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On Mass Killing in America: Using Markov Analysis to Challenge Conventional Understanding & Policy Design

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Author Note: Dillon Riedlinger completed this research while a First Class Cadet at the United States Military Academy as a part of the Honors Program in the Department of Systems Engineering. MAJ Jillian Wisniewski, serving as advisor, provided critical expertise and knowledge in connecting the ideas of this study and in the implementation of systems concepts.

Abstract: This study uses a systems approach to define and connect ideas on imitation, competing interests of societal agents, societal acceptable levels of violence, and differing cohorts of perpetrators. After defining the system within which to understand mass killings, a Markov chain provides a method to understand the agents behind these killings. A killer's progression toward conducting a mass killing has stochastic characteristics and can therefore be modeled as an absorbing Markov chain with five transient and two absorbing states. Defining the system and agents with these techniques provides a means to understand mass killing in America and inform effective policy. The findings challenge conventional understanding and mitigation of mass killing because they highlight the significance of early stage transitions in the timeline of a killer.

Keywords: Imitation, Mass Killing, Media, Sensationalism, Markov Chain

1. Introduction

This study addresses the growing threat of mass killings in America. Over the last 20 years, the number and frequency of mass killings has risen dramatically (Follman, Aronsen, and Pan, 2017). Unfortunately, it is common to hear about events like shooting sprees and school shootings, and unless action is taken it is unlikely this trend will reverse. Media, on a corporate or individual level, is fueled by views and revenue. Sensational stories, like those frequently seen covering mass killings, garner a lot of views and revenue (Meidl & Ivy, 2017), and they are purposely used by media to increase viewership and spur emotional reactions.

Existing bodies of work on societal violence focus on defining the individual risk factors that influence ones propensity for violent behavior. States differ in their access to firearms, their demographic and socioeconomic makeup, and their access to mental health care. Individual risk factors for violence include alcohol and drug use, childhood abuse, binge drinking, male gender (Metzl & MacLeish, 2015), social isolation, and major mental stress or strains (Blum & Jaworksi, 2016). Other violent gun crimes, like homicide and suicide, are strongly influenced by demographic and socioeconomic factors (Metzl & MacLeish, 2015) as well as access to mental health care, firearms, and firearm ownership (Towers, Gomez-Lievano, Khan, Mubayi, and Castillo-Chavez, 2015). Towers et al. (2015) attempt to go beyond defining explanatory variables through regression models by fitting a contagion model to high profile acts of violence to explain the rise of mass killings; however, the findings from this study fall short in delivering mitigation recommendations directly from the contagion model. Meindl and Ivy (2017) critique the Towers et al. model and argue that imitation is a better representation of the cause of the increase of violence, not a contagious ideation for killing.

2. Imitation & Mass Killing in America

2.1 Imitation

Meindl & Ivy (2017) define imitation as "the learned ability to perform behaviors that are similar to behaviors observed or described, even when performance is delayed." Imitation is a skill that everyone possesses and can grow and be strengthened over time. This behavior is more likely when the model is "similar to [the imitator], particularly in terms of age and gender; who is of an elevated social status; who is seen as being rewarded; and who is seen as competent" (Meidl & Ivy, 2017).

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The concept of imitation of violent events is not novel, but literature on the subject centers on suicide with only the most recent publications tangentially referencing any other form of violence. A link between suicide and imitation in the 18th century lead to Goethe's novel *The Sorrows of Young Werther* being banned in many European countries, and the term Werther Effect was coined in 1974 to describe the influence of the media on imitation of violent acts (Pirkis, Blood, Beautrais, Buress, and Skehan, 2006). In their most recent report, the World Health Organization recognizes that media reporting can potentially have imitative effects that lead to further violence, "Research on the imitative effects of media reports about mass shootings and terrorism is not as extensive as research on the copycat effects of media reports about suicides. However, there is some evidence that sensationalist reporting about killings can trigger further homicidal actions" (World Health Organization, 2017).

2.2 Systems Perspective on Mass Killings

Each entity within our society exists with a goal and a strategy to achieve that goal. Figure 2 is the control structure of the system and depicts the relationships between these entities.

