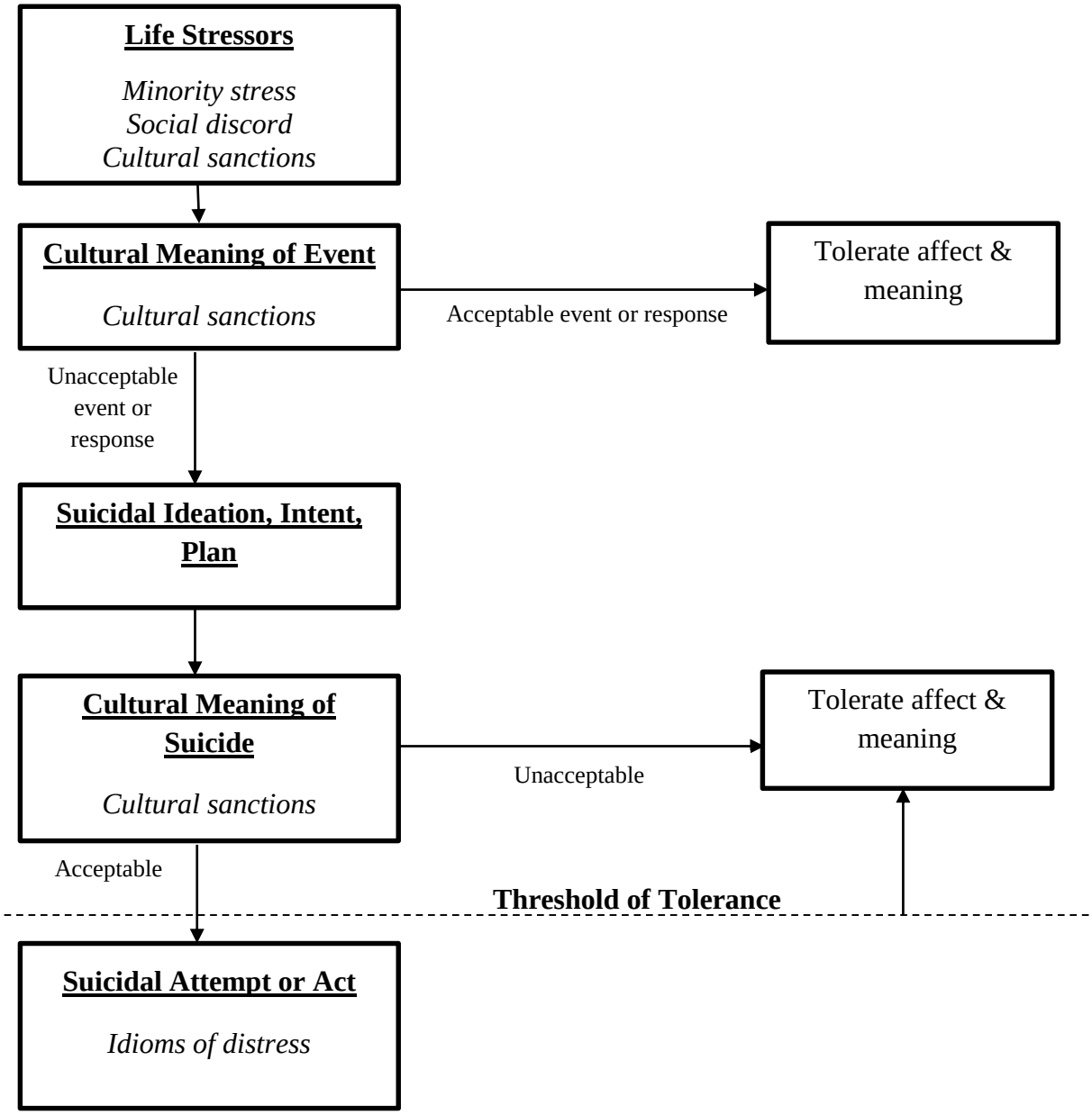


Figure 2.2 The Cultural Model of Suicide (Chu et al., 2010)

The cultural model of suicide was created using a systematic review of studies inductively compiled using a "developmental theoretical framework" of suicidal behavior (Chu et al., 2010, p. 36) for cultural groups, including African American, Asian American, Latino/a, and sexual minorities (Chu et al., 2010). Three theoretical principles are the basis for the cultural

model of suicide: 1) culture affects how suicidal thoughts/intent, plans, and attempts are expressed ("idioms of distress"); 2) culture affects the types of stressors that lead to suicidal behavior; and 3) cultural meanings associated with stressors and suicide affect the development of suicidal tendencies, one's threshold of tolerance for psychological pain, and subsequent suicidal behaviors. Specifically, cultural sanctions and messages of acceptance associated with stressors or a suicidal act plays a role in whether people engage in suicidal behaviors (Chu et al., 2010).

The first step of the model, "Life Stressors" refers to external events of personal (e.g., academic difficulty) or social nature (e.g., bullying) that tax one's ability to cope. These stressors increase one's vulnerability to mental illness or suicide. Social stresses, such as poverty or discrimination, and in particular, stresses that are specific to stigmatized identities of a minority (minority stresses), impact the types of difficulties that exacerbate the risk for suicide.

The next step, "Cultural Meaning of an Event," ascribed to life stressors mediates the development of a suicidal thoughts and behaviors. This framework suggests that life stressors do not operate in isolation of one's interpretation of stressful events and circumstances. Instead a person ascribes meaning to a life event that affects their suicidal thoughts and behaviors. The meaning is influenced by the cultural context of that individual. Next, depending on whether or not suicide is culturally sanctioned by one's culture may influence whether one chooses to perform a suicidal act. The dotted line depicting "Threshold for Tolerance" in this model is based off of cognitive behavioral theories that suggest a suicide attempt or gesture occurs when one's tolerance level for despair is surpassed.

The cultural model for suicide is an important start to accounting for the differences in suicidal behaviors based on one's cultural values and contexts. The model is similar to and varying from existing models of suicide in a number of ways. First, the model accounts for the stressors one may experience as a cultural minority that may influence one's experience of suicidal thoughts and behaviors. Secondly, it calls out a distinct lens through which individuals process the acceptability and value of suicidal thoughts and behaviors and how this affects their motivations. These are missing components from most theories, as many people, regardless of minority status, may struggle with whether or not it is acceptable to consider or attempt suicide.

Though there are merits to this model, there are also some limitations. First, the cultural model of suicide makes an implicit assumption that culture is the only factor that allows one to consider suicidal thoughts or attempts. Instead of viewing culture as a moderator, this model explains that culture mediates suicidal thoughts and behaviors (Chu et al., 2010). Though the cultural meaning of suicide is important, it is arguably not the most important influence on whether or not someone will make a suicidal attempt. More research would be necessary to understand whether cultural meaning is a mediator or moderator of an event.

Another limitation of this model is that there is an iterative component that is implied but not made explicit. For instance, one may wrestle with life stressors, ascribe cultural meaning to these stressors, but it may not automatically lead one to consider thinking about death. In some cases, one life-changing stressor may trigger a suicidal thought. However, for most cases, it is an accumulation of negative life stressors, perhaps over time, that lead one to become increasingly suicidal (Fergusson et al., 2003). These limitations suggest a need for combining existing theories of suicide to understand the etiology and process through which adolescents entertain the idea of suicide as a feasible way to escape from their difficulties.

2.3.3 Developmental Systems Theories

Dr. Richard Lerner, a prominent adolescent development researcher, proposed that the development of teens should be analyzed using a dynamic theory. Developmental Systems Theory (DST) indicates that theorists and research should account for the iterative development that occurs through individuals, their environmental contexts, and relationships (Lerner, Lerner, De Stefanis, & Apfel, 2001; Lerner, von Eye, Lerner, Lewin-Bizan, & Bowers, 2010). DST takes Bronfenbrenner's ecological model one step further examining the effect of reinforcing and balancing (bidirectional) relationships between the biological composition, contexts, and social circles that influence an adolescent's development.

Developmental systems theories emphasize that when the individual and their context benefit the person and his/her ecology, these developmental regulations may be termed "adaptive" (Richard M Lerner et al., 2010). Though developmental systems theory is prolifically used as a basis for adolescent research (Kia-Keating, Dowdy, Morgan, & Noam, 2011; Richard M Lerner, Lerner, von Eye, Bowers, & Lewin-Bizan, 2011; Urban, Lewin-Bizan, & Lerner, 2010), few studies have utilized methodological tools to measure these bidirectional relationships over time.

2.4 Empirical Studies on Suicide during Adolescence

Given the emphasis on using the interpersonal theory of suicide (IPTS) to examine suicide attempts during adolescence and into adulthood, a short review of the empirical work on this theory is outlined. The emphasis here will be on adolescent studies, however there are numerous studies with college students and other populations that have used this theory.

Feedback of attempts and intent to die. Empirical evidence from other studies indicate a feedback relationship with increasing attempts and an intent to die. In an empirical study of 180 adolescents followed for 13 years to adulthood after a psychiatric hospitalization, Goldston and colleagues (2015) examined the suicide attempts and life events. This study indicated that after ages 17-18,the majority of attempts were repeats, or made by individuals with prior suicidal behaviors, with intent for lethality increasing both with age and the number of prior attempts (Goldston et al., 2015). This study demonstrated the evidence of escalation of recurrent suicidal behavior, a key component in IPTS regarding a capability for suicide.

Additionally, some studies demonstrated a significant association between practice and attempts as postulated in IPTS. According to Courtney-Seidler, Burns, Zilber, and Miller (2014), there is recent research supporting IPTS in the relationship between non-suicidal self-injury (NSSI) and suicidal behavior. In their study, repeated experience with NSSI mediated the relationship with distress tolerance and attempts during adolescence (Courtney-Seidler, Burns, Zilber, & Miller, 2014).

Violence and capability for suicide. Another theme in IPTS that has been explored is the longitudinal relationship between violence and suicide from adolescence into young adulthood. Van Dulman et al. (2013) used four waves of Add Health data to conduct a series of path analyses. This study indicated that violence and suicidality mutually affect each over the course of time, especially for males when compared to females, and particularity in early and young adulthood. The study supported previous theoretical research that violence is a risk factor for future suicide, and a history of suicide is associated with a future risk for violence, supporting the postulation of IPTS that violence enhances one's capability for attempting suicide over time.

2.5 Prevention and Intervention

Beyond evidence of correlates of suicide, many experts indicate that these issues are treatable and preventable (American Academy of Child and Adolescent Psychiatry, 2008; Erbacher et al., 2015). Unfortunately, the inability to reduce suicides may be in part due to the inability to detect mental difficulties associated with depression or suicidal ideation until negative behaviors, such as drug and alcohol use, poor school performance, and suicide attempts take place (Wodarski et al., 2003). Additionally, the ineffectiveness of these interventions may be due to gaps in identifying the most effective interventions for diverse groups of adolescents (Joe et al., 2008; Joe & Niedermeier, 2006, 2008). A one-size-fits-all approach to suicide prevention and intervention may not be appropriate or effective for all adolescents.

There are a variety of methods that have been used to prevent and intervene for adolescents who are considering death by suicide. Some suicide interventions focus on adolescents seen in preventative care visits to doctors' offices and emergency rooms. Though perhaps helpful, these types of interventions may incorrectly assume two things: 1) a majority of adolescents receive preventative medical treatment; and 2) most adolescents who attempt suicide receive emergency medical treatment. These assumptions are not necessarily true for adolescents from various racial/ethnic backgrounds. Findings from a 2014 CDC report indicate that prior to 2012, millions of children and adolescents in the United States did not receive preventive clinical services, and inequalities in access were observed by demographic, geography, and healthcare coverage (CDC, 2014b). In regards to the assumption that adolescents might receive medical treatment, across 34 states, only a small proportion of adolescents who attempted to die by suicide (1.4% to 5.6%) were treated by a doctor or nurse (Kann et al., 2014). Again, these

numbers may vary based on an adolescent's values or beliefs, as some studies demonstrate that many minority adolescents do not reach out for treatment for cultural reasons described previously (e.g., Jang et al., 2009).

As an alternative to medical treatment, schools are a natural environment to reach the greatest numbers of adolescents who are risk of developing suicidal thoughts or behaviors (Wyman, 2014). Adolescents spend a considerable amount of their waking hours in school amongst peers, outside adults, and friends (Joe & Bryant, 2007). Therefore school can be an highly effective place to and provide screening and preventative interventions (Joe & Bryant, 2007). Additionally, schools can teach potentially modifiable cognitive skills associated with depression and suicide, such as emotional-regulation, coping mechanisms and thinking styles (Thapar et al., 2012).

2.6 Gaps in Theory, Research, and Methods

There are a number of gaps in theory, research, and methods regarding suicide research during adolescence and adulthood. These gaps include limitations based on correlational approaches to examine suicide and limited theories addressing possible differences by race/ethnicity. These gaps are outlined and discussed below.

Previously used methodologies to examine suicide, though important and informative to understand the correlates of suicidal thoughts and behaviors, do not account for the possible iterative effects and dynamics of how suicidal thoughts and behaviors may develop over time. To date, there are only a handful of studies that have examined the dynamics of suicide using the concept of feedback. Yip, So, Kawachi, & Zhang (2014) published a study depicting a Markov chain to examine an illustration of suicide dynamics using the Rose theorem (Yip, So, Kawachi,

& Zhang, 2014). A Markov chain illness and death model was used to demonstrate that targeting the entire population for suicide prevention is more effective than reducing risk in the higher risk populations in psychological distress from Asian countries (Yip et al., 2014). Markov chains assume that future behaviors of the model depend only at the current state of the model, and not on historical behavior (Meyn & Tweedie, 2009).

Beyond a couple of peer-reviewed experiments, there are few studies that model suicide using feedback. Shiepek et al. (2011) wrote a paper in the journal, *Suicide and Life-Threatening Behavior*, calling for the use of nonlinear dynamics to predict suicides before they occur. The authors suggest that suicides are time dependent and seem "unpredictable," a core feature of chaotic processes. This chaos, however, may result from deterministic processes or result from processes that are intra-systemic (Schiepek et al., 2011). Hence, instead of being 'unpredictable' or a result of various risk factors, suicidal behaviors can potentially be predicted and stopped through theories that account for the dynamic and complex nature of its components. Rogers (2003) also asserts that complexity theories may hold promise for the study of suicide. He states that by using these types of theories, one can model the behavior of complex and dynamic interactive systems with acknowledgment of the impact of small events on subsequent behavior (Rogers, 2003).

Though various perspectives on suicide have been national and international in scope, the literature on suicide has paid little attention to differences in suicide actions and beliefs among racial/ethnic groups within the United States (Range et al., 1999), and especially as it applies to the stage of adolescence (Borowsky, Ireland, & Resnick, 2001). Most of what is known about suicidal behaviors is derived from the dominant culture, namely white middle-class adults

(Leong & Leach, 2008). This is due to a variety of reasons, including the way suicide has been measured in the past and the lack of varying viewpoints on the issue.

First, the highest number of individuals who attempted or died by suicide largely derive from European Americans, with over 90% of individuals who died by suicide being categorized as White. Second, until less than 40 years ago, suicides were either labeled "White" or "Non-White" (Leong & Leach, 2008). Additionally, there have been few calls to the profession to consider the issue based on multiple worldviews (Leong & Leach, 2008). According to Leong & Leach (2008), another reason why there is little emphasis on racial/ethnic differences in suicide, is because most suicidologists are European American males whose main research interests are not focused on these cultural differences.

2.7 Summary

Theories on the development of suicidal inclinations and attempts abound, however few take into account for natural developmental processes that occur during adolescence. Additionally, though theories may exist, there are few theories on suicide that have been tested using a dynamic viewpoint. The next chapter of this dissertation will describe a conceptual framework to test a system dynamics perspective of suicide attempts using the interpersonal theory of suicide (Joiner, 2005) for adolescents.

Chapter 3: Methods

This chapter provides an overview of the conceptual framework, methods, and instrumentation for this study. Additionally, this chapter describes the research design and lists the different experiments that will be tested to answer corresponding research questions. These methods are used to attain findings presented in the following chapter.

3.1 Conceptual Framework

The conceptual framework for this study is based on Joiner's (2005) interpersonal theory of suicide (IPTS). Though aspects of other theories may be utilized in testing, the dissertation will systematically build and test IPTS using system dynamics. Modification of this theory will also be introduced to test and fit a theory that can adequately explain and simulate suicide attempts during adolescence and into adulthood.

There are various methodologies that could be used to answer the research questions asked in this dissertation. For instance, structural equation modeling (SEM) can be used to specify causal relationships between variables and even estimate some bidirectional relationships between variables. However, the notion of these bidirectional relationships, or 'feedback' in SEM, differs somewhat from the typical use of the term 'feedback" among dynamic modelers (Hovmand & Chalise, 2015). This divergence in the definition of "feedback" limits the use of SEM over system dynamics methods. Whereas SEM focuses primarily on understanding *linear* systems of differential equations, system dynamics focuses on *nonlinear* systems (Hovmand & Chalise, 2015). Though both can be utilized to handle nonlinear systems and latent variables,

SEM in the conventional approach may not be the most efficient or effective way to simulate a mathematical model of a dynamic system.

Similarly, agent-based models (ABM), another type of dynamic modeling method, can also be used to simulate the etiology of suicidal thoughts and behaviors in adolescents. However, AB models are essentially decentralized in nature (Borshchev & Filippov, 2004). Therefore, unlike system dynamics or discrete event models that are centralized, there is no such place in an AB model where global system behaviors (dynamics) would be defined (Borshchev & Filippov, 2004). In other words, the modeler defines behaviors at the individual level and global behaviors emerge as a result of many individuals (perhaps tens, hundreds, thousands, millions) that follow their own rules of behavior, living in some environments. This type of modeling may be useful to simulate suicidal thoughts and behaviors at the individual-level, but also assume that disaggregate behaviors will inform global behaviors—a bottom-up approach to examining systems. ABM is not necessarily in opposition to SD. In fact, the two can and have been used together in a number of studies. Though similar, ABM is not utilized in this dissertation because it is an inductive, rather than deductive, theory-based approach to adolescent suicide.

Lastly, traditional statistical procedures are useful, however, they are not able to account for the compounding or dynamic changes that are salient to many social theories incorporating concepts of feedback or iterative development (e.g., Vygotsky's Social Development Model (Vygotsky, 1978) or Bronfenbrenner's Ecological Systems Theory (Bronfenbrenner, 1988)). Traditional theory testing has predominantly been based on statistical measures confirming correlation of cross-sectional data. These methods are dependent upon statistical power, as opposed to experimental manipulation (Meehl, 1990), and subject theories to falsification based on positive or non-positive significance tests. The usefulness of theories tested through

traditional statistical measures are therefore based on a variety of unrelated and practical issues, such as small sample sizes, reliability of measure and logical research design (Meehl, 1990). System dynamics, though it is not a perfect method itself, allows for deeper theoretical modeling by incorporating feedback concepts into simulation and encourages the production of knowledge (Zolfagharian, Akbari, & Fartookzadeh, 2014). Additionally, it allows for an increased mathematical specification of theoretical relationships to enhance understanding of various concepts, qualities that are necessary, especially in predicting suicide (Van Orden et al., 2010).

3.1.1 System Dynamics

The experience of suicide has been conceptualized in various ways. In popular culture, people often refer to suicide as a vicious cycle, an experience that is dynamic and dependent on a variety of influences that may be circular in nature. System dynamics is an approach that relies on modeling and an evaluation of systems of complex feedback loops and is therefore useful in examining this process.

System dynamics takes mental models and applies temporal and spatial constraints that are not possible to include in statistical analyses using simulation (Sterman, 2000). This method allows improvements in discrepancies between the mental and formal (or mathematical) models with changes in basic assumptions such as the model boundary, time horizon and realistic assumptions about human behavior (Sterman, 2000). By mapping through system dynamics, common mental models of how we perceive the occurrence of suicidal thoughts and behaviors can be challenged or confirmed, expanding the boundaries of these mental models and enhancing the ability to generate and learn from evidence (Sterman, 2006). Jay Forrester, MIT professor and founder of system dynamics, would suggest that systems mapping, however, is only the

beginning of using a systems framework to solve dynamic problems (Forrester, 1994). In order to fully realize the potential of this method, systems dynamics should also use computer simulation to test models of systems over time (Forrester, 1994, 2007).

System dynamics emphasizes a four-tiered structural hierarchy: 1) closed boundaries around the system (feedback loops as the basic structural elements within the boundary; 2) level (state/stock) variables representing accumulations within the feedback loops; 3) rate (flow) variables representing activity within the feedback loops that also depict goals, and 4) the observed condition, detection of a discrepancy, and action based on that discrepancy (Forrester, 1969; Richardson, 2011). In these hierarchies, the emphasis in system dynamics is on feedback loops and an "endogenous point of view" (Richardson, 2011, p. 221). The endogenous point of view highlights that a feedback system is a closed system, with dynamic behavior arising within its internal structure. Complex dynamics arise from the interaction of just two types of feedback loops, positive (or self-reinforcing) and negative (or self-correcting/balancing) loops (Richardson, 1999; Sterman, 2000), not simply from the components themselves.

Thus, one of the most important contributions of system dynamics is its influence on uncovering endogenous sources of feedback (Richardson, 2011), particularly by using mathematical specification of relationships. These types of sources of inner-influence are critical to understand how adolescents develop, irrespective of external influences. It suggests that the problem we want to solve is actually influenced by a structure that is inherent in the system. In the example of suicide, it may be that one's desire for suicide may increase as a result of an increasing perception of social isolation. The more one thinks about suicide, the more likely they withdraw from social interaction, thereby increasing this perception. By understanding the

endogenous sources of feedback in the process of suicide, researchers can begin to pull apart the dynamics of this issue and identify ways to effectively reduce suicide through leverage points.

Leverage points in system dynamics refer to areas were small changes in one part of the system can make profound changes in the entire system over time (Meadows, 1999). These areas are considered "points of power" (Meadows, 1999, p. 1). Though the identification of leverage points may seem intuitive, they may also be counterintuitive in a complex system, systematically worsening problems that are targeted for solution (Meadows, 1999). This counterintuitive nature of a leverage point originates from the possibility of various loops of self-correcting or self-reinforcing relationships occurring in a system, a relationship described as "feedback" (Richardson, 1999). For the social isolation and suicide example mentioned previously, a point of leverage to reduce one's desire for suicide may be targeted at reducing one's perception of social isolation. Though this may be one possible point of leverage, experimenting with various ways to reduce this isolation through simulation to analyze the time dosage and amount of intervention needed provides deeper insights as opposed to conjecturing in a complex system.

3.2 Concept Model using System Dynamics

System dynamics is a useful way to examine an individual's intent to die by suicide due to the explicit modeling of decision rules an individual might use to influence their behaviors. The method is characterized by charting an objective reality while recognizing that the actions intended to change that reality are created by actors (Kim & Andersen, 2012). An actor's system model may be influenced by their own mental model of the objective reality, a subjective percept, which may or may not align. A misalignment between an actor's subjective and objective reality thereby lead to decisions which may have monumental consequences, as in the

case of suicide (Kim & Andersen, 2012). For instance, when an adolescent has the propensity to take comments directed at them with ill-intent, they are cognitively structured to process these comments in a negative self-reinforcing cycle of self-esteem. Though the remarks may be innocent in nature, the subjectivity in which an adolescent processes objective information may contribute to his or her rising desire to escape emotional pain.

The next section describes the translation of IPTS as a system dynamics model. The process of converting the theory into a SD diagram is outlined. Using diagramming conventions in system dynamics, a causal loop diagram (CLD) and stock and flow model will be defined .

Causal Loop Diagram of Suicide

A causal loop diagram (CLD) is a tool used to represent processes of feedback. They are important tools for capturing hypotheses about the causes of dynamics, eliciting and depicting mental models, and communicating important feedback relationships that may be responsible for a problem (Sterman, 2000). These types of diagrams depict variables connected by curved arrows with either positive (+) or negative (-) causal links. Positive links imply relationships that are self-reinforcing. Negative links depict relationships that are self-balancing. Link polarities only describe the structure of the system, not the behavior of the variables. That is, these polarities describe what would happen if the variable were to change (Sterman, 2000).

The following causal loop diagram (CLD) (Figure 3.1) shows an example of a simplified CLD of "capability for suicide" as described in ITPS by Van Orden et al. (2010). The boxes around variable names depict those that are used as stocks, or accumulations, in a model.

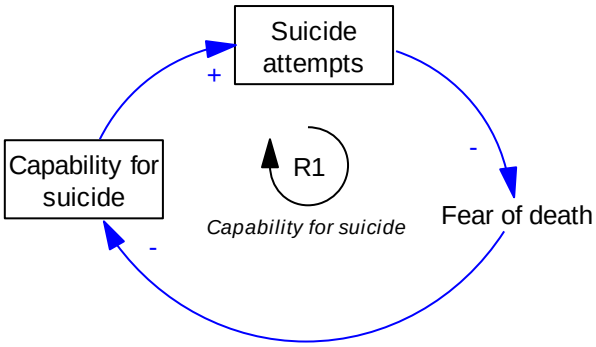


Figure 3.1 CLD of Capability for Suicide

The (R1) label in the center of Figure 3.1 shows the nature of the feedback loop: the R denotes that the entire loop is "reinforcing" and the "1" simply labels the number of the loop. If this loop were a "balancing" loop, it would be depicted by a clockwise or counterclockwise circular arrow with a label, "B".

In Figure 3.1, an increase in suicide attempts leads to a decrease in one's fear of pain from harming oneself (though habituation and diminishing fear). As the fear of death from harming oneself decreases, one capability for suicide increases, further enhancing one's propensity to attempt suicide. These behaviors have been described by Van Orden et al. (2010) as an application of the opponent processes theory (Solomon & Corbit, 1974). The opponent processes theory states that observed emotional responses are a function of the accumulation of two underlying oppositely valenced processes. Processes that are initially fear-inducing may become rewarding through habituation, a process that has been suggested as an explanation for the reward of repeated non-suicidal self-injury.

Stock and Flow Diagram

A “stock and flow” diagram is mathematical depiction of the underlying feedback mechanisms that are depicted in a causal loop diagram (Sterman, 2000). Stocks and flows, along with feedback, are the most central concepts of dynamic systems theory (Sterman, 2000). Stocks are accumulations. They represent accruals of material, information, or levels of intangible or latent concepts, such as self-control or depression. Stocks characterize levels, amounts, or the state of a system, and generate the information upon which decisions are based. These decisions may alter the rates of the flow, changing the stocks and the state of the system over time. Stocks accumulate their inflows less their outflows.

System dynamics uses particular diagramming notation for stocks and flows. Stocks are illustrated by rectangles (suggesting a container holding the contents of a stock), inflows are presented by pipes (arrows) pointing into (added to) the stock. Outflows are depicted by pipes pointing out of (subtracting from) the stock. Valves control the flows and clouds represent the sources and sinks for the flows. A source cloud depicts the stock from which a flow originating outside of the model boundary arises. Sinks depict the stocks into which flows leaving the model boundary drain. Sources and sinks (clouds) are assumed to have infinite capacity and can never constrain the flows they support. Rounded arrows connecting stocks and flows are usually depicted with a positive or negative polarity and are used to demonstrate a causal relationship from one variable to another in the model. Figure 3.3 depicts a simple stock and flow model of suicide attempts for illustration.

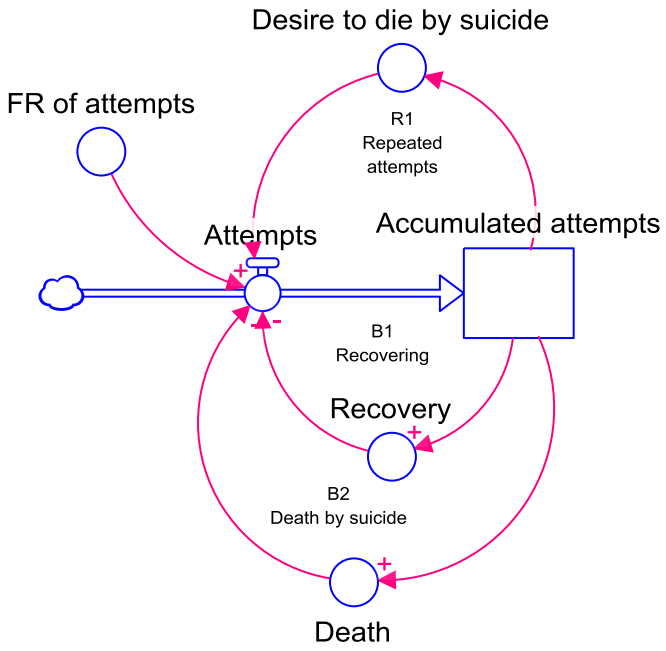


Figure 3.2 Stock and Flow Model of Suicide Attempts

In this example, the stock represented in the rectangular box is representing the number of accumulated suicide attempts. The inflow into the stock describes a rate, *Attempts* (*A)*. This inflow raises the *Accumulated attempts* (*AA*) one experiences. This model can be represented by an integral equation, where the value of the inflow at any time *s* between the initial time t_0 and the current time *t*.

$$AA(t) = AA(0) + \int_0^t (A(u)du\,; AA(0)$$

Therefore, the cumulative number of suicide attempts at time t is equal to the integrated amount of the inflow, or the increase in attempts, from time zero to time *t* with an initial attempt of 0.

These types of stocks and flows work together to characterize the state of the system and provide basis for their actions (Sterman, 2000). Stocks accumulate past events, as the content of

a stock can only change through an inflow or outflow. Networks of stocks and flows are coupled by feedback loops, depicted by arrows from a variable to a flow.

Rates of change (flows) are represented by equations demonstrating that the derivatives of stocks in dynamic systems are generally nonlinear functions of the stocks, the exogenous variables, and any constants (Sterman, 2000). The rates of change dS/dt are a function f( ) of the state vector S, the exogenous variables U and the constants C.

$$dS/dt = f(S, U, C)$$

In Figure 3.3, the rate of *Attempts* (*A*) is equal to the effect of the desire to die by suicide (*DDS*) on attempts subtracted by the effect of recovery on attempts (*R*) combined with the effect of death on attempts *(D)* times the accumulated number of suicide attempts *(AA)* at time *t* multiplied by the fractional rate of attempts (FR of attempts). The balancing loops are grouped together since they reduce the rate of attempts. These are subtracted from the variables that increase the rate of suicide attempts. The flow equation for Figure 3.2 is expressed as follows:

$$A = (DDS - (R + D)) \times AA \times FR\ of\ attempts$$

There are numerous ways to formulate nonlinear relationships. They will be described in the results section of this dissertation as it pertains to actual models.

3.3 Research Design

Using restricted level data from National Longitudinal Study of Adolescent Health (Add Health), this dissertation examines the dynamics of suicidal thoughts and behaviors for diverse groups of adolescents from adolescence into young adulthood from a feedback perspective. Though numerous studies have examined risk and protective factors that are associated with

suicide, few studies have examined the experience of suicide during adolescence using a feedback perspective across the life course (Schiepek et al., 2011).

System dynamics modeling was used test an existing and prolific theory of suicide, the interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010). Data from Add Health was examined using parameters from variables of interest for the general population of adolescents who attempted suicide during adolescence versus those who did not. The model was evaluated on its ability to predict suicide attempts using the reference modes depicted in the previous chapters.

Modifications to this theory were made to the original IPTS model to create a richer understanding of the process of suicidal ideation, attempts, and recovery from adolescence into adulthood. The model was also tested for its ability to predict attempts by an adolescent's self-identified racial identity. Leverage points were tested on the general sample to identify ways to prevent and/or reduce suicide attempts across adolescence and into adulthood.

Individual-Level Modeling

For the purpose of modeling the differences in racial and ethnic cultures, beliefs, and practices as it relates to suicide, an individual-level system dynamics model is used in this dissertation. Individual-level system dynamics models use the same mapping techniques to mathematically describe behaviors at the person-level (as opposed to a population or aggregate level). This type of modeling is helpful when a population displays clustering behavior or when a policy or program may affect one particular type of individual in a way that is unlike others (Osgood, 2009). Individual-level models can also provide insight into models that capture

motivation, learning, memory, localized perception, and adaptive behaviors that may differ heterogeneously by individuals in a particular system.

Just like there are many advantages of using individual-level models over aggregate-level (population) models, there are some drawbacks to consider. First, individual-level models take significantly more time to create, calibrate, and compute in comparison to models that aggregate populations (Fallah-fini, Rahmandad, & Chen, 2014; Osgood, 2009). Additionally, model parameterization and formulation may be more difficult due to the latent constructs represented in many individual-level models. Variables, such as motivation, self-efficacy, and other types of psychological constructs are often difficult to assess with arguable validity. Even so, Levine (2000) has suggested ways to use psychological variables within system dynamics models, focusing on ensuring that latent constructs use a ratio-level variable as opposed to interval variables, as many are typically measured. Despite these drawbacks, there are numerous benefits for this particular research design, as it can help understand the underlying psychological processes that lead an adolescent to take their own life.

3.4 Data

Add Health is the largest, most comprehensive longitudinal survey of adolescents ever undertaken (Harris et al., 2009) including a national cohort of approximately 20,000 adolescents who participated in Wave I surveys when they were in grades 7-12 (ages 12-18). The study began during the 1994-1995 academic year and spanned four waves following the original cohort in Wave I from 1994 to 2009. Wave II was conducted in 1995-1996. Wave III was collected in 2001-2002. By Wave IV (2008-2009), adolescents in the original cohort were 24-32 years old. Wave V is currently being collected and will not be made available until 2018.

Various federal agencies, such as the Eunice Kennedy Shriver National Institute of Child Health and Human Development, the National Institute of Health, National Science Foundation, and a number of private foundations (e.g., MacArthur Foundation, Robert Wood Johnson Foundation) funded the development and distribution of Add Health (Harris et al., 2009). The data has been used to explore the influences of both individual attributes of respondents and their various environments on health and health-related behavior. Some examples of areas covered in Add Health include mental health status (with a focus on depression), suicidal intentions/thoughts, health-service access and use, diet, educational history/high school transcripts, neighborhood and school characteristics, and a variety of other topics related to development (Harris et al., 2009).

Data has been collected from the adolescents themselves, their peers, school administrators, parents, siblings, and romantic partners through multiple data collection processes, including four respondent in-home interviews. Additional data from restricted-use datasets include information on respondent's neighborhoods and communities, and include variables describing income and poverty, unemployment, health service utilizations, church membership, and availability of social programs and policies. Geocodes for neighborhood blocks and tracks are also available for researchers in the restricted-use dataset.

Description of Add Health Study Sites and Sampling Procedures

Sampling of participants for Add Health was conducted through a national school sampling frame sorted by size, school type (private, public, parochial), census region, level of urbanization, curriculum (general, vocational, alternative, special education), and percent white. The sample of schools included 145 middle, junior high, and high schools from a representative sample of public, private, urban, and suburban, and rural areas across the United States.

Additionally, Add Health collected special oversamples, including adolescents who were disabled, blacks from well-educated families, Chinese, Cuban, Puerto Rican, and twin samples.

Figure 4.1 depicts the sampling structure used for each wave of Add Health, including Wave V, which is not yet available or targeted for use in this dissertation.

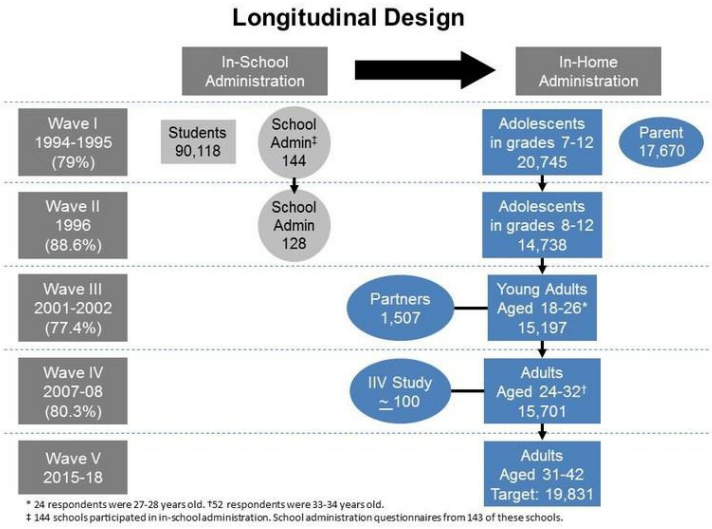


Figure 3.3 Sampling Structure of Add Health

Wave I. Wave I, conducted in 1994-1995, included four different surveys. The first, was an in-school sample, which included a total of 90,118 students who completed a 45-minute in-school questionnaire. The second component of Wave I included 144 school administrators who were asked various questions about their school composition, curricula, and structure. Third, a random sample of 27,000 adolescents who participated in the in-school questionnaire were selected to participate in a more in-depth In-Home Add Health survey. Finally, at least one parent (the resident mother, if available) of the student who was randomly selected to participate in the in-home survey was asked to complete the parent-survey. In-home surveys were conducted

within the private homes of the adolescents by trained survey administrators. The response rate for Wave I was 79% (Harris et al., 2009).

Wave II. Adolescents who were randomly selected for the In-Home survey in Wave I were also interviewed one year later during Wave II. All students, except those who were seniors in high school at Wave I were included for participation. The response rate for Wave II was 88.6% (Harris et al., 2009).

Wave III. Wave III data collection, conducted in 2001 and 2002, included in-home interviews with original respondents from the original "In-Home Wave I" survey. Only respondents who could be located were re-interviewed during the field-work period. Participants in Wave III (n = 15,197), were 18 to 26 years old. If available, their partners were also interviewed. The response rate for Wave III was 77.4% (Harris et al., 2009).

Wave IV. Wave IV was conducted in 2008 and 2009 with the original Wave I respondents (n=15,701). These participants at Wave IV were approximately 24 to 32 years old and settling into young adulthood. The response rate for Wave I was 80.3% (Harris et al., 2009).

Survey Administration

Each Wave of Add Health was distributed either in the school setting or in the respondent's place of residence. In cases were an in-home survey was not possible, survey personnel also met with individuals in coffee shops, libraries, and other public areas. Survey data was collected using a 90-minute Computer-Assisted Personal Interview (CAPI) and Computer-Assisted Self Interviewing (CASI). Both interview processes use computers to conduct sensitive parts of an interview, however CAPI is distinguished from CASI. CAPI surveys, though they have respondents make their respondents on a laptop provided by the interviewer, are asked

questions out loud by the interviewer. These surveys included less sensitive sections of the questionnaire and were administered by the interviewer face-to-face. CASI surveys, on the other hand, were used during more sensitive questionnaire sections. During CASI surveys, respondents self-administer all parts of the survey without an interviewer. Either the respondent reads the questions or listen to the question in cases where questions were prerecorded through audio. The rationale for using CASI is that some questions are so sensitive that researchers may not receive accurate answers unless they use a highly confidential method of responding (Olsen & Sheets, 2008). All adolescents in Waves I and II of Add Health were provided with a list of resources and hotline numbers after taking the survey, regardless of the type of risk (e.g., sexual, suicidal) they may have demonstrated.

3.4.1 Management of Human Subjects

This dissertation uses restricted-level data from the National Longitudinal Study of Adolescent and Adult Health (Add Health). An application for IRB approval to attain this data for Washington University's Social Systems Design Lab was submitted to Washington University's Institutional Review Board (IRB). Washington University's IRB reviewed the study protocols and deemed IRB approval was unnecessary since the project analyzes secondary data. A waiver from the IRB was submitted to the Carolina Population Center at the University of North Carolina at Chapel Hill, as required. The data was attained and securely stored as required through contractual agreement with Add Health.

3.4.2 Instrumentation

Add Health developed questionnaire content with wide consultation by experts on specific health outcomes and with representatives of NIH institutes who contributed co-funding

support to the project (Harris et al., 2009). Though there are a variety of surveys available in the restricted-level dataset, many of the variables used in this simulation model derive from the In-Home surveys for participants in Waves I-IV. The national death index was also used to examine adolescents who actually completed their suicides at some point during Waves I through IV.

Questions from each wave have been selected to specify and test corresponding parameters of the system dynamics model. The complexity of system dynamics models allows numerous parameters to be specified to test theoretical relationships. Therefore, though the appendix provides an outline of the main variables of interest, the variables listed may be expanded upon or constricted based on the process of specifying the SD model. For example, though extracurricular experiences are listed as a potential variable of interest, testing of the model may indicate that it is not as explanatory as a variable, such as social support, to demonstrate the relationship between depression and suicide during adolescence.

3.4.3 Demographic Measures

The following demographic measures were used to specify the computer simulation model of suicide for adolescents using Add Health data. The following variables are of primary interest:

Biological Sex. The biological sex, as noted by the participant in Add Health, will be used to determine the adolescent's sex as assigned at birth. Respondents either noted male or female as responses.

Race/Ethnicity. For the purpose of this dissertation, self-reports of race will be used to examine any social issues associated with particular racial groupings. This is not to attribute any

behavior based upon biological constructions of race or ethnicity, but instead to examine the social effect of these self-identifications on marginalized groups of people.

Though ethnic subgroup analysis is ideal, to manage the numerous comparisons in this dissertation, five major racial subgroups that were self-reported in Wave I of Add Health were analyzed. These groups include: non-Hispanic white (n=7728), non-Hispanic black (n=3038), non-Hispanic Asian (n=1021), Hispanic (n=2340), and Native American (n=136) adolescents. These groups have been defined in previous studies on racial/ethnic disparities using Add Health (e.g. Harris, Gordon-Larsen, Chantala, & Udry, 2006).

Abuse and Neglect. Wave III and IV of Add Health asks participants whether or not they were ever abused or neglected by a family member. Specifically, questions ask: 1) By the time you started 6th grade, how often had your parents or other adult care-givers left you home alone when an adult should have been with you; 2) How often had your parents or other adult caregivers slapped, hit, or kicked you; and 3) How often had one of your parents or other adult caregivers touched you in a sexual way, forced you to touch them in a sexual way, or forced you to have sexual relations? These questions will be used to specify parameters in the system dynamics model for this dissertation.

3.4.4 Psychosocial Measures

Depression – CES-D. The Center for Epidemiological Studies Depression Scale (CES-D) is a measurement instrument that is included in all waves of Add Health. CES-D was developed in 1976 for use in the general adult population, with 20-items of self-report to measure depressive symptoms (Radloff, 1977). Although it is used as an indicator of developing clinical depression or anxiety disorders, it is not intended as a clinical diagnostic tool, but a screening

tool (Perreira, Deeb-Sossa, Harris, & Bollen, 2005). This study will utilize the version of CES-D questions that has been tested and validated across a broad number of adolescent ethnic groups by Perriera et al. (2005). Therefore, although 19 of the 20 standard CES-D questions are asked in Add Health, this survey will utilize the five-item version of CES-D. The five-item version of the CES-D include measures indicating whether adolescents had the blues, felt depressed, were happy, sad, and enjoyed life (Perreira et al., 2005). Survey items which were coded as being positive were reversed and included in the scale. The Cronbach alpha for this version of the CES-D scale for participants sampled in Add Health was considered good ($\alpha = .80$).

Suicide. In all four waves of Add Health, participants were asked about their suicidal thoughts and behaviors and those of others around them. Suicide ideation (thoughts) is based on participant's responses to the question: "During the past 12 months, did you ever seriously think about committing suicide?" Adolescents who answered "yes" will be coded 1 on a dichotomous variable. Suicide attempts will be gauged by the question, "During the past 12 months, how many times did you actually attempt suicide?"

Impulsivity. Impulsivity in childhood has been related to poor anger control and aggressive behaviors, and may hinder adolescents from regulating negative emotions in general, not only anger (d'Acremont & Van der Linden, 2007). Some studies have shown that impulsive adolescents are more depressed and have more suicide ideation than their non-impulsive peers (d'Acremont & Van der Linden, 2007). It has also been suggested that this trait enhances one's propensity to attempt suicide in the interpersonal theory of suicide (Van Orden et al., 2010). Impulsivity in Add Health is measured through the following five-items: 1) I often try new things just for fun or thrills, even if most people think they are a waste of time; 2) When nothing new is happening, I usually start looking for something exciting; 3) I often do things based on

how I feel at the moment; 4) Sometimes I get so excited that I lose control of myself; and 5) I often follow my instincts without thinking through all the details. Respondents provided answers based on a 5-point likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). These items were added to create an indicator of impulsivity for Add Health participants. The Cronbach's alpha of this 5-items scale for participants included in this sample of Add Health is good ($\alpha = .79$).

Self-Esteem. Five items assessing self-esteem were adapted by Add Health from the Rosenberg Self-Esteem Scale (Rosenberg, 1965). On a 5-point likert scale from strongly agree to strongly disagree, participants rate their agreement with statements that 1) they have lots of good qualities; 2) have a lot to be proud of; 3) like themselves as they are; 4) do everything just right; 5) feel socially accepted; and 6) feel loved and wanted. These items form an internally consistent self-esteem scale with Cronbach alpha levels of .83 in Wave 1 and .85 in Wave 2 (Shahar & Henrich, 2010). Analysis for this dissertation demonstrated similar Cronbach alpha scores (Wave 1: $\alpha = .83$, Wave 2: $\alpha = .84$). All items on this scale were reverse coded so scale scores increasing to the maximum scale number (20) were related to having a strong sense of self-esteem and lower values (minimum of 5) corresponded with lower levels of self-esteem.

Hopelessness. Hopelessness was measured using items H1FS8 in Wave I and H2FS8 in Wave II of Add Health. The question asks, "How often was the following true in the last week: you felt hopeful about the future?" This item was reverse coded from the original Add Health coding to depict that 0=never/rarely to 3=most of the time or often.

Burdensomeness. Burdensomeness was measured using items H1PF36 in Wave I and H2PF27 in Wave II of Add Health. The question asked participants, "How often was the

following true in the last week: you feel loved and wanted." The item was reverse coded from the original coding so that 1=strongly agree and 5=strongly disagree.

Individual Experiences

School-Related Discrimination/Segregation. Variables depicting school-level segregation indices are already constructed in Add Health restricted datasets, readily available for use. They indicate each level of segregation in a school for each major racial group: white, Black, Latino/Hispanic, Asian, and other. These variables, along with one's self-report indication of school-related experiences of school prejudice were attained from Wave I in Add Health. Respondents rating of the question, "How strongly do you agree/disagree: students at this school are prejudiced?" were used to specify the simulation model.

Parental Relationships. Adolescent and parent-reports were assessed using items from Wave I In-Home surveys. Questions asking adolescents about engagement with their mother or father in various activities were used to gauge closeness (e.g., Which of the following things have you done with your biological mother in the past four weeks: shopping, sports, religious services, talked about someone you are dating, party you went to, gone to a movie/play/museum/concert, talked about personal problems, serious arguments about behaviors, or talked about school work or grades?). Furthermore self-reports of how satisfied an adolescent is with their mother or father, whether they feel their mother or father is warm and loving, and one's communication effectiveness with their mother or father were utilized.

Social Acceptance. The degree of an adolescent's feeling of social acceptance was gauged using the following questions from Wave I In-Home survey in Add Health: 1) I feel

socially accepted; and 2) I feel loved and wanted. Adolescents responded on a 5-point likert scale from strongly agree to strongly disagree.

Exposure to Violence. An adolescent's exposure to violence was examined using eight variables from Wave I of Add Health to create a count variable. The count ranged from 0 to 14. Questions asked adolescents, "During the past 12 months, how often did each of the following things happen: You saw someone shoot or stab another person; someone pulled a knife or gun on you; someone shot you; someone cut or stabbed you; you got into a physical fight; you were jumped; you pulled a knife or gun on someone; you shot or stabbed someone." Participants responded either 0 (never); 1 (once); or 2 (more than once).

3.5 Data Analysis Plan

This section describes the steps that were taken to attain data, build, specify, and test a system dynamics model for IPTS for adolescents into adulthood. Restricted-level Add Health data were attained and stored through a dissertation fellowship from Washington University's Social System Design Lab (SSDL).

3.5.1 Data Specification

In order to specify the model, data from Add Health were cleaned and weighted using Add Health weights in *SAS 9.4*. Since the data examines longitudinal outcomes by racial subgroups, grand sample weights from the last data set (Wave IV) were utilized in accordance with documentation of Add Health (Ping Chen & Chantala, 2014). Reference modes were attained from Add Health by using individual responses by age from Waves 1-4 and using responses by age to create graphs of developmental means for suicide attempts, hopelessness, burdensomeness, social rejection across age. Though attrition of data may have been a concern

when analyzing Add Health data by age, there were relatively high response rates for each wave overall. In order to prevent as little missing data or cases as possible, Add Health attempted to find each original respondent targeted in Wave I for survey responses. Therefore, an issue of attrition from wave to wave was not necessarily apparent. The response rate for Wave I is 79%. The response rate for Wave II is 88.6%. The response rate for Wave III is 77.4% and 80.3% for Wave IV (Harris, 2013).

3.5.2 Model Creation

After data were cleaned, an individual-level model that depicts the theorized relationship between causal factors of suicide were modeled according to IPTS. The model was created and simulated using *Stella Professional* system dynamics simulation software. Concurrent with model creation was the process of model specification, sensitivity analyses, and testing for model fit. This required not only structural assessments of the system dynamics model, but also specifications of the model with data from Add Health. Modifications to the model were made where necessary to accurately predict suicide attempts for adolescents in Add Health.

a. *General Population*. The first phase of data analysis examined all individuals in Add Health. Though it is possible to include each individual participant arrayed for analysis from Add Health, Osgood (2009) indicates that this is not necessary. Instead, using aggregate levels (means) of data from the general population can be utilized to create a reduced-scale simulation, minimizing computational time and resources (Osgood, 2009). This full population model was simulated using aggregate data parameters obtained from mean levels of corresponding variables attained through *SAS 9.4*. Documentation of behaviors were made throughout simulation runs described in the results chapter of this dissertation.

b. *By Gender and Racial Subgroup.* The second phase of data analysis follows Osgood's (2009) recommendation to run individual level models on sub-populations of adolescents. Grand sample weights were applied to the entire sample of adolescents using *SAS 9.4* to specify parameters. Then, subgroups and of gender and race were simulated to look for differences in patterns of depression and suicide across the adolescence into young adulthood.

3.5.3 Model Fit Testing

The model was documented for reproducibility using best practices for system dynamics model reproducibility, documentation, and validation, as identified by Sterman (2000) and Rahmandad & Sterman (2012). Tests for model specification include boundary adequacy tests, structure assessments, dimensional consistency tests, parameter assessment, extreme conditions, integration error, behavior reproduction, and sensitivity analyses (Sterman, 2000). Before discussing the "validity" of models, it is necessary to revisit a clause in system dynamics literature which suggests that all models are wrong, but some models are useful (Sterman, 2002). No model is fully "validated" just like scientific theories are only supported and not "proven."

Therefore, the process of validating the models is really a process of building confidence through testing to find flaws and errors in the model. Confidence building in models is a process that occurs while modeling. It is inherent in the process of making sure each unit has dimensional consistency with equations in the model, extreme values are tested, and variables that corresponds to real world constructs are utilized.

There are a number of other methods that can be used to build confidence in models using system dynamics. For the purpose of the models in this dissertation, data from simulation runs were compared to data from actual survey results from participants in Add Health on an

ongoing iterative basis. This method of using means and standard deviations from existing nationally representative datasets to compare to simulation results has been previously tested (Rahmandad & Sabounchi, 2011). Additional methods, such as comparing actual and simulated data point-by-point using the coefficient of determination, R^2, is also possible, however, it is not as robust for various reasons.

For instance, because traditional fit statistics focus on finding a point-by-point fit, when used alone, they may be misleading in determining how well a model reproduces observed behavior (Hovmand, 2003). Using Theil's inequality statistics (Theil, 1966), or Theil's U-statistic, one can measure the accuracy by which a model is able to forecast a trend. In order to understand where errors in a simulated model are distributed, the Theil inequality statistic divides the error into three components: bias (U^M), unequal variation (U^S), and unequal covariation (U^C) (Hovmand, 2003; Sterman, 2000). These errors are represented in the following equations.

U^M is a bias component indicating systematic error and determines the extent to which the average values of the average and predicted deviate from each other.

$$U^M = \frac{(\bar{M} - \bar{A})^2}{MSE}$$

$\bar{M}$ is the mean of the model's time series, $\bar{A}$ is the mean of the actual time series, and *MSE* is the mean squared error or $\frac{1}{n}\Sigma(M_i - A_i)^2$. We generally want values that are close to zero, as values near 1 or above suggest that there is a systematic bias and therefore the model must be revised (Watson & Teelucksingh, 2002).