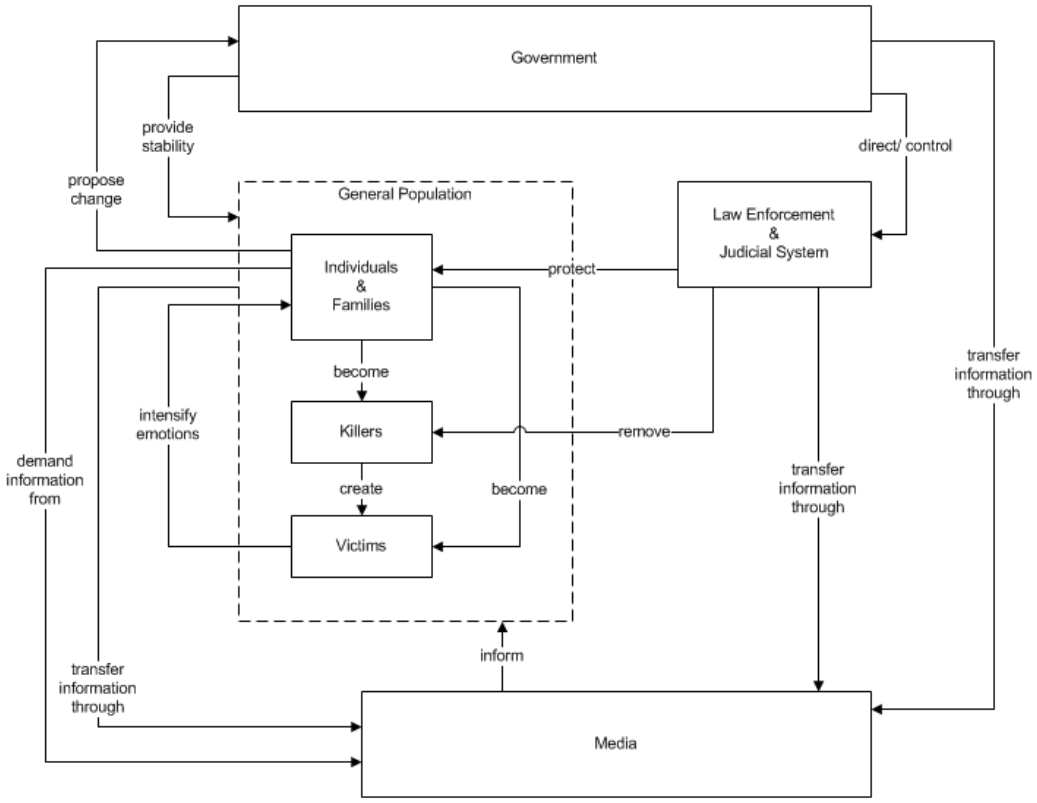

Figure 2. Control Structure

The government wants to provide stability to the general population through directives and control of law enforcement and the judicial system and by transferring information through the media to the general population. Law enforcement and the judicial system protect individuals and families of the general population by removing killers and transferring information through the media. The media informs the general population based on the information they are provided and the information readers or potential readers demand. Individuals and families seek longevity within the system by demanding information from the media and proposing change to the government. The killer wants to transfer information through the media and creates victims in a large enough quantity in order to gain attention from the media.

This structure leads to competing interests. The government's goal of providing stability is an enduring objective characterized by long adjustment times and minimal reactivity. However, when victims are created in large quantities, the emotions of individuals and families are intensified. This is an effect that demands rapid action. Individuals and families now

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seek much more information from the media and propose even more change to the government. This mechanism is described as an availability cascade by Kahneman (2011, p. 142).

As more victims are created from more mass killings, the instability will continue to increase. The government needs to be able to discern whether a pulse in stability as indicated by heightened emotion or impassioned proposals for government change requires a substantial reaction in the form of public policy.

2.3 A Killer's Emergence from the General Population

In order to understand how a killer emerges from the general population, this study breaks down the general population into four classifications: non-vulnerable, inception vulnerable, inception, and planning. Figure 1 shows a timeline of progression for a would-be killer. The non-vulnerable population are what society would consider "normal". They have no intention of committing mass violence nor could they reasonably be convinced to do so.

The inception vulnerable population is almost identical to the non-vulnerable population, potentially even to themselves, except that they are susceptible to committing mass violence. Society may consider this as being weak willed or of a lower mental state. However, this may be an incorrect assumption because just as the influencers for violent acts change, the inception vulnerable population also changes. People may become more or less vulnerable to the inception of the idea of mass violence by life events, societal culture, or other factors.