U^S is the variance proportion that indicates the ability of the model to replicate the degree of variability in the endogenous variable, where S_M is the standard deviation of the model's time

series, and S_A is the standard deviation of the actual time series. The equation for *MSE* is denoted in the equation for U^M.

$$U^S = \frac{(S_M - S_A)^2}{MSE}$$

A large value of the U^S might suggest that the actual values in the series fluctuated considerably while the simulated series did not demonstrate such fluctuation, or vice versa. This is clearly an undesirable occurrence and may lead to a revision of the model. Similar to the above U statistic, a U^S value near 0 is preferred.

U^C represents the remaining error after deviations from average values and average variabilities have been accounted for. This value, unequal covariation, means the model and data are imperfectly correlated, meaning they differ point-by-point (Sterman, 2000).

$$U^C = \frac{2(1-r)S_M S_A}{MSE}$$

In this equation, *r* refers to the correlation between the model and actual time series (Theil, 1966). When added together, the three components equal 1, for example, $U^M + U^S + U^C = 1$ (Hovmand, 2003; Theil, 1966; Watson & Teelucksingh, 2002).

According to Watson & Teelucksingh (2002), the U^C statistic is not as important when compared to the other statistics of bias (U^M) and unequal variance (U^S) in determining model fit. In light of this, the ideal distribution of inequality over the three proportions is $U^M + U^S = 0$ and $U^C = 1$.

Theil statistics were calculated and used to determine whether the model predictions were a good fit for the data. Once the best model was identified to predict suicide attempts by adolescents into adulthood, models were further examined for experimentation. Results of these

tests are defined in the Results chapter. Once the model was tested for confidence, experiments (described in the next section) were conducted.

3.5.4 Model Experimentation and Documentation

Experiments to analyze the effect of various individual characteristics, such as perceived burdensomeness and hopelessness were used to test the model. The model simulations and experimental outcomes were documented using the preferred model reporting requirements, simulation reporting requirements, and optimization reporting requirements identified for reproducibility of system dynamics models for simulation-based research in the social sciences (Rahmandad & Sterman, 2012). Experiments were conducted for the entire population with the goal of reducing suicide attempts for adolescents who had all the behavioral and emotional characteristics that would normally warrant an attempt. Results were documented and reported.

3.6 Summary

This chapter described a conceptual model for testing, the dataset, and outlined the methods for model testing. Using this outline, the model was be tested and results are presented in Chapter 5. Before demonstrating results, Chapter 4 will describe the adolescents who were sampled in Add Health and used for purposes of modeling.

Chapter 4: Sample Description

This chapter provides a description of the sample of adolescents included in the Add Health dataset for this study. Adolescents are categorized by those who attempted suicide during Wave I or II (their adolescence) and those who did not. The values in this chapter are used to specify the models tested in the results section of this dissertation.

4.1 Description of the Sample

The sample in this study includes all participants who attempted suicide during either Wave I or II of the Add Health Study. Add Health grand sample weights for Wave IV longitudinal data were applied to understand general demographic information for the entire sample, for those who did not attempt suicide during adolescence, and adolescents who attempted suicide at least once. Overall, the entire sample had a mean age of 15.03 (SD = .11) in Wave I of the Add Health survey (N=9,421). Fifty percent of the sample identified their biological sex as male. In regards to race, the sample predominantly self-identified as white (65.9%), following by Black (15.5%), Latino (12%), Asian (3.62%), Native American (2.09%) and "Other" (.88%). The mean household income of the sample was $46,060 (SD = $1,770) (Table 4.1).

For those who attempted suicide during adolescence (Table 4.1), the mean age of the sample was 14.91 (SD = .13) and 72.2% indicated they were biologically female (SE = 3.00). The racial composition of the sample of adolescents who attempted suicide did not differ greatly from those who did not attempt or from the main sample.

Table 4.1 General Description of the Sample

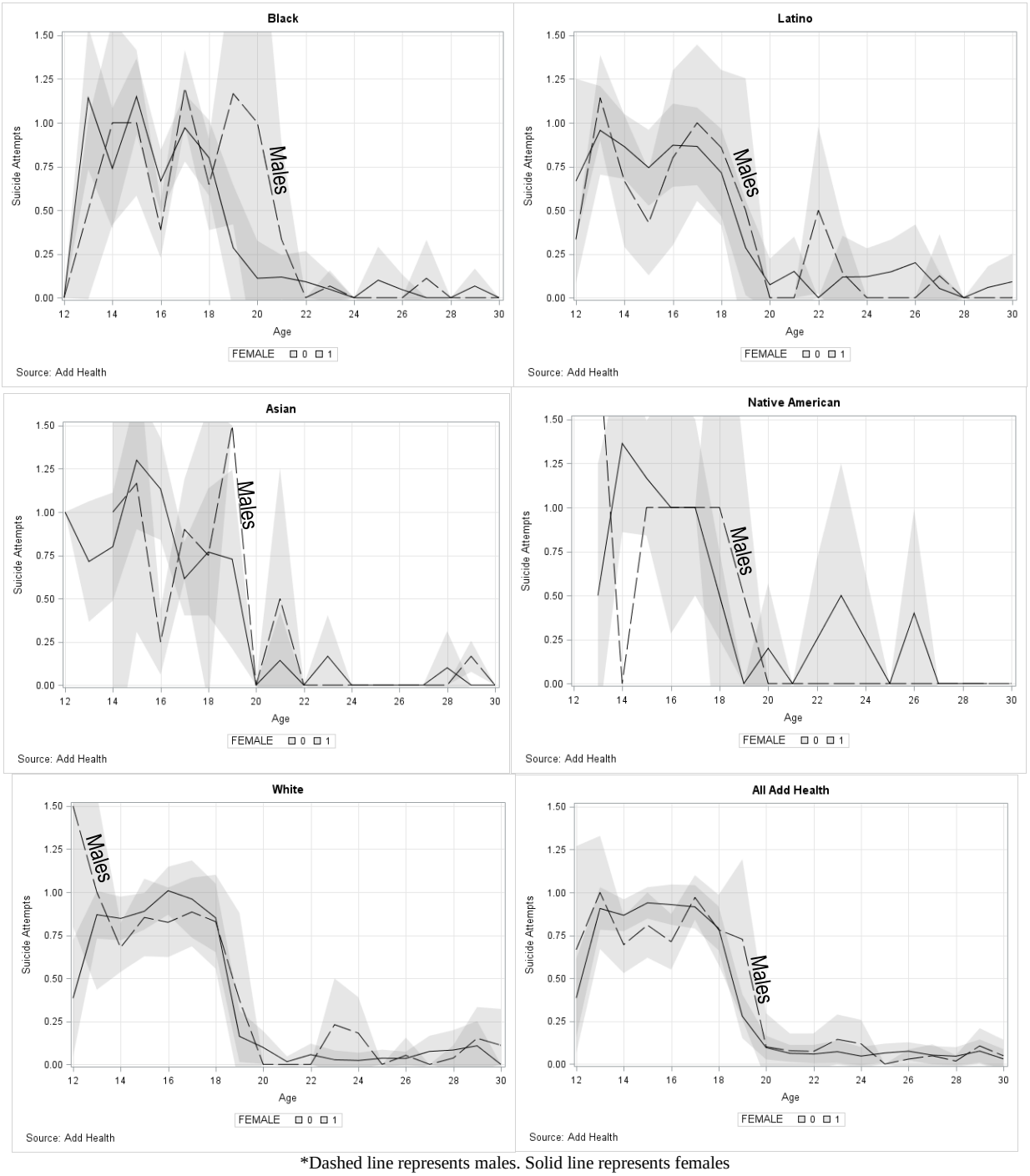
	Entire Weighted Sample (N=9,421)		**No suicide attempts in adolescence**		**Attempted suicide in adolescence**	
Variable	μ / %	SD/SE	μ / %	SD/SE	μ / %	SD/SE
Age (Wave I)	15.03	0.11	15.04	0.11	14.91	0.13
Sex						
Male	50%	.68	48.17%	0.63	72.16%	3.00
Race						
Latino	12%	1.71	12.02%	1.77	11.68%	1.91
Black	15.50%	2.01	15.50%	2.02	15.32%	2.64
Asian	3.62%	0.8	3.64%	.82	3.38%	1.00
Native American	2.09%	0.29	2.03%	.29	2.86%	.90
Other	0.88%	0.17	0.9%	.18	0.57%	.36
White	65.92%	2.84	65.91%	2.88	66.18%	3.33
Household Income (in thousands)	46.06	1.77	46.19	1.79	44.11	3.33

4.2 Suicidal Thoughts and Behaviors

Table 4.2 describes differences between the entire sample, those who did not and did attempt suicide during adolescence, further subdivided by race. In regards to outcomes for the entire sample, data from Add Health indicate that over 13% of adolescents surveyed in Wave I thought about suicide at the time of the Add Health survey. This number decreases to 6.9% during Wave III and increases slightly again in Wave IV to 7%. For adolescents who attempted suicide during Wave I or II, 45.5% had a friend who attempted suicide compared to only 17.3% of adolescents who did not attempt to die by suicide during Wave I or II. Adolescents who attempted also had a higher percentage who had family members who attempted suicide (15.1%) compared to those who did not attempt (4.2%). These figures are also presented for adolescents who attempted suicide by race. On average, Asians who attempted suicide in Wave I or II had the highest mean number of attempts compared to other groups (.99, SD=.26).

Table 4.2 Suicide-Related Variables by Racial Groups with Suicide Attempts during Adolescence

	Entire Sample		**No suicide attempts in adolescence**		**Attempted suicide in adolescence**		**Latino**		**Black**		**Asian**		**Native American**		**White**	
Variable	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD
Suicidal Thoughts																
W1	13.48%	0.48	9.10%	0.41	74.94%	2.1	68.73%	6.13	71.47%	5.99	69.36%	13.34	74.79%	14.4	77.25%	2.56
W2	11.84%	0.47	7.79%	0.39	68.54%	2.83	73.44%	5.65	59.56%	7.44	64.47%	11.88	81.54%	12.06	69.65%	3.73
W3	6.92%	0.39	6.22%	0.39	16.82%	2.04	12.71%	4	12.08%	4.01	15.99	8.91	32.74%	14.93	16.36%	2.55
W4	7.17%	0.39	6.36%	0.37	18.48%	2.14	13.06%	3.98	11.24%	3.62	11.95	10.8	34.62%	14.23	20.94%	2.81
Suicide Attempts																
W1	0.05	0.004	0	0	0.81	0.04	0.84	0.11	0.79	0.1	0.99	0.26	0.72	0.19	0.8	0.04
W2	0.05	0.004	0	0	0.77	0.04	0.94	0.12	0.65	0.11	0.73	0.21	1.17	0.24	0.75	0.06
W3	0.02	0.003	0.02	0	0.09	0.02	0.15	0.07	0.06	0.03	0.09	0.06	0.27	0.14	0.07	0.02
W4	0.02	0.002	0.02	0	0.06	0.01	0.06	0.03	0.03	0.02	0.002	0.002	0.09	0.08	0.06	0.02
Treatment received post attempt	0.92%	0.14	0	0	13.93%	1.89	13.06%	3.98	19.06%	3.26	14.43%	7.86	26.5%	16.56	12.45%	2.39
Friend attempted suicide	19.13%	0.69	17.25%	0.64	45.53%	2.91	42.79%	7.04	25.46%	4.8	32.66%	10.36	48.96%	18.08	51.24%	3.61
Family attempted suicide	4.88%	0.34	4.16%	0.31	15.12%	1.66	10.77%	3.79	17.33%	4.67	7.96%	4.69	13.67%	9.29	15.97%	2.21



*Dashed line represents males. Solid line represents females
**Black n=717; Latino n=731; Asian n = 310; Native American n=114; White = 1946

Figure 4.1 Participants who Attempted Suicide in Add Health by Race and Gender

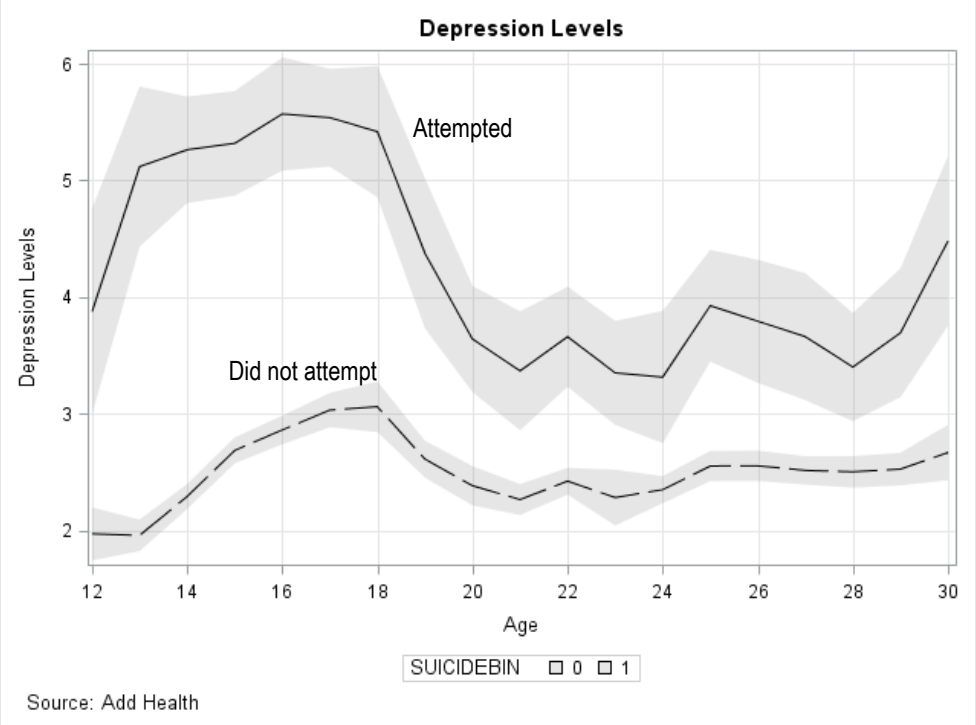
The trends in suicide attempts from adolescence to young adulthood for those who attempted suicide are presented in Figure 4.1. Females are plotted with the solid line, males are plotted in a dashed line. 95% confidence intervals are displayed by the band around each line.

To understand the developmental view of suicide attempts across adolescents, data from those who attempted were attained and plotted from four waves of Add Health using age on the x-axis. The mean number of attempts range from 0 to 1.5 attempts per year, with variations by racial and ethnic group. Given the larger proportion of white adolescents who were surveyed in Add Health, the general trend of data seems to follow that which is demonstrated in white adolescents. However, examining each racial group by gender displays great variations. For instance, though most adolescents decrease in attempts by age 20, Native American females continue to experience spikes in suicide attempts into their late 20s (Figure 4.1).

4.3 Psychological and Individual Attributes by Gender/Race

Latent variables that were examined in the Add Health dataset include level of depression as measured by the CES-D, hopelessness, burdensomeness, social rejection, self-esteem, and impulsivity. These variables are detailed in Table 4.3. Generally, adolescents who tried to die by suicide had elevated levels of depression as a whole and across all racial groups. On a scale of 0 to 15, with cut offs of 0-5 (low); 6-10 (moderate); 11-15 (high), most adolescents across the entire sample had low levels of depression ($\mu = 2.74$, SD = .06). Adolescents who attempted suicide reported moderate levels of depression ($\mu = 5.09$, SD = .2). When broken down by race, levels of depression for adolescents who attempted suicide ranged from a mean of 4.06 (SD = .53) in Asians to the highest in Native American adolescents ($\mu = 6.64$, SD = 1.29).

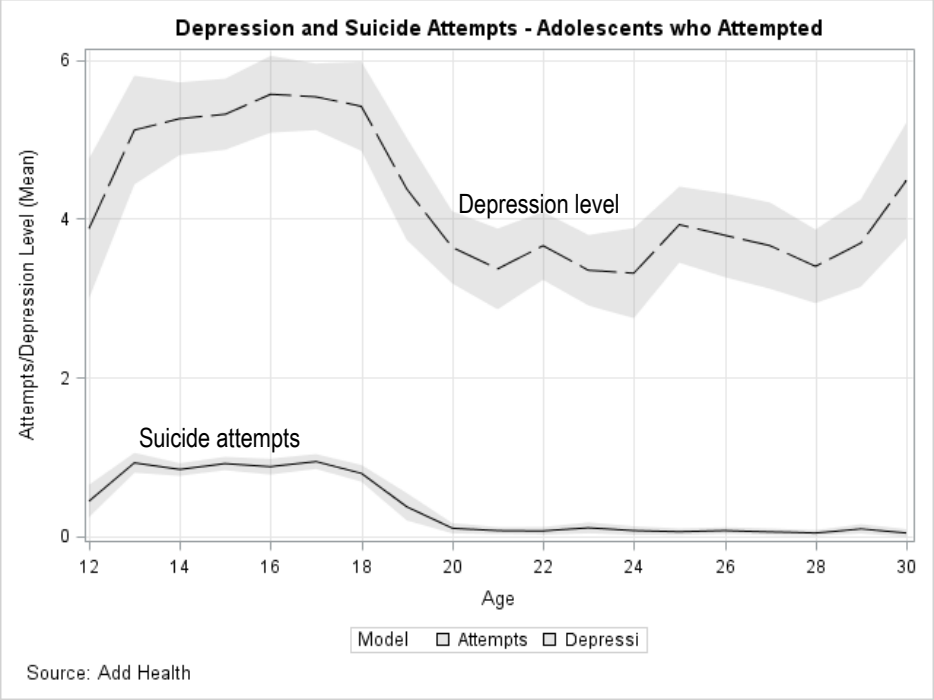
To examine how depression level differs developmentally, participants were organized by age in all four waves of Add Health. Figure 4.1 demonstrates the depression levels reported by participants who did not attempt suicide during their adolescence and by those who attempted suicide during adolescence. Generally, depression levels increase until age 18, however adolescents who attempted suicide reported higher levels of depression during ages 12 to 18 and across young adulthood. Adolescents who did not attempt suicide had relatively stable depression levels, however there was a general increase in depression during ages 13 to 18 with a drop in depression levels from age 21 to 30. Adolescents who attempted suicide reached 'moderate' levels of depression while those who did not had lower levels of depression overall. A simple paired t-test of depression levels during Wave I indicate there is a significant difference ($p < .05$) between depression levels for adolescents who attempted suicide and those that did not.



*Dashed line represents individuals who did not attempt suicide in adolescence.
Solid line represents adolescents who attempted in adolescence.

Figure 4.2 Depression Level across Age by Suicide Attempt Groups

Next, to examine how suicide attempts and depression levels were related, suicide attempts were plotted by age in a graph along with depression levels (Figure 4.3). Though the values vary because of the differing scales, the trend lines are similar, with ages 12 to 13 representing increases in depression levels and suicide attempts, sustaining moderate levels of depression with suicide attempts from ages 13 to 18, with a drop in depression levels and suicide attempts from ages 18 to 21. Depression levels seem to waver from ages 21 to 28 and begins sharply increasing from ages 28 to 30. There is little data beyond age 30 as a majority of Add Health participants were not older than 30 in Wave IV.



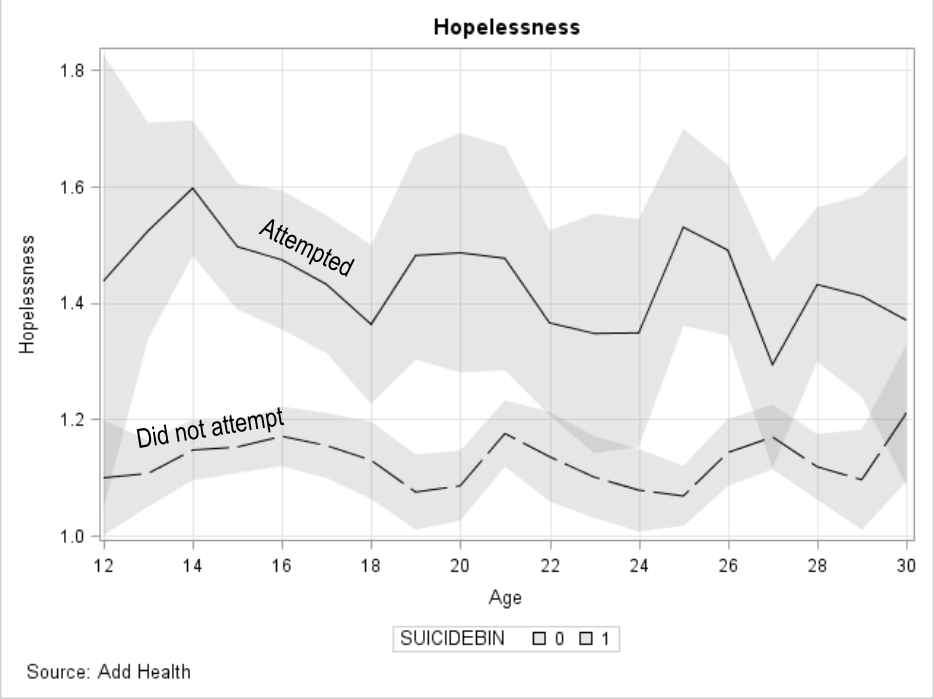
*Dashed line represents depression level. Solid line represents suicide attempts

Figure 4.3 Pattern of Suicide Attempts and Depression Levels across Age

To further examine the experience of depressive symptoms for adolescents who attempted suicide, depression levels and suicide attempts were plotted on the same graph to examine trends. At least during adolescent, ages 12 to 20, it seems there are parallel behaviors between the mean numbers of attempts rising with increases in depressive symptoms (Figure

4.3). The solid line represents the mean number of suicide attempts reported by adolescents. The dashed line demonstrates levels of depression as measured by the CES-D for adolescents who attempted suicide. These parallel patterns of behavior support research suggesting there are correlations between depression and suicide, specifically during adolescence, but also perhaps throughout the life span.

Variables, such as social rejection, hopelessness, burdensomeness, self-esteem and level of impulsivity were also examined (Figure 4.4). There were significant differences between groups by suicide attempt for all of the variables included. As expected, adolescents who attempted suicide had lower levels of these constructs when compared to adolescents who did not attempt suicide. Unlike depression, however, these levels seem to sustain with mild oscillations across time.



*Dashed line represents adolescents who did *not* attempt suicide. Solid line represents those who attempted.

Figure 4.4 Hopelessness by Gender for All Participants

Table 4.3 Psychological Variables by Attempt and Race

	Entire Sample		No suicide attempts in adolescence		Attempted suicide in adolescence		Latino		Black		Asian		Native American		White	
Variable	μ or %	SD	μ or %	SD/SE	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD
Depression (CES-D)																
W1	2.74	0.06	2.57*	0.06	5.09*	0.2	5.08	0.55	5.73	0.49	4.06	0.53	6.64	1.29	4.95	0.24
W2	2.8	0.05	2.62*	0.05	5.26*	0.19	6.75	0.56	5.12	0.39	4.37	0.56	7.04	1.24	5.01	0.24
W3	2.36	0.04	2.26*	0.04	3.7*	0.17	4.56	0.44	3.74	0.52	2.49	0.76	4.42	1.11	3.58	0.2
W4	2.58	0.04	2.51*	0.04	3.73*	0.17	4.22	0.62	3.66	0.33	3.56	0.56	3.93	0.54	3.66	0.21
Social rejection	1.93	0.01	1.91*	0.01	2.19*	0.05	2.1	0.13	2.07	1.03	2.25	2.49	2.49	0.31	2.26	0.07
Burdensomeness	1.7	0.01	1.68*	0.01	2.06*	0.05	2.05	0.16	1.85	0.1	0.65	0.28	2.08	0.33	2.11	0.07
Hopelessness	1.2	0.02	1.18*	0.02	1.49*	0.05	1.41	0.15	1.25	0.12	1.86	0.2	1.14	0.28	1.55	0.07
Impulsivity	13.2	0.1	12.94*	.05	14.32*	0.28	13.5	0.72	14.01	0.78	14.03	1.03	16.54	1.66	14.51	0.35
Self-worth[+]	9.56	0.07	9.42*	0.06	11.53*	0.25	11.5	0.5	9.9.7575	0.54	12.55	12.48	1.48	3.08	11.85	0.3

+ higher ratings on this scale are associated with lower self-esteem. They are reversed when input into the model.
**p < .05 (Statistical tests only performed for adolescents who did not attempt suicide and those who attempted suicide).*
Racial subgroups were not tested.

4.4 Environment and Experiences

Variables regarding the environment and experiences of adolescents were also included in this analysis (Table 4.4). These variables included questions regarding one's perception of school-based prejudice, exposure to violence, perception of having caring friends, parents, teachers, and adults in one's life, as well as the availability of guns in the home, cumulative GPA, and previous history of sexual or physical abuse during childhood. As found in previous studies (King & Merchant, 2008b), adolescents who attempted suicide in this sample had a lower perception of the presence of caring friends, parents, teachers, and adults in their lives. They also had higher levels of exposure to violence, had greater gun availability in the home, higher perceptions of experiencing school prejudice, and had higher reports of sexual and physical abuse than adolescents who did not attempt suicide.

4.5 Summary

The data on adolescents who attempted suicide in Add Health depicts existing literature on the associations and correlations of suicide during adolescence. Thought not all of the parameters expounded upon in this chapter are used in the interpersonal theory of suicide, they are considered important in other studies and are examined in the development of a modified theory of IPTS. The next chapter of this dissertation will report on the results of the modeling process using these data as parameters for testing, specifying, and modifying a model of suicide based on the interpersonal theory of suicide.

Table 4.4 Environment and Experiences by Attempts and Race

	Entire Sample		**No suicide attempts in adolescence**		**Attempted suicide in adolescence**		**Latinos**		**Blacks**		**Asians**		**Native American**		**Whites**	
Variable	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD	μ or %	SD
Immigrant Generation																
1st	4.52%	0.79	4.70%	0.83	2.04%	0.73	5.00%	2.74	0.12%	0.12	45.30%	15.19	NA	NA	NA	NA
2nd	10.95%	0.85	10.98%	0.85	10.44%	1.8	26.37%	6.15	3.77%	2.04	41.12%	13.24	NA	NA	7.62%	1.96
3rd	84.52%	1.52	84.30%	1.56	87.51%	1.97	68.63%	6.8	96.11%	2.05	13.58%	8.99	85.26%	3.83	92.37%	1.96
Foreign-Born	5.29%	0.83	5.50%	0.87	2.29%	0.77	5.33%	2.77	0.12%	0.12	48.73%	14.34	NA	NA	NA	NA
Cumulative GPA	2.58	0.03	2.59	0.03	2.37	0.06	2.18	0.11	1.98	0.1	2.65	0.26	2.16	0.15	2.48	0.07
Experience of Abuse																
Physical	28.50%	0.84	27.96%	0.87	36.18%	2.6	46.41%	7.83	37.04%	6.33	32.58%	10.65	52.71%	20.44	33.21%	3.08
Sexual	4.68%	0.35	4.20%	0.35	11.50%	1.79	9.25%	3.82	15.78%	5.7	8.82%	5.43	21.55%	13.44	10.56%	2.16
Gun availability in the home	28.90%	1.4	28.50%	1.46	34.15%	2.44	25.23%	6.43	35.81%	5.82	14.61%	3.22	35.64%	16.08	36.37%	3
Exposure to violence	0.54	0.03	0.5	0.03	1.01	0.12	1.95	0.39	1.38	0.3	1.13	1.94	2.34	0.77	0.73	0.1
Perceived prejudice	3.13	0.05	3.12	0.05	3.25	0.09	3.19	0.16	2.7	0.2	3.31	0.21	3.7	0.23	3.38	0.11
Perceived presence of caring																
Friends	4.25	0.01	4.23	.80	4.18	0.04	4.27	0.12	4.08	0.09	4.16	0.17	4.21	0.19	4.34	0.05
Parents	4.8	0.01	4.83	0.009	4.51	0.05	4.46	0.18	4.68	0.07	4.37	0.15	4.74	0.14	4.48	0.06
Teachers	3.52	0.03	3.54	0.03	3.21	0.07	3.17	0.16	3.38	0.17	3.04	0.13	2.99	0.34	3.21	0.09
Adults	4.4	0.01	4.43	0.02	4.05	0.06	4.15	0.15	4.23	0.13	3.78	0.19	4.13	0.23	4.02	0.07

Chapter 5: Results

This section presents models that were created and tested using the interpersonal theory of suicide (IPTS). This section will outline results that target the following research questions:

1. How do we prevent suicide attempts for adolescents from adolescence into adulthood?
2. How do suicide attempts occur for adolescents from various racial groups?

First, this chapter will give an overview of how models were tested using system dynamics. Next, the chapter will discuss the models that were built according to existing theories and explore how models support or may be limited in predicting suicides across adolescence into young adulthood. Lastly, a model modified from existing theories and research will be presented. Experiments from various situations will be presented for adolescents who are at high risk of attempting suicide.

5.1 Testing the Interpersonal Theory of Suicide

The first step of this research was to test the interpersonal theory as postulated by Joiner (2005) and modified by Van Orden (2010). This section presents the results of building and testing IPTS (Joiner, 2005) and determines whether the theory can replicate the experience of suicide attempts for adolescents who have a history of attempting suicide.

In order to build Joiner's theory of suicide as a system dynamics model, original texts (e.g., Joiner, 2005; Joiner et al., 2009; Van Orden et al., 2010) were analyzed for key themes and

constructs. Table 5.1 describes the key components of Joiner's model and how it was translated into the system dynamics model in Figure 5.1.

Table 5.1 Joiner (2005) Interpersonal Theory of Suicide Components as a SD Model

Theory Components	Source	Translated into Model
1. The combination of perceived burdensomeness and social rejection instill a desire for death.	Joiner et al. 2009 (p. 1)	- This original model from Joiner was modified by Van Orden to include that a combination of these issues leads to a chronic hopelessness that can affect one's desire for suicide. This is demonstrated in the model.
2. Individuals will not act on the desire for death unless they have developed the capacity to do so through exposure and thus habituation to painful and/or fearsome experiences.	Joiner, 2005	- All models have capability for suicide represented as a stock. Impulsivity, exposure to violence, and repeated attempts increase one's capability. However, there is a threshold desire for suicide that must be passed before an attempt is made. The same is true for capability for suicide.
3. Presence of hopelessness - that one's burdensomeness and social alienation is chronic and insurmountable in order to desire death by suicide.	Van Orden et al., 2010	- Chronic hopelessness is depicted as a stock with Perceived burdensomeness and thwarted belonging as inputs into one's stock of chronic hopelessness.

Model Boundaries

Using the text and analysis of themes as a guide in Table 5.1, a model boundary chart was created. A model boundary chart is used in system dynamics to summarize the scope of a model. Table 5.2 depicts the model boundaries of the first model in this dissertation study. Key variables, such as hopelessness and suicidal thoughts and attempts are included as endogenous variables, variables by which a system generates dynamics from interacting with each other and other variables/agents in the model (Sterman, 2000). Exogenous variables are those being influenced outside the boundary of the model, and includes variables that can be manipulated,

such as rates of intervention and personality. According to Sterman (2000), exogenous inputs should be small and each exogenous input must be carefully examined to consider whether variables may be influenced from endogenous elements.

Variables that are labeled "Excluded" in Table 5.2 include variables documented in Joiner's interpersonal theory of suicide as summarized by Van Orden et al. (2010) as important, but perhaps not singly the most explanatory in regards to the wide-spread application and usefulness of the theory to explain suicide attempts. Van Orden et al. (2010) suggests that though a myriad of risk factors, including biological, psychodynamic, cognitive-behavioral, and developmental/systems etiologies, may be theorized in the occurrence of suicide, useful theories are able to account for the imprecision and complicated mix of risk factors. One risk factor, in and of itself is not enough to predict a suicide attempt, therefore, a comprehensive theory of suicidal behavior should be able to account for many of these risk factors and demographic differences by gender, age, and cultural (Van Orden et al., 2010). Van Orden et al. (2010) thus interprets these risk factors as funneling into a few main constructs. The model boundary chart below (Table 5.2).

Table 5.2 Model Boundary Chart for the Interpersonal Theory of Suicide

Endogenous	**Exogenous**	**Excluded**
• Hopelessness	• Social isolation (family, adult, peers)	• Access to treatment post attempt
• Desire for suicide	• Perceived burdensomeness	• Substance/Drug Use
• Capability for lethal suicide	• Lethality of method	• Gender
		• Mental disorder
• Fear of death	• Thwarted belonging	• Sleep disturbances
• Suicide attempts	• Impulsivity	• Stressful life events
	• Exposure to violence	• Incarceration

Using the model boundary chart and analysis of texts, a CLD of the interpersonal theory of suicide (ITPS) was created. Figure 5.1 is a causal loop diagram (CLD) representation of ITPS as Joiner (2005) and Van Orden et al. (2010) have expressed it. The model was presented and explained to the original theorist of IPTS, Dr. Thomas Joiner, over a Skype call. He indicated that though this is not how he currently thinks about suicide, it is true to the original text of IPTS (T. Joiner, personal communication, July 2, 2015).

IPTS, when built as a system dynamics model, demonstrates only one reinforcing mechanism (R1: capability for suicide) and leaves characteristics, such as perceived burdensomeness and social isolation as exogenous variables, or variables that are not influenced by the system itself. This model demonstrates that at best, it can create some effect on suicidal thoughts/attempts, but may be inadequate in predicting changes that occur post attempt.

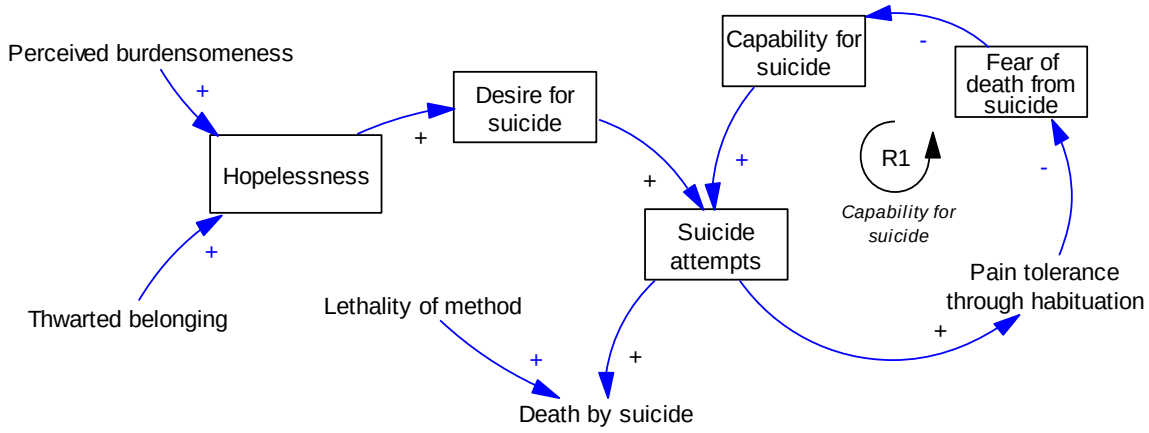


Figure 5.1 SD Model of the IPTS (Joiner, 2005; Van Orden, 2010)

Perceived Burdensomeness. In this model, one's perceived burdensomeness is a modifiable constant and represented as a proportion. The combination of perceived burdensomeness and thwarted belonging may influence one's sense of hopelessness.

Thwarted Belonging. Thwarted belonging is tied to one's perceived level of social connection. The perception that one does not socially belong is described as an "unmet need" Van Orden et al. (2010) p. 9, and may influence one's desire for suicide, when combined with perceived burdensomeness. In this model, thwarted belonging is depicted as a proportion of one's perceived social belonging over the total possible. The variable is left as an exogenous, modifiable variable, as theorized in IPTS.

Hopelessness. According to Van Orden et al. (2010), a sense of hopelessness about one's situation and the chronicity of that hopelessness can lead an individual to contemplate suicide. In this model, hopelessness is a stock variable, therefore as a level of hopelessness increases, it leads to an increased desire for suicide. Hopelessness is expressed by an integral equation that says hopelessness, at time t, is equal to the initial level of hopelessness at time 0 plus the integral of change in hopelessness from time 0 to time t, with an initial level of hopelessness of 1.

$$Hopelessness(t) = Hopelessness(0) + \int_0^t Hopelessness(u)du\,; Hopelessness(0) = 1$$

A change in hopelessness (*CH*) equals the desire to die from thwarted belonging (DDTW) plus the desire to die from burdensomeness (*DDB*) multiplied by hopelessness minus hopelessness (*H*), divided by the adjustment time to change hopelessness (*ATCH*).

$$CH(t) = \frac{(DDTW + DDB) \times H - H}{ATCH}$$

Desire for Suicide. Both perceived burdensomeness and thwarted belonging influence one's sense of hopelessness. Hopelessness leads to a desire for suicide, which is represented as a stock variable. The desire for death by suicide at time *t* is equal to the initial level of one's desire

for suicide at time 0 plus the integral of the desire for death by suicide from time zero to time t, when the initial level is set to .1.

$$Desire\ for\ death\ by\ suicide(t)$$

$$= Desire\ for\ death\ by\ suicide(0) + \int_0^t Desire\ for\ death\ by\ suicide(u)du\,;$$

$$Desire\ for\ death\ by\ suicide(0) = .1$$

The remainder of rate equations and a figure of the stock and flow model used for this simulation are listed in the appendix for reference.

ITPS Model Simulation

Figure 5.1 was specified as a stock and flow model (See Appendix for full model and equations). There are four stocks in the system structure. *Stella Pro,* a system dynamics modeling software, was used to create and simulate the model. The time step, the points at which the model simulates, was specified at 0.125 times per year and the euler integration method was used. The time dimension was specified as years ranging from 12 to 30 to represent age. Using model testing procedures as described in the methods section of this dissertation, the model was tested for dimensional consistency, sensitivity, and structural consistency.

The next phase of testing determined whether the model was adequate to explain the phenomenon of suicide attempts across adolescence into young adulthood for the general population of participants from Add Health. Assuming the interpersonal theory of suicide is correctly modeled, it should be able to replicate shape and values from Add Health data. To

determine the fit of the model, parameters from Add Health's general adolescent population were used to specify and the IPTS model (Table 5.3).

Table 5.3 Parameters from Add Health Participants

		Total Sample of Add Health		Attempted Suicide		Did not attempt suicide	
Variable	**Name in the Model**	**μ**	**SD**	**μ**	**SD**	**μ**	**SD**
Social rejection*	Thwarted belonging	1.93	.77	2.27	.98	1.90	.75
Exposure to violence*	Violence exposure	.65	1.49	1.41	1.41	.56	1.36
Burdensomeness*	Burdensomeness	1.74	.73	2.17	.98	1.70	.70
Impulsivity*	Impulsivity	12.95	4.86	14.17	5.03	12.95	4.82
Suicidal thoughts in adolescence	Desire for suicide	.13	.34	.09	.29	.81	.39
Suicide attempts in adolescence	Attempts	.05	.29	.98	.77	0	0

**This variable was used as a proportion of the entire possible scale points.*
[+]Lower values correspond with higher levels of self-esteem.

Results of this simulation compared to Add Health data are demonstrated in Figure 5.2. The 95% confidence intervals are shaded. Only at age 16 or 17 does the predicted line fit the line of the actual data. It is apparent that the shape does not fit the data from Add Health participants for ages 12 to 15 and 17 to 30.

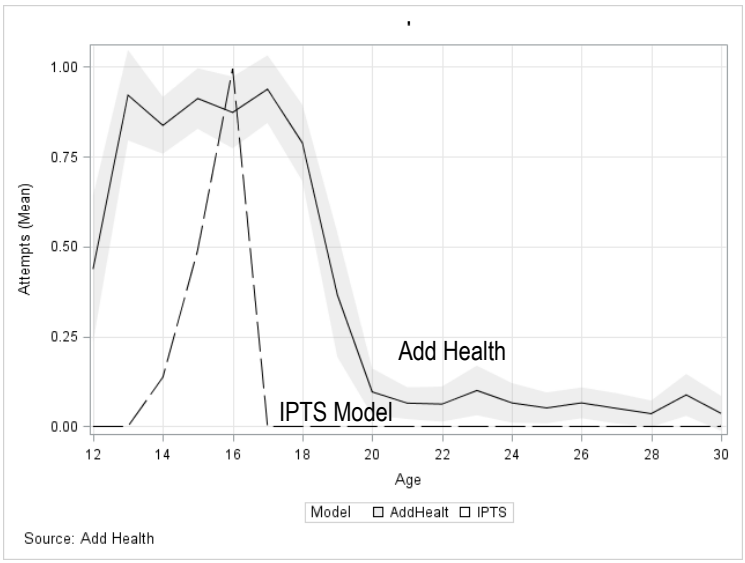


Figure 5.2 Simulation of IPTS Model versus Add Health Data

In this simulation, attempts remain at 0 until it exponentially increases at age 30. Though the general shape is similar, the applicability to a developmental view of IPTS is limited for predicting suicide attempts across adolescence with precision. In particular, there seems to be a mechanism that sustains a pattern of multiple attempts from ages 13 to 18. Though Joiner (2005) and Van Orden et al. (2010) may accurately predict a spike of suicides, it may not be specific enough to explain developmental trends across adolescence. Theil statistics could be calculated to gauge the fit of this model, however, it seemed unnecessary given the clear inability for the model simulation to reproduce the actual data. The Theil U statistic was calculated anyway, to demonstrate the model's accuracy in replicating the Add Health data and resulted in a value of U = .96. As mentioned in the methods section of this dissertation, a Theil's *U* statistic near 1 is considered better than guessing, however far from being able to accurately predict trends from actual data. Values closer to zero are considered a better fit, therefore this model is not necessarily ideal in prediction suicide attempts across adolescence and into adulthood.

Additionally, there are a number of other issues that limit the confidence of this model. Similar to the first model of IPTS, the only feedback loop is the reinforcing loop for the capability for suicide. The lack of balancing mechanisms in the original theory is not adequate to explain a developmental view of suicide attempts across time. Additionally, there is a lack of confidence in the model in regards to the reproducibility of other variables, For instance, the model does not account for the diminishing desire for suicide that occurs across adolescent development. As previously mentioned, the ability for a model to accurately reproduce multiple reference modes is an important confidence building test.

Given the inability of the IPTS model to replicate previous data, the model was altered in discussion with Dr. Thomas Joiner. Over a conference call, we discussed possible balancing mechanisms that were apparent in suicide attempts for those who attempted suicide but survived into young adulthood. Another iteration of this model was created to incorporate developmental possibilities that the first few attempts may result in the attainment of help or interventions to reduce and/or provide adolescents with the tools necessary to avoid future attempts. The next section will explain the development and testing of this model.

5.2 Developmental Systems Model of IPTS

Given the inability for the original IPTS model to replicate the experience of suicide attempts for adolescents and young adults, ages 12-30, other iterations of the model were formulated and tested. In the interest of parsimony, only the model that had the greatest confidence is presented. This model will be called the Developmental Systems Model of IPTS and integrates components from a cultural view of suicide along with modifications based on an intervention approach.

5.2.1 Causal Loop Diagram

In building this model, a structured qualitative analysis of studies (i.e., Barzilay et al., 2015; Joiner, 2005; Van Orden et al., 2010) based on Kim & Andersen's (2012) article on building confidence was used. Causal maps were generated through purposive text data and grounded theory was used to create the causal links in model, presented in Figure 5.3. Labels for each causal link are found on Figure 5.3 with references denoted with a grey circle containing a number. The corresponding reference list is displayed in Table 5.3 below. The full stock and flow model can be found in the appendix section.

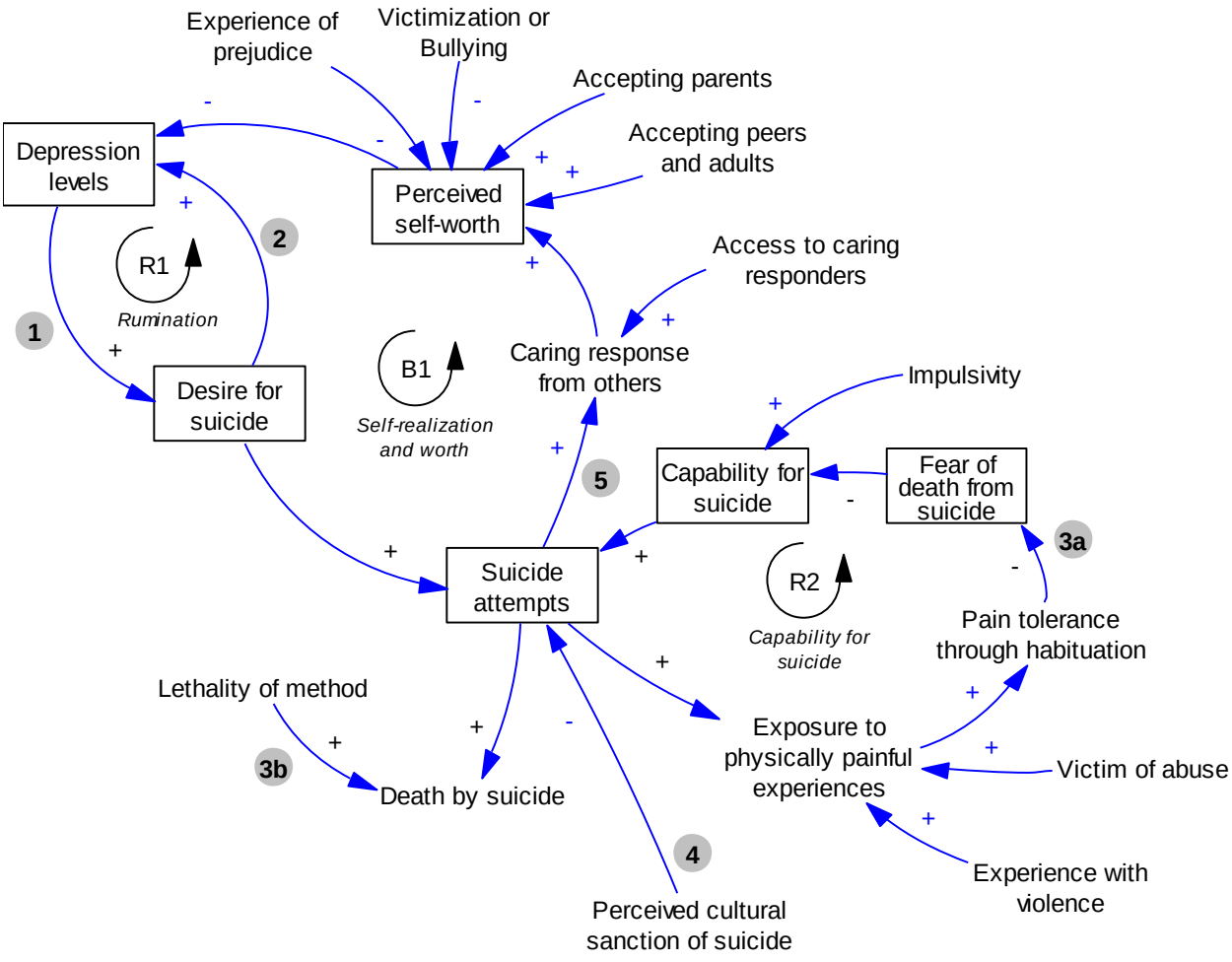


Figure 5.3 Developmental Systems Model of IPTS

Reference 1: (Table 5.4) In accordance with findings that tested IPTS with adolescents (Barzilay et al., 2015), thwarted belonging and burdensomeness were removed to keep the model parsimonious. In the referenced Barzilay et al. (2015) study, depression is a mediator between the two constructs and a desire for suicide during adolescence. Table 5.4 lists the studies that demonstrate the other links in this model.

Reference 2: The link between the desire for suicide and depression is a reinforcing relationship, according to Miranda & Nolen-Hoeksema (2007). This study suggests that the act of rumination can lead one who is experiencing depression, to contemplate suicide, which diminishes a cognitive capability to diminish their depression, and causing reinforcing patterns of behavior on suicide, sustaining the length of depression.

Reference 3 (a and b): These references derive from Joiner's (2005) IPTS model and the Van Orden et al. (2010) iteration of the model discussed previously. Reference 3a suggests that an increased tolerance for pain can lead to a diminished fear of death by suicide, increasing one's capability to attempt suicide. Reference 3b was discussed in IPTS but not made explicit in this and the previous model because it examines the lethality of an attempt. According to IPTS, the outcome of a suicide attempt will depend on the lethality of the method chosen to end one's life.

Reference 4: The cultural stigma/sanction associated with a suicide attempt may hinder one from trying to attempt suicide, according to Chu et al. (2010) in the cultural model of suicide. This reference is represented in the model as a balancing mechanism for suicide attempts. The greater the cultural stigma, the less likely one will attempt suicide. This is an example of a situation where having a shame-based culture may provide protective benefits in the area of suicide, but perhaps not for receiving mental health services.

Reference 5: In order to address the concern that there is a lack of balancing mechanisms that could explain the original IPTS model for a developmentally appropriate explanation of suicide attempts, research was examined to understand what helps adolescents recover from attempting suicide. Bostik & Everall (2007) conducted a qualitative study of 41 adolescents, ages 13 to 19 to understand how they overcame feeling suicidal. This study used a grounded theory approach to determine that attachment relationships and changing self-perceptions were pivotal in their healing process (Bostik & Everall, 2007).

Table 5.4 Studies informing Causal Links in Figure 5.3

#	Causal Relationship	Study Reference	Notes
1	Increasing depression increases the desire for suicide	(Barzilay et al., 2015)	This study found that depression may be a mediator between thwarted belonging and perceived burdensomeness, taking out the need to model those particular constructs directly.
2	Ruminating on one's depression may lead one's desire for suicide to increase.	(Miranda & Nolen-Hoeksema, 2007)	This study suggests that rumination may lead to suicide ideation which may inhibit one's ability to deal with their depression.
3	a. Increased pain tolerance leads to a diminished fear of death by suicide. b. Death by suicide is dependent upon using lethal means	(Joiner, 2005)	Also in the original IPTS model. This was not explicitly depicted in the original IPTS model in this study, but is included in the CLD, though not modeled in the actual simulation.
4	Cultural sanctions for suicide may inhibit the attempt of a suicide.	(Chu et al., 2010)	This is an exogenous variable that suggests one's belief that suicide is stigmatizing may serve as a protective factor and inhibit one from trying.
5	A caring response after a suicide attempt may lead to a growing sense of social connection.	(Bostik & Everall, 2007)	This qualitative study on adolescents who survived a series of suicide attempts used qualitative interviews to understand what helped adolescents heal. One of the main findings was the presence of a

	caring and supportive social attachment post attempt.

5.2.2 Feedback Loops and Equations

B1: Self-Realization and Worth. According to Orbach (2003), adolescents who suffer from low self-worth believe they do not deserve to live and have a tendency to withdraw. Though the relationship between self-worth and depression is reinforcing through the process of rumination, the relationship between self-worth and suicide desire after an attempt is conceptualized as having a balancing effect on desire. This balancing effect, or recovery from suicide attempts, is postulated as cognitive change.

There are a few studies that have used qualitative interviews to understand how adolescents recover from suicidal thoughts and behaviors. This balancing loop was created from analysis of these research projects (e.g., Bostik & Everall, 2007; Chi et al., 2014). In available studies, authors concluded that a cognitive change where adolescents became aware that their life was worth living and that they were loved and cared for by others helped them stop attempting suicide. Many times, these experiences were created from a spiritual awakening or belief that they were loved by God, in particular (Bostik & Everall, 2007; Chi et al., 2014). Though spiritual reasons are often cited as playing a role in an individual's recovery (Balis & Postolache, 2008), it is not explicitly modeled in the developmental systems model of IPTS as the change that occurs in one's self-worth can capture this change. Therefore, as one's perceived level of self-worth increases, their depression level decreases, creating a balancing effect on the desire for suicide.

The equation for this balancing loop is expressed using a stock and rate of change equation that accounts for the effect of depression, perceptions of care from peers and parents,

and experiences of victimization or prejudice. The stock, *perceived self-worth*, is the initial level of perceived self-worth added to the integral of perceived self-worth (*PSW*) from time zero to time t, with an initial value of 15.

$$PSW(t) = PSW(0) + \int_0^t PSW(u)du\,;PSW(0) = 15$$

The rate equation for change in perceived self-worth is expressed where a change in self-worth is equal to the effect of self-worth from peers and family (*SWPF*) minus the multiplied effects of self-worth from depression (*SWD*), self-worth from victimization (*SWV*), and self-worth from prejudice (*SWP*) times the initial value of perceived self-worth (*PSW*) all divided by the adjustment time it takes to change one's self-worth (*AT to change SW*).

$$Change\ in\ SW = \frac{((SWPF - (SWD \times SWV \times SWP)) \times PSW)}{AT\ to\ change\ SW}$$

R1: Rumination. The loop labeled *R1* demonstrates the relationship between depression and a desire for suicide. Individuals who have increasing levels of depression increase in their desire for suicide from perhaps a passive desire to disappear to a more active desire to die by suicide (therefore desire for suicide is represented by a box to denote that is a stock variable. The more one desires suicide, the more rumination occurs which may increase an individual's experience of depression

This feedback relationship for depression, a stock, is represented by three equations (1 stock equation and two rate equations).

Depression level (D) is equal to initial level of depression at time =0 plus the integral of depression from time 0 to *t* with an initial value of 6.

$$D(t) = D(0) + \int_0^t ID(u) - DD(u)du\,; D(0) = 6$$

The rate equations for depression level include an inflow, *increasing depression*, and outflow, *decreasing depression.* To demonstrate how depression levels and the desire for suicide are related, the structure of depression levels is used as a co-flow for the desire for suicide, where rates of increasing and decreasing depression influence each other.

Increasing depression (*ID*) is equal to the effect of self-worth on depression (*EffSWD*) plus 1 times the fractional rate of depression (*FR of D*) times depression level (*D*). The addition of the one ensures that if the effect is zero, it will not cancel out the fractional rates or level of depression through multiplying.

$$ID = (Effect\ of\ self\ worth\ on\ depression + 1) \times FR\ of\ D\ \times D$$

The outflow, decreasing depression (*DD*) is equal to the depression level (*D*) divided by the average duration of depression (*AveD*).

$$DD = (Effect\ of\ self\ worth\ on\ depression + 1) \times FR\ of\ D\ \times D$$

The inclusion of the causal link depicting a perceived stigma of mental health problems leading to fear or embarrassment/shame which diminishes suicide attempts and seeking help was modified from Chu et al. (2010).

The desire to die by suicide (*DDS*) is a stock variable that is linked to depression levels as a coflow structure. The desire for suicide (*DDS*) is equal to the integral for the desire for suicide from time zero to time *t* plus the initial level of desire, with an initial level of .1.

$$DS(t) = DDS(0) + \int_0^t ISD(u) - DDS(u)du\,; DDS(0) = .1$$

An increase in one's desire for suicide (*IDS*) is a rate equation that is influenced by one's increasing rate of depression (*ID*) and the marginal increase in desire for suicide for each unit of depression (*DSperD*):

$$IDS = ID \times DSperD$$

A decrease in one's desire for suicide (*DDS*) is an outflow equation that is equal to a decrease in depression multiplied by the average desire for suicide (*ADS*) multiplied by the effect of self-worth on the desire for suicide (*EffSWDes*) plus the effect of getting treatment after a suicide attempt (*EffTreat*).

$$DDS = DD \times ADS \times (EffSWDes + EffTreat)$$

R2: Capability for Suicide. The reinforcing loop, capability for suicide, is the same capability loop that was described in the first model testing IPTS. The equations for this structure can be found in the appendix.

The developmental systems model for IPTS also incorporates stressors that have that have been theorized as important in the adjustment of adolescents during their search for identity, social, and emotional adjustment. Parameters listed in Table 5.5 in previous sample descriptions in Chapter 4 were used to calibrate the model. Proportions were calculated and used where appropriate.

Table 5.5 Parameters by Gender for Add Health Participants who Attempted Suicide

		Males		Females	
Add Health Variable	**Name in the Model**	**μ**	**SD**	**μ**	**SD**
Social rejection	Thwarted belonging	2.17	.96	2.31	.99
Burdensomeness	Burdensomeness	2.00	.92	2.23	1.00
Impulsivity*	Impulsivity	15.7	4.98	13.59	4.86
Exposure to violence	Violence exposure	2.40	3.16	.99	1.82
Suicidal thoughts in adolescence	Desire for suicide	.80	.40	.81	.39
Suicide attempts in adolescence	Attempts	.94	.76	.99	1.83

***Converted to a proportion by taking the mean value divided by total points in scale possible*

5.2.3 Simulation and Calibration of the Model

Following the methods outlined in Chapter 3 and the previous section testing the IPTS model, the next step after model creation was to iteratively test and calibrate the simulation model.

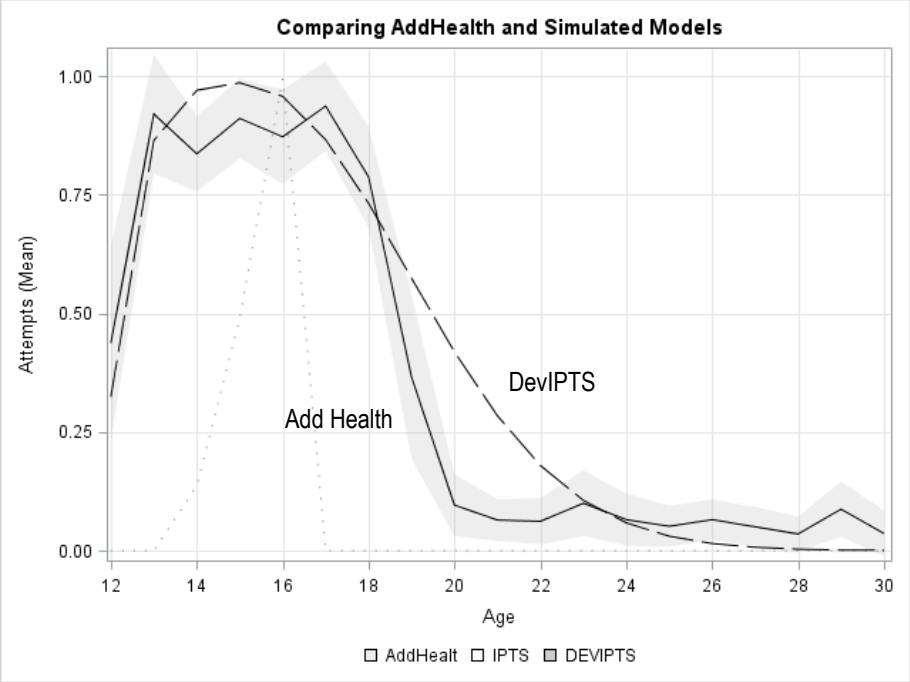


Figure 5.4 Developmental Systems Model of the Interpersonal Theory of Suicide

Other graphs of note to build confidence in this model includes data on depression levels and self-worth. These graphs were cross-referenced with data from Add Health and demonstrate similar shapes for a sample of adolescents who attempted suicide during Wave I and II.

Theil statistics that were calculated for the model indicate a U^M value of 0.01 and a U^S value of 0.43. When added together, $U^M + U^S = 0.44$, which is considered decent. The U^M value indicates the points predicted in the model were extremely close to the points in the actual data. The relatively higher U^S value indicates that there may be wide fluctuations in the actual data that are not represented in the simulated data. These fluctuations in the actual data are visible in Figure 5.4, however may not necessarily be important given the data needs to simply follow the trend of data. Generally, Theil statistics close to zero indicate little systematic error, and therefore the model is better than guessing and generally useful. According to Sterman (2002), if the majority of the error is concentrated in unequal covariation, U^C, the model captures the mean and trends in the data well, differing from the actual data only point by point. Using this model, the next section will demonstrate experiments that were conducted to identify leverage points to reduce suicide attempts into adulthood.

5.3 Model Experimentation

To continue testing the utility of the developmental systems view of IPTS, two different experiments will be described and conducted. These tests examine subgroups by gender and race, and determine the types of leverage points to prevent and/or reduce suicide attempts in adolescents across development.

5.3.1 Experiments

There are two questions that are examined in the experiments that follow:

1. Is the model adequate to predict suicide attempts by subgroups of gender and race?
2. How can we prevent/reduce suicide attempts from adolescence into young adulthood?

Predicting Suicide Attempts by Gender and Race

In order to answer the first portion of the first question, the model was fit the model with parameters for females and males (listed in Chapter 4) who attempted suicide during Wave I or II and then plotted with data from Add Health. The model was then examined to determine whether it could accurately depict the curves produced for each subgroup. Calibrating the model to demonstrate differences for males and females resulted in some changes.

The model was calibrated for males by changing the desire per depression unit value to .53 and the FR of depression to .16. The average duration of depression was set to 2.2 years and the adjustment time to diminish a fear of death by suicide was set to .78. Results of the models are demonstrated in Figure 5.5.

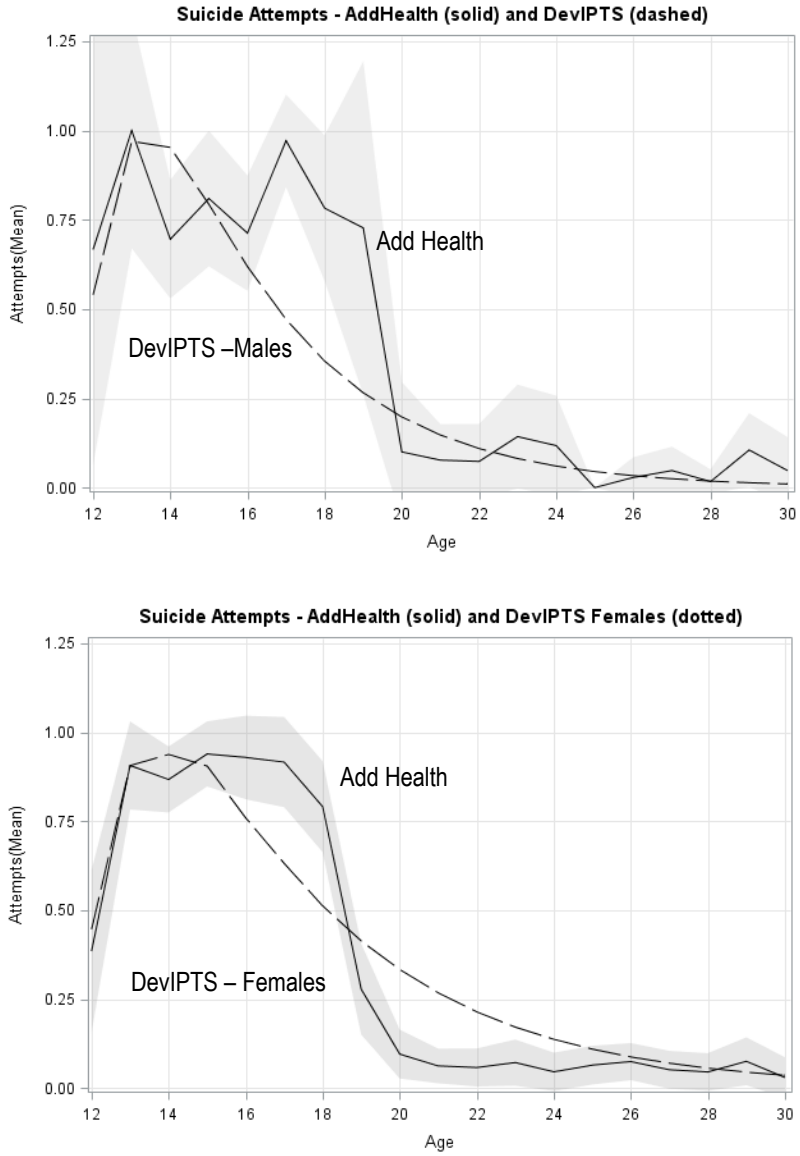


Figure 5.5 Add Health Data compared to Simulated Data by Gender

Figure 5.5 demonstrates simulated data versus actual Add Health data for males (left) and females. Though the general shape matches, there are peaks around ages 18 to 20 for males that are not accounted for in the model, even with calibration. For females, there are reinforcing and balancing mechanisms that are unaccounted for from ages 16 to 18, with exponential declines from 18 to age 20. The model is does not adequately fit each gender, however. Though the fit is not exact, the shape is somewhat similar.

To fit the model for racial groups, parameters from Chapter 4 were attained in Table 4.3 and Table 4.4 for used to test each group. Using these parameters, the following graphs were compared with data for each group in Add Health. Figure 5.6 demonstrates differences for each group mean with solid lines depicting Add Health data.

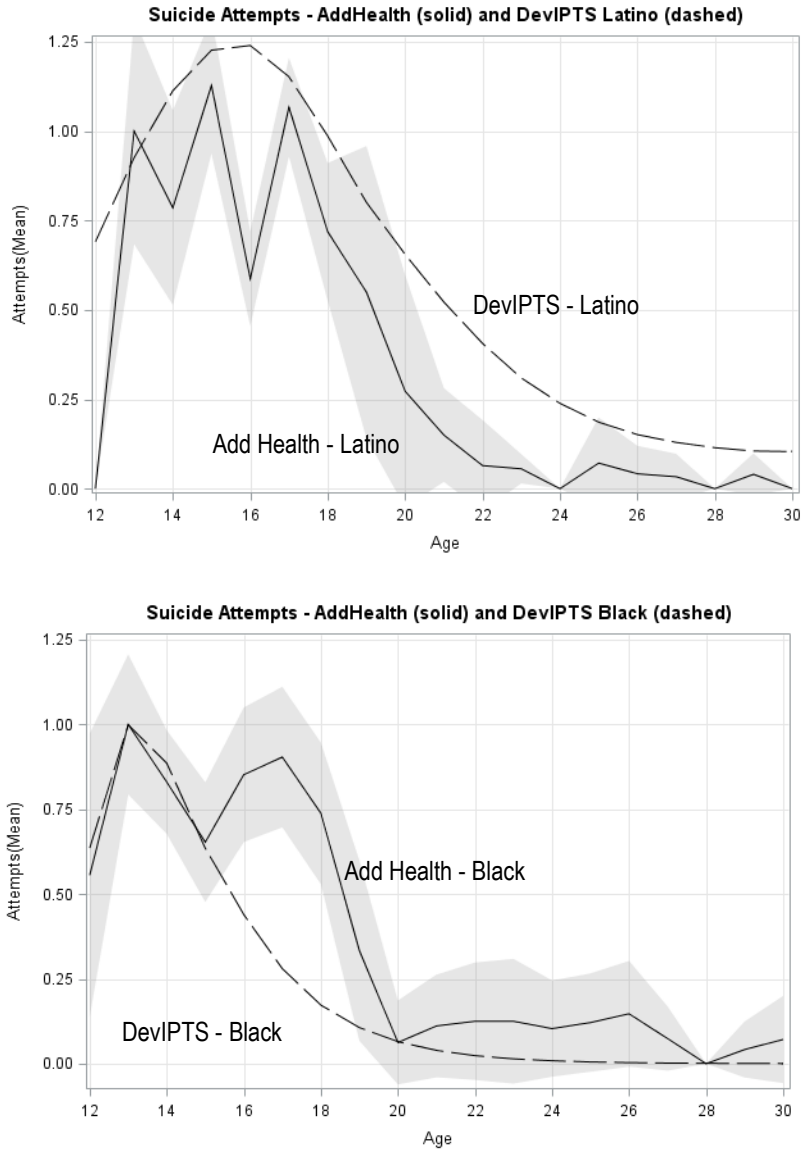


Figure 5.6 Simulating DevIPTS by Racial Group: Latino, Black

For Latinos, calibrating the model for suicide included changing the FR of depression to .36 1/years, setting the average duration of depression to 1.6 years, and changing the time to increase capability to .6 years. The desire per depression units was set to .38 desire units per depression units. The number of attempts they made per unit of desire was also set to .51. Doing so resulted in Figure 5.6, which follows the shape of Latino adolescents (left) who attempted suicide. Black adolescents are plotted using the developmental systems model of IPTS on right.

From simulating both gender and some subgroups of race, it is clear that the developmental systems model of IPTS is not extremely useful in understanding differences by subgroup. For instance, spikes in suicide attempts were not well accounted for in these graphs. And though a reference mode simply looks at the trend over time, versus a point-by-point plot of behaviors, these lines demonstrate poor fit, even when calibrating the model for time and peak attempts.

Additionally, without nuanced theoretical information and data, it was difficult to tell whether cultural variables, such as cultural sanctions/stigma associated with attempts were useful in predicting suicide attempt trajectories for each racial category of adolescents. Information, such as shame or perceived mental health stigma were not variables measured in the Add Health data. Though proxy variables, such as immigrant generation or primary language spoken at home could help understand one's cultural affinity, it is not enough to understand whether an adolescent in that setting holds various cultural standards. Using these variables would only allow us to make demographic speculations, which are not particularly helpful in understanding the individual process.

Prevention and Intervention through Simulation

The next step was to understand where any leverage points may exist for the general population model. The Developmental Systems IPTS model was tested for ways to decrease the accumulation of suicide attempts across time. Two different strategies were targeted: the reduction of depression and the restriction of means to develop a capability for suicide.

One way to effectively reduce suicide attempts into adulthood for all adolescents through the simulation model was to reduce the average duration of depression experienced. Though decreasing the time of duration for depression from .8 years by half to .4 years did not prevent all suicide attempts, it did reduce the stock of accumulating suicide attempts (long-dashed lined in Figure 5.7 compared to the solid line depicting the baserun model).

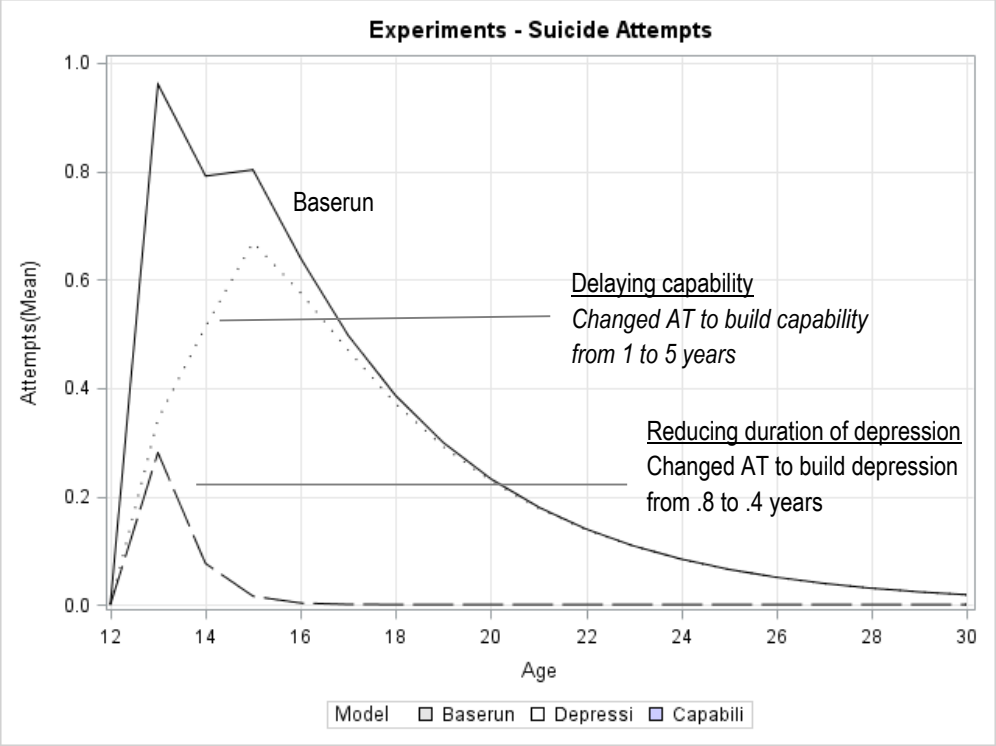


Figure 5.7 Experiments with Depression and Capability for Suicide

Figure 5.7 also demonstrates the results of experimenting with the baserun model by increasing the time it takes to build a capability for suicide. In this experiment, the idea is that even though depression may be expressed across the normal time of duration (.8 years), by

increasing the time it takes to build capability, perhaps by limiting access to information on how to attempt suicide or diminishing the exposure to violence an adolescent experiences, one could reduce the number of suicide attempts made by an adolescence.

Though useful in reducing attempts (see the thin dotted line in Figure 5.7), even increasing the capability to attempt suicide from 1 year to 5 years did not entirely diminish attempts. Overall attempts from ages 12 to 16 were reduced, however, they did not decrease to the level of that occurred when reducing the duration of depression by half (dashed line in Figure 5.7). The general shape also follows the baserun model (solid line in Figure 5.7) and meets the number of attempts at age 17. Therefore, though increasing the time it would take to build a capability for suicide would help, it is not the most effective means to reduce attempts across time. It seems that an adolescent would eventually build capability even with an increased delay.

In a real world situation, reducing attempts would equate to less potential medical visits, psychological distress, and a decreased likelihood of death by suicide. Results from these two simple experiments demonstrate that practical ways to do this may include initiatives that would identify depression earlier. Interventions, such as universal depression screenings in schools or doctors' offices, could assist in identifying adolescents suffering from depression to expedite treatment. In reality, however, reducing the length of depression may not be the simplest place to intervene, as depression is a disease that is not entirely well-understood and easy to treat, especially during the stage of adolescence (Thapar et al., 2012). Depression as a leverage point has been, however, cited as one of the best places to intervene in regards to suicide treatment (Wilde, Kienhorst, & Diekstra, 2001). This experiment suggests that even diminishing the duration that one experiences depression can help reduce attempts in a substantial way.

5.4 Summary

Simulating various models and iterations to predict suicide attempts for adolescents into their adulthood resulted in two models that were presented in this chapter. The first model was the original interpersonal theory of suicide as presented by Joiner (2005) and Van Orden et al. (2010). Though useful in demonstrating the lead up to perhaps one attempt, the model was not able to adequately predict suicide attempts throughout adolescence. This inability was perhaps due to the lack time specification for attempts and balancing mechanisms that occur during the ages 12 to 18.

Though less parsimonious than IPTS and its various iterations, the developmental systems model of IPTS that was created and presented in this chapter helped convey an understanding of the mechanisms that can predict suicide attempts in adolescence. Additionally, it was used to decrease attempts and how these variables affect the developmental trajectory of adolescents over their teenage years into young adulthood. The model does not, however accurately differentiate trajectories for racial groups, as demonstrated with participants in Add Health. It is likely there are mechanisms, feedback loops and other structures that can account for these behaviors. Future research studies should examine the experience of recovery through qualitative interviews and other rigorous methods to understand how adolescents stop attempting suicide.

Chapter 6: Discussion

This dissertation is one of the first known studies that uses system dynamics to examine the presence of feedback mechanisms in an individual's decision to attempt suicide from adolescence into young adulthood. Moreover, this study is a first attempt to examine Joiner's (2005) interpersonal theory of suicide (IPTS) through a feedback perspective for adolescents. The overall findings of this study suggest there are various reinforcing and balancing mechanisms that may be responsible for explaining a developmental view of adolescence. This study does not, however, adequately explain suicide trajectories for individuals based on race or gender. Implications for future research, practice, and policies are outlined.

6.1 Overall Findings

The main findings of this study indicate there are reinforcing and balancing feedback loops that can explain the experience of suicide attempts for adolescents from ages 12 to 30. These feedback loops help build a capability for suicide through repeated attempts, exposure to violence, and the experience of depression. The model, however, was not adequate at differentiating trajectories in suicide attempts for adolescents from subgroups by race or gender.

The experiments in this study provided a new method to approach suicide prevention that could be useful for simulating policies and treatment for the greatest impact. Experiments conducted on the model to diminish suicide attempts across time included reducing the average duration of depression and increasing the time to build a capability for suicide. Though both methods were effective in reducing attempts during adolescence, reducing the average duration of depression during adolescence was more effective at diminishing attempts across time.

Additionally, this study provides another perspective on IPTS for the period of adolescence into young adulthood using nationally representative longitudinal data from U.S.-based participants in the National Longitudinal Survey of Adolescent and Adult Health (Add Health). Using a longitudinal view, this research incorporates the possibilities that feedback loops can explain how suicide attempts grow and subside during puberty and into young adulthood. Overall, this study indicates that the Interpersonal Theory of Suicide (Joiner, 2005; Van Orden et al., 2010) is adequate in predicting a suicide attempt as an event, but does not adequately demonstrate the trajectory of suicide attempts across development for subgroups of adolescents. There are various implications, limitations, and directions for future research gained from this study that are described hereafter.

Testing Previous Theories of Suicide

Numerous studies have been used to understand and test the Interpersonal Theory of Suicide (Gunn, 2014). This study adds to existing literature by attempting to measure and build IPTS as a systems theory. Though successfully translated into as system model, this study demonstrated that IPTS as described by Joiner (2005) and Van Orden et al. (2010) is not adequate to predict suicidal behaviors from a developmental perspective for adolescents across time. Balancing loops, or explanations that describe what diminishes attempts across time were not present in the original IPTS model.

Modifications of this theory using existing empirical studies resulted in a systems model that accounted for a variety of reinforcing and balancing loops to predict the trends of suicide attempts across time. The modified model, the Developmental Systems Model of IPTS, incorporated the effect of suicide attempts on future attempts by balancing one's desire for

suicide post-attempt. This balancing loop suggested that post-attempt responses of prompting a cognitive change in one's desire for suicide could diminish overall attempts across time. This is just one of the many possible balancing loops that may explain the sharp decrease in attempts at around ages 17 to 18 for adolescents.

The modified model also included reinforcing loops that may have been driving suicide desire, such as rumination. Ruminating on one's hopelessness or depression has been found in other studies to play a role in the development of suicidal behavior, exacerbating an individual's suicide risk (Lester, 2014). This loop, when included in the developmental systems model of IPTS seemed to drive behavior for adolescents across ages 16 to 18. More testing with data better suited to examine rumination is necessary to examine this loop further.

The new developmental systems model of IPTS was also useful in replicating suicide attempts across age. Similar to previous studies (e.g., Joiner et al., 2009), this project demonstrated that one of the biggest predictors of future suicide attempts is previous attempts. Having a history of suicide attempts was highly predictive of suicide, and though this seems intuitive, it suggests there is an imperative to care for and intervene with individuals who have tried in the past.

In regards to capturing sustained attempts that occurred between ages 13 to 17 for the general population of adolescents in Add Health, the model was adequate. It was not apparent in the current study, why these attempts sustained. However, qualitative literature on post-attempts may provide a rationale for the plateau of sustained attempts (depicted in the behavior over time graphs in Figure 1.1). Some studies describe this sustained pattern of behavior as the process of living to die and dying to live (see Bergmans, Langley, Links, & Lavery, 2009). Participants in

qualitative studies such as Bergmans et al. (2009) indicated that recovery took years, with periods of increased desire to live, followed by increased desires to die. The oscillation between both feelings, however, led to what participants in that study described as "pockets of recovery," (Bergmans et al., 2009, p. 123) or the process by which they slowly started to get better.

Though the model replicated general patterns of suicide attempts for the general population of adolescents in Add Health, there were also serious limitations. It could not differentiate trajectories for various groups of adolescents by race or gender. The inability to recreate trajectories by race may be due to factors that are not represented in the model. These differences are important to account for as demonstrated in many studies.

For example, one study suggests there are differences between white and black adolescents who attempt suicide in regards to the expression of their psychological profile. Unlike white adolescents, who present more hopelessness and suicidal ideation (characteristics that are considered internalizing psychiatric symptoms), black adolescents seem to display more externalizing symptoms (Merchant, Kramer, Joe, Venkataraman, & King, 2009). These differences were not necessarily accounted for in the current study. Other intangible factors, such as perceptions of shame regarding the receipt of mental health services, suppression of emotional distress, or other attitudes could help explain some of these differences. These attitudes, however, were not included in data from Add Health and were therefore difficult to test.

The model was also unable to predict difficulties with depression and self-worth simply from using the inputs of depression and self-worth. The causes and interactions on these constructs are complicated and characterized by dynamics that are not included in the model boundaries of this particular model. Future iterations and testing of this model could benefit from

using studies, such as Wittenborn, Rahmandad, Rick, and Hosseinichimeh (2015), which systemically mapped the feedback loops of major depression disorder as a causal loop diagram.

Other components that are likely important when examining a feedback perspective suicide but were not included in the model are risky behaviors, such as self-harm, substance or alcohol use, or sexually risky behaviors. Additionally, processes, such as identity-formation and self-actualization are not adequately addressed. Though understanding these way these behaviors are interrelated may be critical to describing experiences of suicide from a developmental perspective, they were excluded because they were not included in Joiner's original IPTS model. Theories that examine how these behaviors may affect suicide outcomes can provide further insight on a developmental perspective of suicide.

Tipping Points in the Individual Experience of Suicide

Another aspect of this study that is important to address is the idea of a tipping point, or a set of conditions that divide two polarized, internally driven behavior modes (Taylor & Ford, 2008). Popular literature, such as Malcolm Gladwell's (2000) book on *The Tipping Point* indicates that a tipping point is a dramatic moment in an epidemic where everything changes in an instant. Gladwell even discusses suicide as a tipping point, however, in the context of contagion theories at the population level. According to Taylor & Ford (2008), feedback loops can explain tipping point dynamics. Though their study examined construction project delays, a similar framework can be used to examine the model of suicide presented in the developmental systems model of IPTS.

The tipping point is an idea that is not explicitly discussed in existing theories of suicide. Joiner (2005) alludes to this point by saying both desire and capability is required to attempt

suicide. This phenomenon is presented in this study as the place where an individual capability to bear the social isolation and hopelessness from depression, combined with a built capability to attempt suicide, led to a series of suicide attempts. The possible feedback loops at work for this tipping point includes one's capability for suicide, which increases rapidly once an attempt has been made. This is possibly because one's learning from a thwarted or incomplete attempt is used to increase capability for future attempts.

It is not only important, however, to examine the increase in suicide attempts as a tipping point, but the rapid decrease in attempts across time. From ages 12 to 18, there is an increasing behavior, a plateau and maintenance of attempts, and then a sharp decrease in suicide attempts from ages 18 to 24. The balancing loops that cause this sudden shift in behavior should be studied in greater detail in future studies. Perhaps there is a structural shift as environments change with adolescents moving onto college, becoming a legal adult, and/or moving out of the house and into full-time employment. Some qualitative studies on suicide attempt survivors indicate that this tipping point may simply be the result of various recovery mechanisms (in systems language, balancing loops) finally gaining dominance over time (Bergmans et al., 2009).

Given this drastic shift in suicide attempts, though we have general information on the cognitive changes that occur post attempt, there are specific questions to be answered about recovery. For instance, there are questions regarding whether recovery can be attributable to development in one's biophysical processes or environmental shifts that causes the change in desire and thereby rapid decrease in attempts. Understanding these mechanisms could be useful in preventing suicide attempts in the future.

6.2 Limitations

Like many research studies, there are a number of limitations to its applicability and findings. Many of these limitations are attributable to the models. Other issues are attributed to the data. Furthermore, there were limitations in this study due to the time frame modeled.

First, there were various factors that were not captured in the individual model of events leading to a desire for suicide. For instance, Abrutyn (2014) details various socioemotional structures that may lead to different types of suicide as described by Durkheim. These various types range from anomic suicides (driven from a lack of regulation or change in social status), egoistic suicides (produced from a lack of social ties), to a mixture of the two. For the purpose of this dissertation, egoistic suicides were given the greatest focus, as it seemed the discrepancy between identities could be depicted through a sense of social rejection. Future studies should incorporate the anomic suicide to understand discrepancies between two identities.

Deaths by Suicide. Though Add Health is nationally representative, there were a small percentage of individuals who were listed in the National Death Index to have died by suicide (n=22 or about .1% of the sample). These participants were not included in the Wave 4 weighting since they were deceased before the Wave 4 collection. Therefore, though this study was on suicide, it was hard to understand which characteristics were important in predicting the death of these 22 individuals. Due to these factors, it was inappropriate to generalize characteristics from this sample on national implications for death by suicide.

Genetic predisposition. One aspect of suicide that was not discussed or modeled in this dissertation is genetic predisposition. In Joiner's (2005) book, he discusses the possibility that people who died by suicide have varying long and short alleles that could be used to predict risk.

Twin studies were used between monozygotic and dizygotic twin pairs to understand any relative links. However, inherently in studies such as these, there are numerous confounding factors, such as sharing the same environment (e.g., same parents, socioeconomic, and cultural factors) but perhaps not the same experiences (e.g., preferential treatment from one parent, traumatic event), or the interpersonal effects of loved ones attempting suicide on one's despair, depression, and concurrently desire to also die by suicide.

Though a variety of conversations on suicide and depression suggest the importance of one's genetic predisposition in the development of suicide, a predisposition does not automatically assign one's outcome. In psychological terms, this susceptibility is referred to as the diathesis-stress model, a psychological theory predicting that psychiatric disorders result from interactions of either genetic, cognitive, diatheses predispositions with negative life events. The theory proposes that when an underlying vulnerability is strong, less stress is required to trigger the outcomes or behavior; when the susceptibility or predisposition is weak, a greater amount of stress is typically necessary before an individual develops the outcome of note (Beck & Dozois, 2011). The diathesis stress model is proposed to interact with impulsivity in suicide by changes through epigenetic mechanisms from early-life adversity (Mann & Currier, 2010).

A genetic predisposition through the diathesis-stress model is certainly a plausible way to understand the escalation of suicide attempts for young people. Genetic predisposition, however, is not a promise of death. Though possibly a vulnerability, this theory still requires a trigger event or circumstance. For instance, consider two individuals with the same type of genetic predisposition to suicide. Though biologically similar, environmentally, the triggers that may engage a suicidal response can vary widely. Person A may have a strong social network of friends and family who provide support and encouragement, whereas holding all other factors

constant, Person B may be situated in a place where that network is limited and even distressing. Though both individuals have the same susceptibility of developing suicidal thoughts and behaviors, it is less likely that an individual with the environmental social supports will become suicidal. These social factors are important to highlight.

Data. Another limitation of this study is that the spacing of Add Health waves may be less than ideal to examine important developmental information. I attempted to correct for this by using developmental age, regardless of which wave was being surveyed, to analyze similarities and differences between people. Though this strategy was used to understand developmental differences, there are limitations in the applicability of this study since individuals were not matched across observations. This issue was also addressed by using a population mean approach to individual modeling (see Osgood, 2009).

In addition to the uneven spacing of waves, another limitation of the data is that there were various parameters that were not adequately addressed by existing data. For example, the capability for suicide was a variable that was not directly measured in Add Health data. In order to determine one's capability for suicide, the construct was composed of variables from text on what builds capability according to Joiner (2005) and Van Orden et al. (2010). Other variables, such as fear for death by suicide was also inferred from other existing variables. Though this is a limitation in this model, it was helpful to model for possible inclusion in new studies examining suicide.

Timeframe. In regards to the timeframe, this model is only intended to examine suicide attempts across adolescence. It does not look at each individual attempt, as the data and time points did not allow for individual predictions. Though it would be helpful to model each

attempt, it is arguably just as important to predict and mitigate attempts across the life span as capability increases across the years. This has been postulated as one of the reasons why suicidal lethality increases with time (Goldston et al., 2015). Perhaps the learning and capability acquired from attempting during adolescence leads to plans that are much more lethal in intent as adults.

Racial/Cultural Factors. Another limitation of this dissertation is the lack of emphasis that was placed on aspects of suicide that may be pertinent to various racial identities. Initially, the dissertation attempted to understand differences between racial groups. As the models were being constructed, it became apparent that cultural attitudes or experiences as a racial minority may enhance depression or hopelessness. However, the lack of available data on these constructs, combined with the limited inclusion of these aspects in respect to IPTS, restricted the ability to model these components. Future iterations of this model should incorporate and test balancing loops that may explain differences by various attitudes and experiences based on race and culture. For instance, the rate of access to highly effective interventions and care post-attempt seem to be important for future studies.

Special populations. Another limitation of this study is its emphasis on non-clinical samples. For instance, adolescents who attended non-traditional schools (i.e., homeschool, alternative schools) were not included due to the sampling frame of Add Health. Additionally, high-risk populations, such as adolescents identifying as gay, lesbian, questioning, or transgender were not explicitly discussed. Therefore, the implications of this model cannot be generalized to these subpopulations.

Other risky behaviors. Another issue to stress in the applicability of this model is the presence of other types of risky behaviors that could be linked to suicidality. For instance, issues,

such as drug abuse, alcoholism, eating disorders, and self-harm are often tied to suicidal behavior (Bae, Ye, Chen, Rivers, & Singh, 2005; Courtney-Seidler et al., 2014). They are not, however, included as covariates in the model because they are not explicitly theorized in the IPTS model. These types of risky behaviors are important to consider as some have cited these issues as unexpected protective factors against completing a suicide. For instance, some adolescents indicate that the pain from self-harm provides analgesic effects that decrease one's experience of pain, providing a sense of relief and peace from previous difficulties (Gordon et al., 2010), and thereby initially dissipating a desire for suicide.

Understanding how these types of risky behaviors may serve as balancing loops for the desire for suicide is intriguing and important, especially as it pertains to the opponent process theory. These behaviors should also be studied alongside other types of balancing mechanisms, such as emotion regulation and healthy coping, with an emphasis of examining these effects over time. Though risky behaviors may provide immediate dissipative effects, there may be long term implications that make suicidal desires increase with practice.

6.3 Implications for Research, Practice, and Policy

Despite the various limitations, this study was the first of its kind to use nationally representative data to test a systems model of suicide using the concept of feedback for adolescents. Given the type of data that was available, it provided some insight into the process of suicide for adolescents by testing the Interpersonal Theory of Suicide. Though the final model was not able to reproduce trajectories of suicide attempts for the subsamples by gender and race, it was able to recreate the general population's experience of suicide across adolescence. The implications that result from this study span research, practice, and policy.

Regarding implications for research, it is apparent that the way adolescents experience depression, increase their desire to die, and gain the capability mentally, emotionally, and physically to attempt a suicide is limited by current theories. The entire process of emotional and physical maturation during adolescence is hardly accounted for in current suicide theories. However, these developmental phases are critically important. Many of the difficulties adolescents experience during this time are hidden from the physical work. From dealing with existentialism for the first time (e.g., "What is my purpose in life?") (Hacker, 1994)) to becoming increasingly abstract in their thinking about emotions and social situations (Blakemore & Choudhury, 2006), adolescence is a stage where people begin to question their relationships, the intent of people around them, and their future.

Additionally, this research stresses the importance of understanding how the experience of suicide may differ for adolescents from various subgroups. Entering parameters for adolescents who attempted suicide by subgroup did not result in replications of actual suicide attempt trajectories for those groups. This suggests there are attitudinal differences that are not reflected in the previous models of suicide. Cultural meanings of suicide from Chu's Cultural Theory of Suicide were not easily translated into the model as data on these parameters (e.g., culturally sanctioned meaning) were not available (Chu et al., 2010) to test. Future research on suicide prevention should examine these issues and ask individuals about the role of their familial values and beliefs on attempts and receiving help. Quantitative evidence is helpful in this arena and ideally, future studies will use well-designed, large scale qualitative surveys to tease out differences in attitudes regarding increasing suicide attempts and recovery.

There are various fields of practice that are affected by this research, from teachers who see the changing emotional affect of students on a daily basis, social workers who operate in

schools, and medical professionals, such as nurses and doctors who are often the first practitioners to respond post-attempt. The emphasis on responding to first attempts is apparent, as repeated attempts builds one's capability for suicide and the possibility of lethal suicide attempts. Using suicide or depression screening tools, such as the Signs of Suicide (SoS) (NREPP, 2012), can identify whether adolescents are experiencing any emotional difficulties. Identifying adolescents at-risk can accelerate exposure to preventative services that may mitigate trajectories of suicidal behavior in a drastic, life-altering way.

Additionally, another implication of this study for practitioners is to work towards sensitively identifying and connecting adolescents to depression treatments that can diminish its duration. Experiments from this study suggest that decreasing the duration of depression can help reduce attempts across adolescents and into adulthood. Ways to do this may be through the aforementioned depression screenings. However, other ways to reduce the duration of depression may be to encourage young people in one's care to adhere to their medications, if applicable, or to access counseling or other treatment services as culturally appropriate.

6.4 Future Directions

There are implications of this study in regard to future directions for research. Because this study was the first of its kind to understand the escalation of suicide attempts during adolescence using a feedback perspective, the subsequent research trajectories are vast. This section will discuss learnings from this study and its implications for data collection, theory, simulation, and modeling.

Data collection. A common issue that occurred in this dissertation process was in the area of data. Though Add Health is extensive and well-designed, the type of data available for the

purposes of building an individual-level suicide model were limited. There were various questions that arose in regards to latent variable processes, such as emotion regulation and understanding the nuance between attitudinal variables, such as perceived shame, family-affinity, and perceived stigma for mental health processes. Having these variables in the future from both qualitative and quantitative sources could provide a better understanding of the attitudinal differences in suicide trajectories for individuals by experience.

Theory. One aspect of this study that was not extensively explored was the incorporation of emotion regulation and coping skills as a balancing loop. These loops are inherent in emotion regulation research, however, they were not incorporated in the developmental systems theory of IPTS for a number of reasons. First, previous theories have not widely integrated an emphasis on de-escalation of suicide attempts, therefore these balancing mechanisms are not made explicit. Secondly, this study did not include an emphasis on emotion regulation and coping because the data were not included in the Add Health study. Examining the effect of these intangible cognitive processes are critical for understand individual suicide attempts.

Future theoretical work should also determine factors influencing repeated suicide attempts for adolescents who attempted and survived. Asking questions, such as "What was the response from your parents?" or "What happened after your first attempt?" can help gain a clearer picture of how an adolescent recovers. This information can help unfold the plateauing process that seems to occur from ages 14 to 17 in the models demonstrated in this study. Additionally, studies that incorporate attitudes of stress, shame, and the value of intervention can provide increased understanding on suicidal behaviors for adolescents across the lifespan.

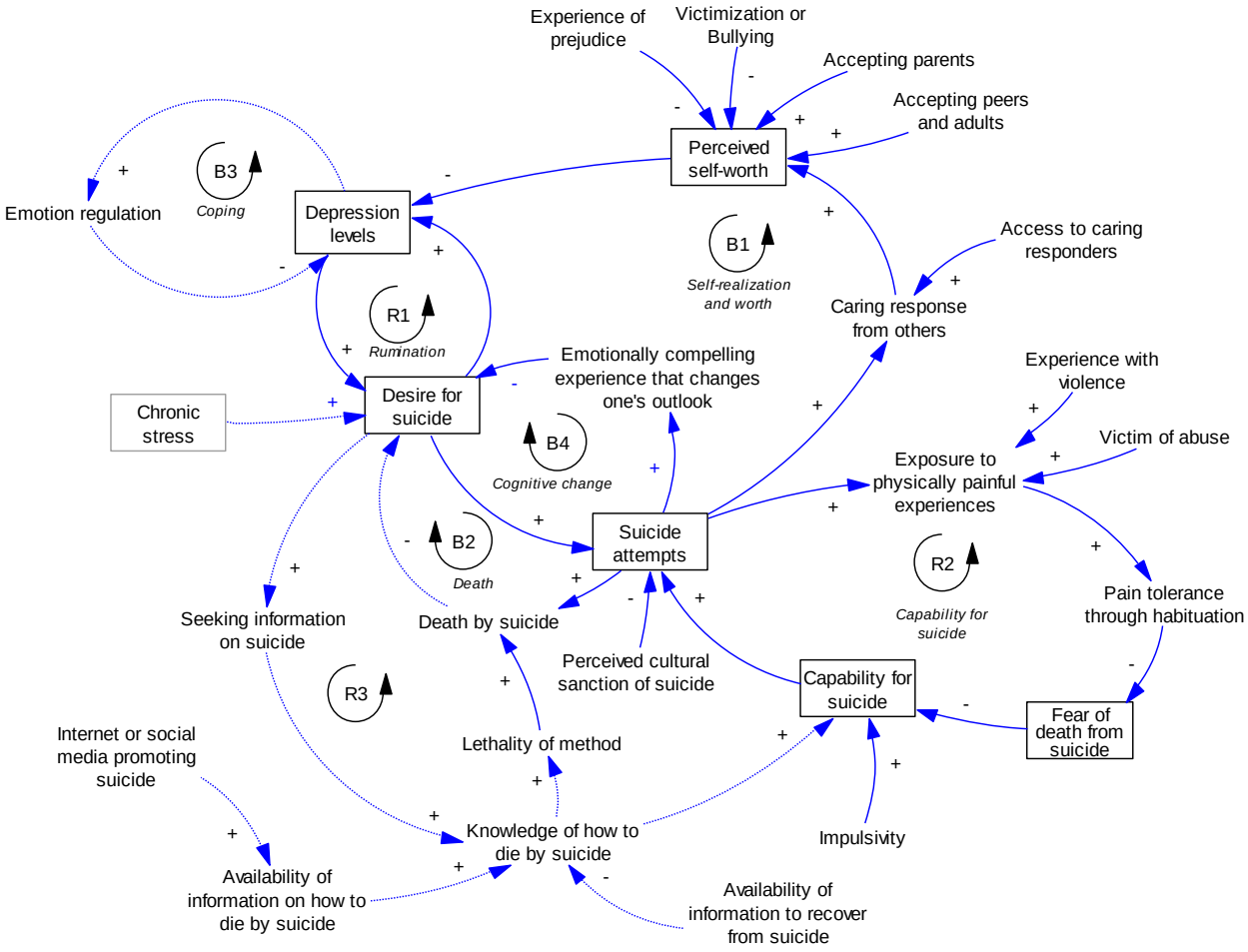
Another suggestion for future research is to modify the model to include self-harm and the role of self-harm in suicide attempts. The data were not available in Add Health, nor were these specific behaviors explicitly included in the IPTS model, however, a variety of studies suggest the reasons and relationship between self-harm and suicide vary greatly and therefore should be analyzed separately (Barzilay et al., 2015; Eastabrook, Flynn, & Hollenstein, 2013; Hawton, Saunders, & O'Connor, 2012). Future surveys that disaggregate the role of self-harm in the process of suicide can be helpful. In particular, examining self-harm as playing a dual-role of being protective (i.e., dissipating a desire to die through the analgesic effects of emotional pain-relief) and risk-building (i.e., building a capability for suicide through diminishing fear of pain) may be helpful to understand the development of capability and desire across time.

Simulation/Modeling. The process of simulation and building individual-models on suicide could also be enhanced using a variety of techniques to enhance parameter estimation for underspecified variables. In this project, there were a few parameters that were estimated given the lack of data (e.g., fear of death). In order to provide reliable advice from the model, estimation of parameters can be conducted in a systematic way by using bootstrapping or maximum likelihood methods (Struben, Sterman, & Keith, 2015)

Additionally, simulation modeling for this project could be further enhanced using hybrid simulation techniques. Combining agent-based modeling with system dynamics modeling can allow for increased understanding of individual decisions and rules at an aggregate level while allow allowing for a deductive approach. The identification of leverage points in such a structure can thereby be used to influence complex behaviors of the entire system of individuals (Scholl, 2001). Thus, individual behaviors that influence population-level epidemics can be examined.

Future research on this issue is necessary as the epidemic itself is highly individualized, but often examined as a whole.

Specifically for this project, the next steps would be to attain information on the possible balancing loops that occur during adolescence that aid in the recovery process. Figure 6.1 depicts the original causal loop diagram with variables for future research included for testing in dashed lines. Loops include three new balancing loops (B2-B4) and one new reinforcing loop.



The first new balancing loop (B2) is labeled “death”. This was not explicitly included in the current model because there were no deaths in our sample. It is a small technical issue that is

important to include, however, when discussing suicide. The more one attempts to die by suicide, the more likely one will die, which will reduce their desire for suicide.

Next, the balancing loop (B3) labeled "Coping" is included as a next step. As mentioned previously, there is a growing field of literature discussing the role of emotion regulation and coping skills as potential leverage structures that can reduce depression and thereby one's desire for death (e.g., Cisler, Olatunji, Feldner, & Forsyth, 2010; Eastabrook et al., 2013; Pisani et al., 2013). The emphasis on coping as a balancing mechanism may be important in the findings from the original model that suggests reducing the duration of depression is more effective at reducing attempts over time than simply restricting capability. The work on emotion regulation research (e.g., cultural considerations, strategies used to regulate emotions, development of emotion regulation abilities) is rapidly increasing and gaining new insights that may be pertinent to suicide research (See Gross, 2014; Sheppes et al., 2014).

The last balancing loop (B4) labeled "Cognitive change" refers to the result of an attempt on what many survivors describe as an emotionally significant event that changes one's outlook (Bergmans et al., 2009). Whether this be an emotional, spiritual, or cognitive event is unclear, however, other studies on suicide discuss that this is the type of experience is what led to a person's recovery (e.g., Bergmans et al., 2009; Chi et al., 2014). Identifying how cognitive changes occur will be critical in targeting effective interventions for survivors of suicide.

Another concept that I would like to explore in future studies is the idea of accessibility to media spurring on one's capability to attempt suicide and provide information on lethal means. Though restricting capability may not necessarily be as effective as reducing depression, the idea that capability is quickly built by internet and media accessibility may be particularly

important for adolescents who attempt suicide (Yandoli, 2014). Exposure to suicide and topics of self-harm on the Internet via sites, such as Tumblr and Instagram, may be somewhat attributable to the decreasing age of adolescents who attempt suicide for the first time and/or sustained attempts into late adolescence. Additionally, this reinforcing loop may also provide the structure to implement interventions increasing access to suicide-related help. For instance, pro-suicide hashtags could be used to direct adolescents to suicide hotlines or information on how to get help. Google searches on "how to die by suicide" can be automatically directed to a list of numbers to call or things to do to dissipate one's desire for suicide, masking sites that may include this potentially harmful information. This would be an example of turning vicious feedback loops into virtuous ones—the potential of understanding these mechanisms for the purpose of intervention is critical.

6.5 Conclusion

This dissertation has demonstrated that our understanding of suicidal inclinations, attempts, and recovery are greatly limited by our lack of understanding in how the systems in which we interact, socially, emotionally, and physically, can enhance these types of outcomes. In efforts to recreate the individual experience of escalating suicide attempts, it became increasingly apparent that the structures influencing this seemingly individualistic act are in fact, quite dependent on the community of peers, family, and people around us. The societal structure of how we approach and care for those who are in distress may be helpful in upending the seemingly unstoppable. The positive outcome of these findings suggest that the same systems and structures that build suicide attempts can also be used to decrease these harsh outcomes.

John Sterman, in his reflections, "All models are wrong: reflections of becoming a systems scientist," said, "…when human beings evolved, the challenge was survival in a world dominated by systems we could barely influence but that determined how we lived and died. Today the challenges we face are the result of systems we have created." (Sterman, 2002, p. 527). There are many stories where even the experience of suicide seems to be an unstoppable element of nature. Why try to stop something we cannot control? Hopefully, the implications of this study are that perhaps suicides are not so complex to stop and difficult to predict. The answer to diminishing suicide attempts and premature death by suicide, is located in the system itself. As social workers, researchers, friends, family, mentors, and peers, we are all players in the system of the individuals around us. Therefore, we all play an important role in the prevention, identification, and rehabilitation for those who may be susceptible to this devastating phenomenon.

References

2012 National Strategy for Suicide Prevention: Goals and Objectives for Action. (2012). Washington, DC.

Allen-Meares, P., Colarossi, L., Oyserman, D., & Deroos, Y. (2003). Assessing depression in childhood and adolescence: A guide for social work practice. *Child and Adolescent Social Work Journal*, *20*(1), 5–20.

American Academy of Child and Adolescent Psychiatry. (2008). Teen suicide. *American Academy of Child and Adolescent Psychiatry*. Retrieved from http://www.aacap.org/cs/root/facts_for_families/teen_suicide

Amstutz, A. E. (1967). *Computer Simulation of Competitive Market Response*. Cambridge, MA: MIT Press.

APA. (2002). *Guidelines on multicultural education, training, research, practice, and organizational change for psychologists*. *Public Interest*.

Avenevoli, S., Swendsen, J., He, J.P., Burstein, M., & Merikangas, K. R. (2015). Major depression in the national comorbidity survey--adolescent supplement: prevalence, correlates, and treatment. *Journal of the American Academy of Child & Adolescent Psychiatry*, *54*(1), 37–44.e2. doi:10.1016/j.jaac.2014.10.010

Bae, S., Ye, R., Chen, S., Rivers, P. a, & Singh, K. P. (2005). Risky behaviors and factors associated with suicide attempt in adolescents. *Archives of Suicide Research*, *9*, 193–202. doi:10.1080/13811110590904034

Balis, T., & Postolache, T. T. (2008). Ethnic differences in adolescent suicide in the United States. *International Journal of Child Health and Human Development*, *1*(3), 281–296. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2845977&tool=pmcentrez&rendertype=abstract

Barzilay, S., Feldman, D., Snir, A., Apter, A., Carli, V., Hoven, C. W., … Wasserman, D. (2015). The interpersonal theory of suicide and adolescent suicidal behavior. *Journal of Affective Disorders*, *183*, 68–74. doi:10.1016/j.jad.2015.04.047

Beck, A. T., & Dozois, D. J. A. (2011). Cognitive therapy: current status and future directions. *Annual Review of Medicine*, *62*, 397–409. doi:10.1146/annurev-med-052209-100032

Bergmans, Y., Langley, J., Links, P., & Lavery, J. V. (2009). The perspectives of young adults on recovery from repeated suicide-related behavior. *Crisis*, *30*(3), 120–127. doi:10.1027/0227-5910.30.3.120

Bhui, K. S., Dinos, S., & Mckenzie, K. (2012). Ethnicity and its influence on suicide rates and risk. *Ethnicity & Health*, *17*(1-2), 141–148.

Blakemore, S. J., & Choudhury, S. (2006). Development of the adolescent brain: implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry*, *47*(3-

4), 296–312. doi:10.1111/j.1469-7610.2006.01611.x

Borowsky, I. W., Ireland, M., & Resnick, M. D. (2001). Adolescent suicide attempts: Risks and protectors. *Pediatrics*, *107*(3), 485–493.

Borshchev, A., & Filippov, A. (2004). From system dynamics to agent based modeling: Reasons, techniques, tool. In *The 22nd International Conference of the System Dynamics Society*.

Bostik, K. E., & Everall, R. D. (2007). Healing from suicide: adolescent perceptions of attachment relationships. *British Journal of Guidance & Counselling*, *35*(1), 79–96. doi:10.1080/03069880601106815

Bronfenbrenner, U. (1988). Interacting systems in human development: Research paradigms, present and future. In N. Bolger, A. Caspi, & M. Moorehouse (Eds.), *Persons in Context: Developmental Processes*. New York: Cambridge University Press.

Burgess, E. W., & Locke, H. J. (1945). *The Family: From Institution to Companionship*. New York: American Book Company.

Campos, B., Ullman, J. B., Aguilera, A., & Dunkel Schetter, C. (2014). Familism and psychological health: the intervening role of closeness and social support. *Cultural Civersity & Ethnic Minority Psychology*, *20*(2), 191–201. doi:10.1037/a0034094

Canetto, S. S., & Sakinofsky, I. (1998). The gender paradox in suicide. *Suicide & Life-Threatening Behavior*, *28*(1), 1–23. doi:10.1111/j.1943-278X.1998.tb00622.x

Cash, S. J., & Bridge, J. A. (2009). Epidemiology of youth suicide and suicidal behavior. *Current Opinions in Pediatrics*, *21*(5), 613–619. doi:10.1097/MOP.0b013e32833063e1.Epidemiology

CDC. (2014a). *Suicide prevention: youth suicide*. *Centers for Disease Control*. Retrieved December 2, 2015, from http://www.cdc.gov/violenceprevention/pub/youth_suicide.html

CDC. (2014b). *Use of clinical preventative services in infants, children, and adolescents*. Retrieved from http://www.cdc.gov/childpreventiveservices/key-findings.html

CDC. (2015). *Suicide Prevention*. *Suicide Prevention: Youth Suicide*. Retrieved from http://www.cdc.gov/violenceprevention/pub/youth_suicide.html

Chen, P., & Chantala, K. (2014). Guidelines for Analyzing Add Health Data. Chapel Hill, NC: Carolina Population Center.

Chen, P., & Vazsonyi, A. T. (2011). Future orientation, impulsivity, and problem behaviors: a longitudinal moderation model. *Developmental Psychology*, *47*(6), 1633–45. doi:10.1037/a0025327

Chi, M. T., Long, A., Jeang, S. R., Ku, Y. C., Lu, T., & Sun, F. K. (2014). Healing and recovering after a suicide attempt: A grounded theory study. *Journal of Clinical Nursing*, *23*(11-12), 1751–1759. doi:10.1111/jocn.12328

Chu, J. P., Goldblum, P., Floyd, R., & Bongar, B. (2010). The cultural theory and model of suicide. *Applied and Preventive Psychology*, *14*(1-4), 25–40. doi:10.1016/j.appsy.2011.11.001

Cisler, J. M., Olatunji, B. O., Feldner, M. T., & Forsyth, J. P. (2010). Emotion regulation and the anxiety disorders: An integrative review. *Journal of Psychopathology and Behavioral Assessment*, *32*(1), 68–82. doi:10.1007/s10862-009-9161-1

Costello, J. E., Erkanli, A., & Angold, A. (2006). Is there an epidemic of child or adolescent depression? *Journal of Child Psychology and Psychiatry*, *47*(12), 1263–71. doi:10.1111/j.1469-7610.2006.01682.x

Courtney-Seidler, E. A., Burns, K., Zilber, I., & Miller, A. L. (2014). Adolescent suicide and self-injury: Deepening the understanding of the biosocial theory and applying dialectical behavior therapy. *International Journal of Behavioral Consultation and Therapy*, *9*(3), 35–41.

d'Acremont, M., & Van der Linden, M. (2007). How is impulsivity related to depression in adolescence? Evidence from a French validation of the cognitive emotion regulation questionnaire. *Journal of Adolescence*, *30*(2), 271–82. doi:10.1016/j.adolescence.2006.02.007

Dunham, R., & Wilson, G. (2007). Race, within-family social capital, and school dropout: An analysis of Whites, Blacks, Hispanics, and Asians. *Sociological Spectrum*, *27*(2), 207–221. doi:10.1080/02732170601123435

Durkheim, E. (1956). Education: its nature and its role. In *Education and Sociology* (pp. 61–90).

Eastabrook, J. M., Flynn, J. J., & Hollenstein, T. (2013). Internalizing symptoms in female adolescents: Associations with emotional awareness and emotion regulation. *Journal of Child and Family Studies*, *23*(3), 487–496. doi:10.1007/s10826-012-9705-y

Erbacher, T. A., Singer, J. B., & Poland, S. (2015). *Suicide in Schools*. New York, NY: Routledge.

Fallah-fini, S., Rahmandad, H., & Chen, H. (2014). Connecting micro dynamics and population distributions in system dynamics models, *29*(4), 197–215. doi:10.1002/sdr

Fergusson, D. M., Beautrais, A. L., & Horwood, L. J. (2003). Vulnerability and resiliency to suicidal behaviours in young people. *Psychological Medicine*, *33*, 61–73. doi:10.1017/S0033291702006748

Fergusson, D. M., Horwood, L. J., Ridder, E. M., & Beautrais, A. L. (2005). Suicidal behaviour in adolescence and subsequent mental health outcomes in young adulthood. *Psychological Medicine*, *35*, 983–993. doi:10.1017/S0033291704004167

Ford, D. H., & Lerner, R. M. (1992). *Developmental Systems Theory: An Integrative Approach*. Thousand Oaks, CA: Sage Publications, Inc.

Forrester, J. W. (1969). *Urban Dynamics* (1st ed.). Boston: MIT Press.

Forrester, J. W. (1994). System dynamics, systems thinking, and soft OR. *System Dynamics Review*, *10*(2), 1–14.

Forrester, J. W. (2007). System dynamics--a personal view of the first fifty years. *System Dynamics Review*, *23*(2/3), 345–358. doi:10.1002/sdr

Frey, W. H. (2011). The new metro minority map: Regional shifts in Hispanics, Asians, and Blacks from Census 2010. *The Brookings Institution*, (August), 1–18.

Ghanem, M., Gamaluddin, H., Mansour, M., Samiee', A. A., Shaker, N. M., & El Rafei, H. (2013). Role of impulsivity and other personality dimensions in attempted suicide with self-poisoning among children and adolescents. *Archives of Suicide Research*, *17*, 262–74. doi:10.1080/13811118.2013.805645

Goldston, D. B., Daniel, S. S., Erkanli, A., Heilbron, N., Doyle, O., Weller, B., … Faulkner, M. (2015). Suicide attempts in a longitudinal sample of adolescents followed through adulthood: evidence of escalation. *Journal of Consulting and Clinical Psychology*, *ePub*(ePub), ePub–ePub. doi:10.1037/a0038657

Goldston, D. B., Molock, S. D., Whitbeck, L. B., Murakami, J. L., Luis, H., & Hall, G. C. N. (2009). Cultural considerations in adolescence suicide prevention and psychosocial treatment. *American Psychologist*, *63*(1), 14–31. doi:10.1037/0003-066X.63.1.14.Cultural

Goodyer, I. M. (2001). *The Depressed Child and Adolescent*. Cambridge: Cambridge University Press. Retrieved from http://libproxy.wustl.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=146219&site=ehost-live&scope=site

Gordon, K. H., Selby, E. a, Anestis, M. D., Bender, T. W., Witte, T. K., Braithwaite, S., … Joiner, T. E. (2010). The reinforcing properties of repeated deliberate self-harm. *Archives of Suicide Research*, *14*, 329–341. doi:10.1080/13811118.2010.524059

Gross, J. J. (2014). Emotion regulation: Conceptual and empirical foundations. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (2nd ed.). New York: The Guilford Press.

Gunn, J. F. (2014). The interpersonal-psychological theory of suicide. In J. F. Gunn & D. Lester (Eds.), *Theories of Suicide: Past, Present and Future*. Springfield, IL: Charles C Thomas.

Hacker, D. J. (1994). An existential view of adolescence. *Journal of Early Adolescence*, *14*(3), 300–327.

Han, M. (2007). Familism and mental health: Variation between Asian American children of refugees and immigrants. *International Journal of Applied Psychoanalytic Studies*, *4*(4), 333–348. doi:10.1002/aps

Harris, K. M. (2013). *The Add Health study: Design and accomplishments*. Chapel Hill, NC. Retrieved from http://www.cpc.unc.edu/projects/addhealth/data/guides/DesignPaperWIIV.pdf

Harris, K. M., Gordon-Larsen, P., Chantala, K., & Udry, J. R. (2006). Longitudinal trends in race/ethnic disparities in leading health indicators from adolescence to young adulthood. *Archives of Pediatrics & Adolescent Medicine*, *160*, 74–81. doi:10.1001/archpedi.160.1.74

Harris, K. M., Halpern, C. T., Whitsel, J., Hussey, J., Tabor, J., Entzel, P., & Udry, J. R. (2009). *The National Longitudinal Study of Adolescent to Adult Health: Research Design*. Retrieved from http://www.cpc.unc.edu/projects/addhealth/design

Hawton, K., Saunders, K. E. a, & O'Connor, R. C. (2012). Self-harm and suicide in adolescents.

The Lancet, *379*(9834), 2373–2382. doi:10.1016/S0140-6736(12)60322-5

Hovey, J. D., & King, C. A. (1996). Acculturative stress, depression, and suicidal ideation among immigrant and second-generation Latino adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry*, *35*(9), 1183–1192. doi:10.1097/00004583-199609000-00016

Hovmand, P. S. (2003). *Managing a prosecutor's office domestic violence caseload to increase assailant accountability: A system dynamics approach*. Michigan State University.

Hovmand, P. S., & Chalise, N. (2015). Simultaneous linear estimation using structural equation modeling. In H. Rahmandad, R. Oliva, & N. D. Osgood (Eds.), *Analytical Methods for Dynamic Modelers* (pp. 71–93). Cambridge, MA: The MIT Press.

Hovmand, P. S., Ford, D. N., Kyriakakis, S., Brown, G. W., & Brown, W. (2009). Victims arrested for domestic violence: unintended consequences of arrest policies. *System Dynamics Review*, *25*(3), 161–181. doi:10.1002/sdr

Jang, Y., Chiriboga, D. a, & Okazaki, S. (2009). Attitudes toward mental health services: age-group differences in Korean American adults. *Aging & Mental Health*, *13*(January 2015), 127–134. doi:10.1080/13607860802591070

Joe, S., & Bryant, H. (2007). Evidence-Based Suicide Prevention Screening in Schools. *Children & Schools*, *29*(4), 219–228.

Joe, S., Canetto, S. S., & Romer, D. (2008). Advancing prevention research on the role of culture in suicide prevention. *Suicide & Life-Threatening Behavior*, *38*(June), 354–362. doi:10.1521/suli.2008.38.3.354

Joe, S., & Niedermeier, D. (2006). Preventing suicide: A neglected social work research agenda. *Journal of Social Work*, *38*(3), 507–530. doi:10.1016/j.biotechadv.2011.08.021.Secreted

Joe, S., & Niedermeier, D. M. (2008). Social work research on African Americans and suicidal behavior: a systematic 25-year review. *Health & Social Work*, *33*, 249–257. doi:10.1093/hsw/33.4.249

Joiner, T. E. (2005). *Why People Die by Suicide*. Cambridge, MA: Harvard University Press.

Joiner, T. E., Van Orden, K. a, Witte, T. K., Selby, E. a, Ribeiro, J. D., Lewis, R., & Rudd, M. D. (2009). Main predictions of the interpersonal-psychological theory of suicidal behavior: empirical tests in two samples of young adults. *Journal of Abnormal Psychology*, *118*(3), 634–646. doi:10.1037/a0016500

Kann, L., Kinchen, S., Shanklin, S. L., Flint, K. H., Kawkins, J., Harris, W. a, … Zaza, S. (2014). *Youth risk behavior surveillance--United States, 2013. Morbidity and Mortality Weekly Report.* (Vol. 63 Suppl 4). Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/24918634

Kia-Keating, M., Dowdy, E., Morgan, M. L., & Noam, G. G. (2011). Protecting and promoting: an integrative conceptual model for healthy development of adolescents. *The Journal of Adolescent Health*, *48*(3), 220–8. doi:10.1016/j.jadohealth.2010.08.006

Kim, H., & Andersen, D. F. (2012). Building confidence in causal maps generated from

purposive text data: mapping transcripts of the Federal Reserve. *System Dynamics Review*, *25*(1), 311–328. doi:10.1002/sdr

King, C. A., & Merchant, C. R. (2008a). Social and interpersonal factors related to adolescent suicidality: A review of the literature. *Archives of Suicide Research*, *12*(3), 181–196. doi:10.1080/13811110802101203.Social

King, C. A., & Merchant, C. R. (2008b). Social and interpersonal factors relating to adolescent suicidality: a review of the literature. *Archives of Suicide Research*, *12*, 181–196. doi:10.1080/13811110802101203

Le, T. N., & Kato, T. (2006). The role of peer, parent, and culture in risky sexual behavior for Cambodian and Lao/Mien adolescents. *The Journal of Adolescent Health*, *38*(3), 288–96. doi:10.1016/j.jadohealth.2004.12.005

Leong, F. T. L., & Leach, M. M. (Eds.). (2008). *Suicide among Racial and Ethnic Minority Groups: Theory, Research and Practice*. New York, NY: Taylor & Francis.

Lerner, R. M., Lerner, J. V, von Eye, A., Bowers, E. P., & Lewin-Bizan, S. (2011). Individual and contextual bases of thriving in adolescence: a view of the issues. *Journal of Adolescence*, *34*(6), 1107–14. doi:10.1016/j.adolescence.2011.08.001

Lerner, R. M., Lerner, J. V., De Stefanis, I., & Apfel, A. (2001). Understanding developmental systems in adolescence: Implications for methodological strategies, data analytic approaches, and training. *Journal of Adolescent Research*, *16*(1), 9–27. doi:10.1177/0743558401161003

Lerner, R. M., von Eye, A., Lerner, J. V, Lewin-Bizan, S., & Bowers, E. P. (2010). Special issue introduction: the meaning and measurement of thriving: a view of the issues. *Journal of Youth and Adolescence*, *39*(7), 707–19. doi:10.1007/s10964-010-9531-8

Lester, D. (1989). A depression paradox theory of suicide. *Personality and Individual Differences*, *10*(10), 1103–1104. doi:10.1016/0191-8869(89)90263-8

Lester, D. (2014). Cognitive theories of suicide. In J. F. Gunn & D. Lester (Eds.), *Theories of Suicide: Past, Present and Future* (pp. 87–105). Springfield, IL: Charles C Thomas.

Lester, D., & Rodgers, J. (2013). *Suicide: A Global Issue*. Santa Barbara, CA: ABC-CLIO, LLC.

Lewis, J. (2012). *The Business of Martyrdom: A History of Suicide Bombing*. Annapolis, MD: Naval Institute Press.

Mann, J. J., & Currier, D. M. (2010). Stress, genetics and epigenetic effects on the neurobiology of suicidal behavior and depression. *European Psychiatry*, *25*(5), 268–271. doi:10.1016/j.eurpsy.2010.01.009

Maughan, B., Collishaw, S., & Stringaris, A. (2013). Depression in childhood and adolescence. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *22*(February), 35–40. doi:10.1097/00005053-198307000-00004

McArdle, J. J., Hamagami, F., Chang, J. Y., & Hishinuma, E. S. (2014). Longitudinal dynamic analyses of depression and academic achievement in the Hawaiian high schools health survey using contemporary latent variable change models. *Structural Equation Modeling: A*

Multidisciplinary Journal, *21*(4), 608–629. doi:10.1080/10705511.2014.919824

Mcintosh, J. L. (2002). Quantitative methods in suicide research: Issues associated with official statistics. *Archives of Suicide Research*, *6*, 41–54. doi:10.1080/13811110290100237

Meadows, D. H. (1999). Leverage points: places to intervene in a system. *Sustainability Institute*, (12).

Meadows, D. H., & Meadows, D. L. (n.d.). THE LIMITS TO ·.

Meehl, P. E. (1990). Why summaries of research on psychological theories are often uninterpretable. *Psychological Reports*, *66*, 195–244.

Merchant, C., Kramer, A., Joe, S., Venkataraman, S., & King, C. A. (2009). Predictors of multiple suicide attempts among suicidal black adolescents. *Suicide & Life-Threatening Behavior*, *39*(April), 115–124. doi:10.1521/suli.2009.39.2.115

Meyn, S. P., & Tweedie, R. L. (2009). *Markov Chains and Stochastic Stability* (Vol. 92). Cambridge, MA: Cambridge University Press. doi:10.2307/2965732

Miranda, R., & Nolen-Hoeksema, S. (2007). Brooding and reflection: Rumination predicts suicidal ideation at one-year follow up in a community sample. *Behavioral Research Therapy*, *45*(12), 3088–3095. doi:10.1016/j.micinf.2011.07.011.Innate

Mortality in the United States, 2012. (2014). *NCHS Data Brief*. U.S. Department of Health and Human Services Centers for Disease Control and Prevention. doi:10.1056/NEJM184002260220306

NREPP. (2012). *SOS Signs of Suicide*. Retrieved from file:///C:/Users/Saras/Downloads/ReportNew.pdf

Olsen, R., & Sheets, C. (2008). *Computer-Assisted Self-Interviewing (CASI) : SAGE Research Methods*. *Encyclopedia of Survey Research Methods*. Retrieved March 30, 2015, from http://srmo.sagepub.com/view/encyclopedia-of-survey-research-methods/n82.xml

Osgood, N. (2009). Lightening the performance burden of individual-based models through dimensional analysis and scale modeling. *System Dynamics Review*, *25*(2), 101–134. doi:10.1002/sdr

Peña, J. B., Wyman, P. a., Brown, C. H., Matthieu, M. M., Olivares, T. E., Hartel, D., & Zayas, L. H. (2008). Immigration generation status and its association with suicide attempts, substance use, and depressive symptoms among Latino adolescents in the USA. *Prevention Science*, *9*, 299–310. doi:10.1007/s11121-008-0105-x

Perez, G. K., & Cruess, D. (2011). The impact of familism on physical and mental health among Hispanics in the United States. *Health Psychology Review*, (February 2015), 1–33. doi:10.1080/17437199.2011.569936

Perreira, K. M., Deeb-Sossa, N., Harris, K. M., & Bollen, K. (2005). What are we measuring? An evaluation of the CES-D across race/ethnicity and immigrant generation. *Social Forces*, *83*(4), 1567–1601.

Phinney, J. S., & Ong, A. D. (2007). Conceptualization and measurement of ethnic identity:

Current status and future directions. *Journal of Counseling Psychology*, *54*(3), 271–281. doi:10.1037/0022-0167.54.3.271

Pisani, A. R., Wyman, P. a, Petrova, M., Schmeelk-Cone, K., Goldston, D. B., Xia, Y., & Gould, M. S. (2013). Emotion regulation difficulties, youth-adult relationships, and suicide attempts among high school students in underserved communities. *Journal of Youth and Adolescence*, *42*(6), 807–20. doi:10.1007/s10964-012-9884-2

Prinstein, M. J. (2008). Introduction to the special section on suicide and nonsuicidal self-injury: a review of unique challenges and important directions for self-injury science. *Journal of Consulting and Clinical Psychology*, *76*(1), 1–8. doi:10.1037/0022-006X.76.1.1

Rahmandad, H., & Sabounchi, N. S. Z. (2011). Building and estimating a dynamic model of weight gain and loss for individuals and populations. In *International System Dynamics Conference* (pp. 1–29). Washington, DC: System Dynamics Society.

Rahmandad, H., & Sterman, J. D. (2012). Reporting guidelines for simulation-based research in social sciences. *System Dynamics Review*, *28*(4), 396–411. doi:10.1002/sdr

Range, L. M., Leach, M. M., McIntyre, D., Posey-Deters, P. B., Marion, M. S., Kovac, S. H., … Vigil, J. (1999). Multicultural perspectives on suicide. *Aggression and Violent Behavior*, *4*(4), 413–430. doi:10.1016/S1359-1789(98)00022-6

Regier, D. A., Kuhl, E. A., & Kupfer, D. J. (2013). The DSM-5: Classification and criteria changes. *World Psychiatry*, *12*(June), 92–98. doi:10.1002/wps.20050

Richardson, G. P. (1999). *Feedback Thought in Social Science and Systems Theory*. Waltham, MA: Pegasus Communications.

Richardson, G. P. (2011). Reflections on the foundations of system dynamics. *System Dynamics Review*, *27*(3), 219–243. doi:10.1002/sdr

Rogers, J. R. (2001). Theoretical grounding: The "missing link" in suicide research. *Journal of Counseling & Development*, *79*(1), 16–25. doi:10.1002/j.1556-6676.2001.tb01939.x

Rogers, J. R. (2003). The anatomy of suicidology: a psychological science perspective on the status of suicide research. *Suicide & Life-Threatening Behavior*, *33*(1), 9–20. doi:10.1521/suli.33.1.9.22783

Root, M. (2003). The use of race in medicine as a proxy for genetic differences. *Philosophy of Science*, *70*(December), 1173–1183. doi:10.1086/377398

Sabbath, J. C. (1969). The suicidal adolescent: The expendable child. *Journal of the American Academy of Child Psychiatry*, *8*, 272–285.

Schiele, J. H., & Hopps, J. G. (2009). Racial minorities then and now: the continuing significance of race. *The Social Worker*, *54*, 195–199.

Schiepek, G., Fartacek, C., Sturm, J., Kralovec, K., Fartacek, R., & Plöderl, M. (2011). Nonlinear dynamics: Theoretical perspectives and application to suicidology. *Suicide and Life-Threatening Behavior*, *41*(December), 661–675. doi:10.1111/j.1943-278X.2011.00062.x

Scholl, H. J. J. (2001). Agent-based and system dynamics modeling: A call for cross study and joint research. In *HIcSS '01 Proceedings of the 34th Annual Hawaii International Conference on System Sciences* (p. 3003). Washington, D.C.: IEEE Computer Society.

Shahar, G., & Henrich, C. C. (2010). Do depressive symptoms erode self-esteem in early adolescence? *Self and Identity*, *9*, 403–415. doi:10.1080/15298860903286090

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2014). Emotion regulation choice: a conceptual framework and supporting evidence. *Journal of Experimental Psychology*, *143*(1), 163–81. doi:10.1037/a0030831

Siener, S., & Kerns, K. a. (2012). Emotion regulation and depressive symptoms in preadolescence. *Child Psychiatry and Human Development*, *43*(3), 414–30. doi:10.1007/s10578-011-0274-x

Smith, A. R., Witte, T. K., Teale, N. E., King, S. L., Bender, T. W., & Joiner, T. E. (2008). Revisiting impulsivity in suicide. *Behavioral Science Law*, *26*(6), 779–797. doi:10.1002/bsl.848.Revisiting

Solomon, R. L., & Corbit, J. D. (1974). An opponent-process theory of motivation. I. Temporal dynamics of affect. *Psychological Review*, *81*(2), 119–145. doi:10.1037/h0036128

Sterman, J. D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World* (1st ed.). Boston: Irwin McGraw-Hill.

Sterman, J. D. (2002). All models are wrong: Reflections on becoming a systems scientist. *System Dynamics Review*, *18*(4), 501–531. doi:10.1002/sdr.261

Sterman, J. D. (2006). Learning from evidence in a complex world. *American Journal of Public Health*, *96*(3), 505–14. doi:10.2105/AJPH.2005.066043

Strategic Research Priorities. (2015). *National Institute of Mental Health*. National Institute of Mental Health. Retrieved from http://www.nimh.nih.gov/research-priorities/strategic-objectives/index.shtml

Struben, J., Sterman, J., & Keith, D. (2015). Parameter estimation through maximum likelihood and bootstrapping methods. In *Analytical Methods for Dynamic Modelers* (pp. 3–38).

Suicide. (2015). *American Psychological Association*. Retrieved from http://www.apa.org/topics/suicide/

Suveg, C., Hoffman, B., Zeman, J. L., & Thomassin, K. (2009). Common and specific emotion-related predictors of anxious and depressive symptoms in youth. *Child Psychiatry and Human Development*, *40*(2), 223–39. doi:10.1007/s10578-008-0121-x

Taylor, T. R. B., & Ford, D. N. (2008). Managing tipping point dynamics in complex construction projects. *Journal of Construction Engineering and Management*, *134*(6), 421–431. doi:10.1061/(ASCE)0733-9364(2008)134:6(421)

Thapar, A., Collishaw, S., Pine, D. S., & Thapar, A. K. (2012). Depression in adolescence. *Lancet*, *379*(9820), 1056–67. doi:10.1016/S0140-6736(11)60871-4

Theil, H. (1966). *Applied Economic Forcasting*. Chicago: Rand McNally and Company.

Thompson, K. M., & Tebbens, R. J. D. (2007). Eradication versus control for poliomyelitis: an economic analysis. *Lancet*, *369*(9570), 1363–71. doi:10.1016/S0140-6736(07)60532-7

Tuisku, V., Kiviruusu, O., Pelkonen, M., Karlsson, L., Strandholm, T., & Marttunen, M. (2014). Depressed adolescents as young adults - Predictors of suicide attempt and non-suicidal self-injury during an 8-year follow-up. *Journal of Affective Disorders*, *152-154*, 313–319. doi:10.1016/j.jad.2013.09.031

Urban, J. B., Lewin-Bizan, S., & Lerner, R. M. (2010). The role of intentional self regulation, lower neighborhood ecological assets, and activity involvement in youth developmental outcomes. *Journal of Youth and Adolescence*, *39*(7), 783–800. doi:10.1007/s10964-010-9549-y

Valois, R. F., Zullig, K. J., & Hunter, A. a. (2013). Association between adolescent suicide ideation, suicide attempts and emotional self-efficacy. *Journal of Child and Family Studies*, Advance online publication. doi:10.1007/s10826-013-9829-8

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E. (2010). The interpersonal theory of suicide. *Psychological Review*, *117*(2), 575–600. doi:10.1037/a0018697

Vygotsky, L. S. (1978). *Mind in Society*. (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.) (14th ed.). Cambridge, MA: Harvard University Press. doi:(Original manuscripts [ca. 1930-1934])

Wakefield, W. D., & Hudley, C. (2007). Ethnic and racial identity and adolescent well-being. *Theory Into Practice*, *46*(2), 147–154. doi:10.1080/00405840701233099

Wasserman, D., Cheng, Q., & Jiang, G.-X. (2005). Global suicide rates among young people aged 15-19. *World Psychiatry*, *4*(2), 114–20. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1414751&tool=pmcentrez&rendertype=abstract

Watson, P. K., & Teelucksingh, S. S. (2002). *A Practical Introduction to Econometric Methods: Classical and Modern*. Kingston, Jamaica: University of the West Indies Press.

WHO. (n.d.). *ICD-10 Version: 2015*. *2015*. Retrieved March 6, 2015, from http://apps.who.int/classifications/icd10/browse/2015/en#/F32

Wilde, E. J. De, Kienhorst, I. C. W. M., & Diekstra, F. W. (2001). Suicidal behaviour in adolescents. In I. M. Goodyer (Ed.), *The Depressed Child* (pp. 267–291). Cambridge, MA: Cambridge University Press. doi:10.1080/13811119508251957

Wittenborn, A. K., Rahmandad, H., Rick, J., & Hosseinichimeh, N. (2015). Depression as a systemic syndrome: mapping the feedback loops of major depressive disorder. *Psychological Medicine*, 1–12. doi:10.1017/S0033291715002044

Wodarski, J. S., Dulmus, C. N., & Wodarski, L. A. (2003). *Adolescent Depression and Suicide: A Comprehensive Empirical Intervention for Prevention and Treatment*. Springfield, Ill: Charles C Thomas. Retrieved from http://libproxy.wustl.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=446317&site=ehost-live&scope=site

Wolfe, K. L., Foxwell, A., & Kennard, B. (2014). Identifying and treating risk factors for suicidal behaviors in youth. *International Journal of Behavioral Consultation & Therapy*, *9*(3), 11–15.

Wyman, P. a. (2014). Developmental approach to prevent adolescent suicides. *American Journal of Preventive Medicine*, *47*(3), S251–S256. doi:10.1016/j.amepre.2014.05.039

Yandoli, K. L. (2014, September 7). Inside the secret world of teen suicide hashtags. *BuzzFeed*. Retrieved from http://www.buzzfeed.com/krystieyandoli/how-teens-are-using-social-media-to-talk-about-suicide

Yip, P., So, B. K., Kawachi, I., & Zhang, Y. (2014). A Markov chain model for studying suicide dynamics: an illustration of the Rose theorem. *BMC Public Health*, *14*, 625. doi:10.1186/1471-2458-14-625

Zolfagharian, M., Akbari, R., & Fartookzadeh, H. (2014). Theory of knowledge in System Dynamics models. *Foundations of Science*, *19*, 189–207. doi:10.1007/s10699-013-9328-9

Zuberi, T. (2000). Deracializing Social Statistics: Problems in the Quantification of Race. *The ANNALS of the American Academy of Political and Social Science*, *568*(1), 172–185. doi:10.1177/0002716200568001013

Appendix

Figure 1. Stock and Flow Model of ITPS

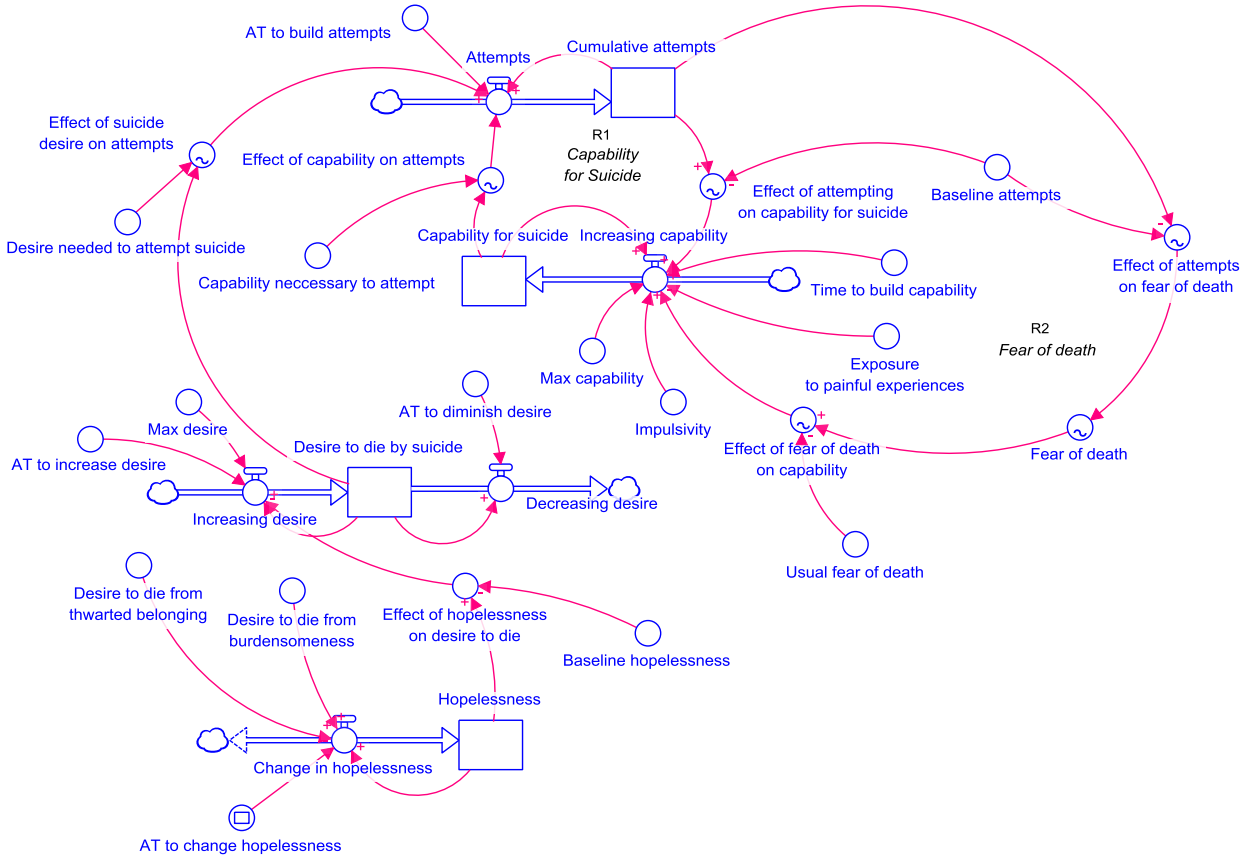


Table 1. *Equation Listings –IPTS*

The stock and flow model for IPTS was built and simulated in *Stella Pro 1.0.* The model was set to run from a time of 12 (years of age) to 30 (years of age) with the euler integration method. The Delta Time (DT) or simulation time step was set to .125 and the time unit was set to 'years'. Graphical (table) functions were specified as coordinates (x, y) in *Stella Pro* using a continuous graph, therefore data between time points are interpolated.

Variable	**Description**	**Type & *Units***	**Equation and Initial Value**
Desire to die by suicide (DDS)	The desire to take one's life by suicide.	Stock *desire units*	$DDS(t) = DDS(0) + \int_0^t ID(u) - DD(u)du$; DDS(0)=.09
Increasing desire to die by suicide (ID)	Rate of increasing desire to die by suicide	Flow *desire units/year*	$ID = \frac{\left((EffHD) \times DD \times (\frac{MaxD - DD}{MaxD})\right)}{AT\ to\ increase\ desire}$
Decreasing desire to die by suicide (DD)	Rate of decreasing desire to die by suicide	Flow *desire units/year*	$DD = \frac{DD}{AT\ to\ diminish\ desire}$
Hopelessness (H)	Level of hopelessness	Stock *hopelessness units*	$H(t) = H(0) + \int_0^t ChangeinH(u)du; H(0) = 1$
Change in hopelessness (ChangeinH)	Change in level of hopelessness	Biflow *hopelessness units/year*	$Change\ in\ hopelessness = \frac{(DDBelong + DDBurden) * H - H}{ATto\ change\ H}$
AT to build attempts	Time it takes to build an attempt	Constant *years*	.1 years
AT to diminish desire (AT to diminish desire)	Time it takes to reduce one's desire for suicide	Constant *years*	.25 years
Accumulating attempts (AA)	The total number of attempts across time		$AA(t) = AA(0) + \int_0^t A(u)du; AA(0) = .1$
Attempts (A)	The rate of attempts per year	Flow *Attempts per year*	$A = \frac{(EffCap * EffDes) \times AA - AA)}{AT\ to\ build\ attempts}$ Baseline attempts = .1
Desire to die from burdensomeness (DDBurden)	FR of desire to die from burdensomeness	Fractional Rate 1/years	1
Desire to die from Thwarted belonging (DDBelong)	FR of desire to die from thwarted belonging	Fractional rate 1/years	1
Capability for suicide (C)	The capability for an individual to attempt to die by suicide	Stock *Capability units*	$C(t) = C(0) + \int_0^t IC(u)du; C(0) = 5$
Increasing capability (IC)	The rate of increase in capability per year	Flow *Capability units/year*	$IC = \frac{(EfACS + EP - EfFearC) \times I \times CS \times \frac{MC - CS}{MC}}{ATC}$
Attempts per desire*	The number of attempt per desire unit	Constant *Attempts/Desire units*	*2.5 attempts/desire units*

Fear of Death (FD)	The fear one feels of death	Table function *dmnl*	$FD = EffAFD$ (0.000, 2.000), (0.200, 2.000), (0.400, 1.991), (0.600, 1.852), (0.800, 1.520), (1.000, 1.066), (1.200, 0.734), (1.400, 0.454), (1.600, 0.201), (1.800, 0.026), (2.000, 0.000)
Effect of attempting on capability (EffACS)	The effect of attempting on one's capability for suicide	Table function *Dmnl*	$EffACS = \frac{AA}{Baseline\ attempts}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.131), (0.600, 0.402), (0.800, 0.934), (1.000, 1.493), (1.200, 1.747), (1.400, 1.852), (1.600, 1.895), (1.800, 1.956), (2.000, 1.948)
Effect of capability on attempts (EffCA)	The effect of a capability for suicide on attempts	Table function *dmnl*	$EffCA = \frac{CS}{Capability\ necessary\ to\ attempt}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 0.716), (1.400, 0.978), (1.600, 1.135), (1.800, 1.179), (2.000, 1.205)
Effect of fear of death on capability (EffFC)	The effect of fear of death on capability for suicide	Table function *dmnl*	$EffFC = \frac{FD}{Usual\ fear\ of\ death}$ (0.000, 2.000), (0.200, 1.991), (0.400, 1.939), (0.600, 1.869), (0.800, 1.677), (1.000, 1.319), (1.200, 0.000), (1.400, 0.000), (1.600, 0.000), (1.800, 0.000), (2.000, 0.000)
Effect of attempts on fear of death (EffAFD)	The effect of attempting one's fear of death	Table function *Dmnl*	$EffAFD = \frac{AA}{Baseline\ attempts}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 1.493), (1.400, 1.729), (1.600, 1.852), (1.800, 2.000), (2.000, 2.000)
Effect of hopelessness on desire to die (EffHDD)	The effect of feeling hopeless on one's desire to die by suicide	Auxiliary *dmnl*	$EffHDD = \frac{H}{Baseline\ Hopelessness}$
Effect of suicide desire on attempts (EffDes)	The effect of desiring suicide on attempting suicide	Table function *dmnl*	$EffDes = \frac{DDS}{Desire\ needed\ to\ attempt}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 0.000), (1.400, 1.328), (1.600, 1.476), (1.800, 1.581), (2.000, 1.651)
Fractional rate of impulsivity*	The fractional rate of impulsivity	Fractional rate *1/years*	.51
Max capability	The maximum level of capability for suicide	Constant *Capability units*	10 capability units
Usual fear of death*	Usual average fear of death	Constant *Fear units*	10 fear units
Exposure to painful experiences (EP)*	The proportional rate of exposure to painful experiences	Constant *Dmnl*	.2
Time to build capability (ATC)	The time to build one's capability for suicide	Delay *Years*	.25 years
AT to change hopelessness (AT to change H)	Time it takes to change one's hopelessness	Delay *Years*	.25 years

**denotes exogenous variables*

Figure 2. Stock and Flow Model of the Developmental Systems Model of IPTS

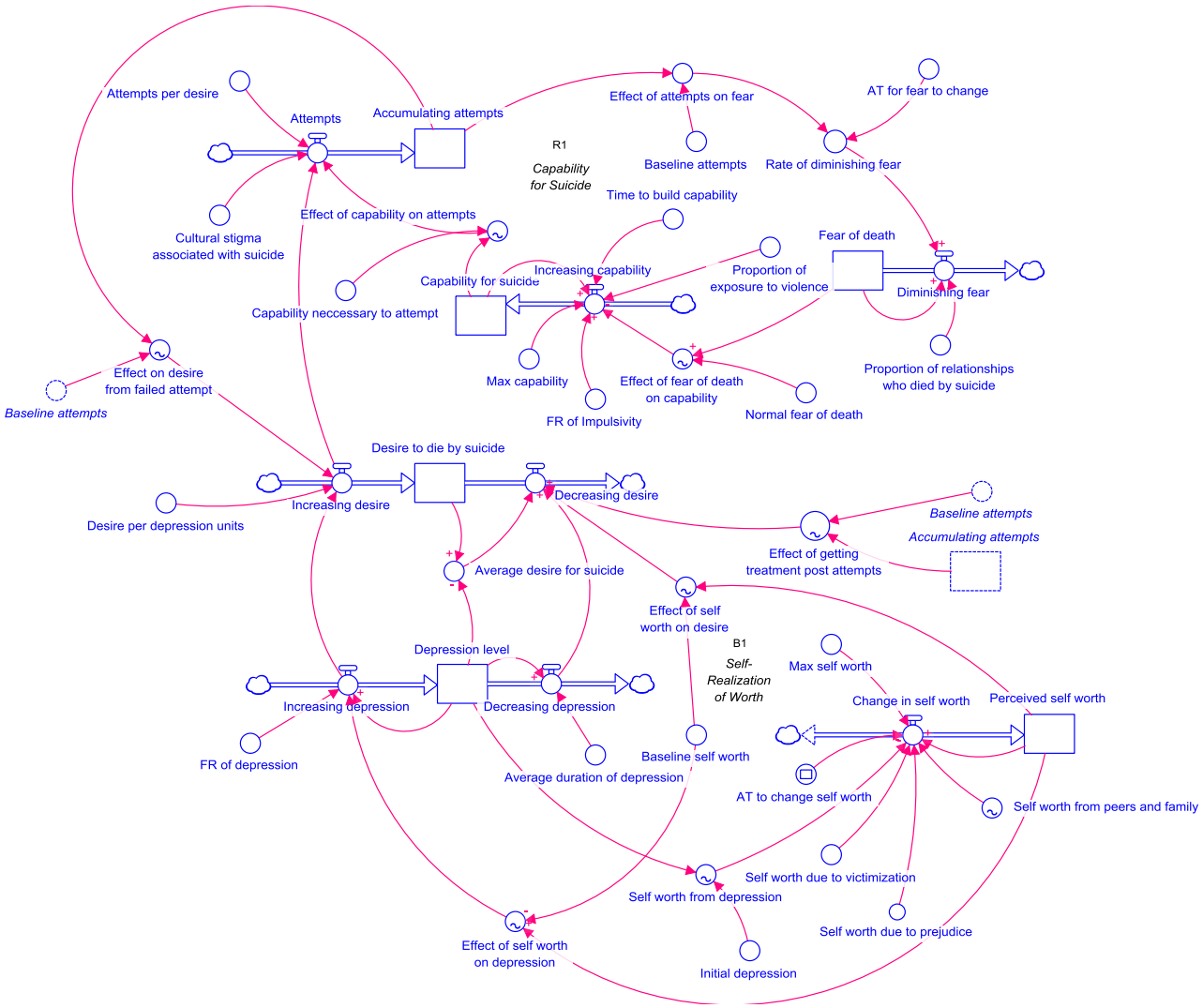


Table 2. *Equation Listings – Developmental Systems Model of IPTS*

The stock and flow model for the developmental systems model of IPTS was built and simulated in *Stella Pro 1.0.* The model was set to run from a time of 10 (years of age) to 30 (years of age) with the euler integration method. The Delta Time (DT) or simulation time step was set to .125 and the time unit was set to 'years'. Graphical (table) functions were specified as coordinates (x, y) in *Stella Pro* using a continuous graph, therefore data between time points are interpolated.

Variable	**Description**	**Type & *Units***	**Equation and Initial Value**
Desire to die by suicide (DDS)	The desire to take one's life by suicide.	Stock *desire units*	$DDS(t) = DDS(0) + \int_0^t ID(u) - DD(u)du; DDS(0) = .09\ \ 0$
Increasing desire (ID)	Rate of increasing desire to die by suicide	Flow *desire units/year*	$ID = (ID\ \times\ DD\ \times (EffFA + 1)$
Decreasing desire (DD)	Rate of decreasing desire to die by suicide	Flow *desire units/year*	$DD = (EffSWD + EffTPA) \times AveDS \times DDS$
Effect of self-worth on desire for suicide (EffSWD)	The effect of self-worth on one's desire for suicide	Table Function *Dmnl*	(0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 2.070), (1.400, 2.476), (1.600, 2.803), (1.800, 3.000), (2.000, 3.000)
Accumulating attempts (AA)	The total number of attempts across time	Stock *Attempts*	$AA(t) = AA(0) + \int_0^t A(u)du; AA(0) = .10$
Attempts (A)	The rate of attempts per year	Flow *Attempts per year*	$A = (AperD\ \times ID\ \times (EffCA - CS)$
Capability for suicide (C)	The capability for an individual to attempt to die by suicide	Stock *Capability units*	$C(t) = C(0) + \int_0^t IC(u)du;\ \ \mathrm{C}(0) = 0$
Increasing capability (IC)	The rate of increase in capability per year	Flow *Capability units/year*	$IC = \frac{(EffFD) \times PEV \times FRimp \times CS \times (\frac{MC - CS)}{MC}}{ATC}$
Depression level (D)	Depression level	Stock *Depression units*	$D(t) = D(0) + \int_0^t IDep - DDep,(u)du;$ $D(0) = 6$
Increasing depression (IDep)	The rate of increasing depression per year	Flow *Depression units/year*	$IDep = (EffSWDep + 1) \times FRDep \times D$
Decreasing depression (DDep)	The rate of decreasing depression per year	Flow *Depression units/year*	$DDep = \frac{D}{AveDep}$
Fear of death (FD)	The fear one has of death by suicide	Stock *Fear units*	$FD(t) = FD(0) + \int_0^t -DF(u)du\,; FD(0) = 10$
Diminishing fear (DF)	The rate at which fear of death diminishes	Flow *Fear units/year*	$DF = RateDF \times FD \times PRelDS$
Perceived self-worth (SW)	One's perception of self-worth	Stock *Self worth units*	$SW(t) = SW(0) + \int_0^t CSW(u)du\,; SW(0) = 15$

Change in self-worth (CSW)	The net rate at which self-worth increases or decreases	Flow *Self-worth units/year*	$CSW = \frac{((SWPF - SWD \times SWV \times SWP)) \times SW - SW \times \frac{(MSW - SW)}{MSW}}{ATSW}$
Attempts per desire*	The number of attempt per desire unit	Constant *Attempts/Desire units*	*2.5 attempts/desire units*
Adjustment time for fear to change (ATF)*	The time it takes to change one's fear of death	Delay *Years*	*.25 years*
Average desire for suicide (ADS)	One's average desire for suicide per depression unit	*Desire units/depression units*	$ADS = \frac{DDS}{D}$
Average duration of depression*	The average time it takes for depression to diminish	Constant *Years*	.8 *years*
Effect of attempts on fear (EffAF)	The effect of attempts on a fear of death	Auxiliary *dmnl*	$EffAF = \frac{AA}{Baseline\ attempts}$
Effect of capability on attempts (EffCA)	The effect of a capability for suicide on attempts	Table function *dmnl*	$EffCA = \frac{CS}{Capability\ necessary\ to\ attempt}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 0.969), (1.400, 1.467), (1.600, 1.616), (1.800, 1.677), (2.000, 1.703)
Effect of fear of death on capability (EffFC)	The effect of fear of death on capability for suicide	Table function *dmnl*	$EffFC = \frac{FD}{Normal\ fear\ of\ death}$ (0.000, 2.000), (0.200, 2.000), (0.400, 2.000), (0.600, 1.983), (0.800, 1.721), (1.000, 1.231), (1.200, 0.454), (1.400, 0.192), (1.600, 0.017), (1.800, 0.000), (2.000, 0.000)
Effect of getting treatment post attempts (EffTPA)	Effect of getting treatment post-attempts	Table function *dmnl*	$EffTPA = \frac{AA}{Baseline\ attempts}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.017), (0.600, 0.210), (0.800, 0.716), (1.000, 1.301), (1.200, 1.572), (1.400, 1.581), (1.600, 1.389), (1.800, 1.205), (2.000, 0.961)
Effect of self-worth on depression (EffSWD)	Effect of self-worth on depression	Table function *dmnl*	$EffSWD = \frac{SW}{Baseline\ self-worth}$ (0.000, 4.000), (0.200, 4.000), (0.400, 3.755), (0.600, 2.271), (0.800, 0.681), (1.000, 0.000), (1.200, 0.000), (1.400, 0.000), (1.600, 0.000), (1.800, 0.000), (2.000, 0.000)
Effect of self-worth on desire for suicide (EffSWDD)	Effect of self-worth on desire for suicide	Table function *dmnl*	$EffSWDD = \frac{SW}{Baseline\ self-worth}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 2.070), (1.400, 2.476), (1.600, 2.803), (1.800, 3.000), (2.000, 3.000)
Effect of desire from failed attempt (EffDFA)	The effect on one's desire for suicide from a failed attempt.	Table function *dmnl*	$EffDFA = \frac{AA}{Baseline\ attempts}$ (0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.000), (0.800, 0.000), (1.000, 0.000), (1.200, 0.838), (1.400, 1.179), (1.600, 1.301), (1.800, 1.301), (2.000, 1.284)

Fractional rate of depression*	The fractional rate of increasing depression	Fractional rate *1/years*	.2/*years*
Fractional rate of impulsivity*	The fractional rate of impulsivity	Fractional rate *1/years*	.7/*years*
Max capability	The maximum level of capability for suicide	Constant *Capability units*	10 capability units
Max self-worth	The maximum level of self-worth	Constant *Self-worth units*	25 self-worth units
Normal fear of death*	An average fear of death for 'healthy' populations	Constant *Fear units*	10 fear units
Proportion of exposure to violence*	The proportional rate of exposure to violence	Constant *Dmnl*	.2
Proportion of relationships who died by suicide*	The proportional rate of deaths from family and peers who died by suicide	Constant *Dmnl*	.42
Rate of diminishing fear (RDF)*	The rate that fear diminishes	Rate *Fear units/year*	$RDF = \frac{EffAF}{ATF}$
Self-worth due to prejudice (SWPrej)*	The proportion of prejudice on self worth	Constant *Dmnl*	*.65*
Self worth due to victimization (SWV)*	The effect on self-worth due to prejudice	Constant *Dmnl*	*.47*
The effect of self worth from depression (EffSWD)	The effect on self-worth from depression	Table function	$EffSWD = \frac{D}{Baseline\ normal\ depression}$ (0.000, 2.000), (0.200, 2.000), (0.400, 2.000), (0.600, 2.000), (0.800, 2.000), (1.000, 2.000), (1.200, 0.419), (1.400, 0.035), (1.600, 0.000), (1.800, 0.000), (2.000, 0.000)
The effect on self-worth from peers and family*	The effect on self-worth from feeling close to peers and family	Table function	(0.000, 0.000), (0.200, 0.000), (0.400, 0.000), (0.600, 0.035), (0.800, 0.183), (1.000, 0.376), (1.200, 1.415), (1.400, 1.721), (1.600, 1.921), (1.800, 2.000), (2.000, 1.983)
Time to build capability (ATC)	The time to build one's capability for suicide	Delay *Years*	5 *years*
Adjustment time to change self-worth (ATSW)	The time it takes to change self-worth	Delay *Years*	1 years

**denotes exogenous variables*