The next classification is the inception population. These people have already identified that mass violence could be an answer to their problem or could help make their statement or ideas known to the world. They have not committed to performing any action, may not exhibit any different behavior from the previous two populations, and may not even want to consider violence as a valid option. This population is most affected by the dangers of imitation caused by sensational media coverage. Agents could first be introduced to the ideation of mass violence by media and progress to this stage from the inception vulnerable population, or they could be convinced that violence is the best course of action for them and progress to next stage.

The final classification is the planning population. They have committed time and resources to commit an act of violence. They have made the decision to act. This stage consists of planning, methods selection, logistics, and coordination.

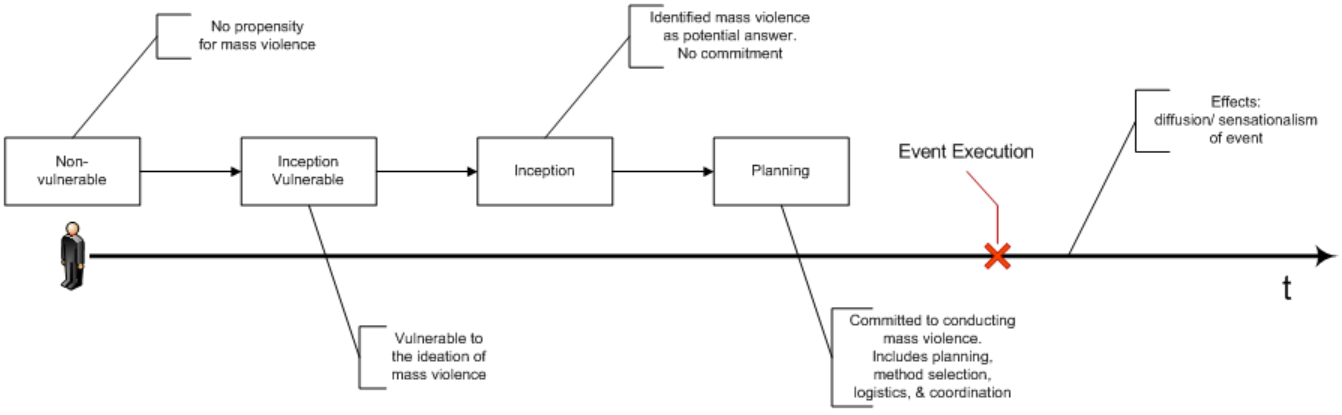

Figure 1. Timeline of a Killer

3. Markov Analysis

The model for analysis of agent progression is based on theory of absorbing Markov chain. To understand more about the fundamentals of Markov chain theory see Beichelt (2006), Ching and Ng (2006), and for an example methodology see Brezavscek, Bach, and Baggla (2017).

The general form of the probability matrix of an absorbing Markov chain with r absorbing and t transient states is given by (1). In the transition probability matrix (1) **Q**, **R**, **0**, and **I** represent matrices where **Q** expresses transitions between transient states, **R** expresses the transitions from transient states to the absorbing states, **0** is the zero matrix, and **I** is the identity matrix.

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$$\mathbf{P} = \begin{pmatrix} \mathbf{Q} & \mathbf{R} \\ \mathbf{0} & \mathbf{I} \end{pmatrix} \tag{1}$$

A useful characteristic of an absorbing Markov chain is the probability of absorption. This is determined from the fundamental matrix **N** which can be calculated from (2) where **I** denotes the identity matrix of size $t \times t$ (different from the size of **I** in (1) which is $r \times r$) and **Q** denotes the sub-matrix from the transition matrix (1).

$$\mathbf{N} = (\mathbf{I} - \mathbf{Q})^{-1} \tag{2}$$

The probability of absorption f_{ij} can be obtained from the matrix **f**, which is calculated from (3) where **N** is the fundamental matrix and **R** is the sub-matrix from the transition matrix (1). The value f_{ij} represents the probability that a Markov chain will be absorbed into an absorbing state j when it started in the transient state i.

$$\mathbf{f} = \mathbf{NR} \tag{3}$$

In order to describe the system, a Markov chain with six states will be used. The states consist of: non-vulnerable {1}, inception vulnerable {2}, inception {3}, planning {4}, executing {X}, executed {E}, and busted {B}. States 1 through 4 are defined in section 2.3 A Killer's Emergence from the General Population. An agent is in the executing state when they are currently conducting an operation to inflict mass violence. An agent reaches the executed state when they have exited the system after conducting a mass killing. This typically occurs through death of the perpetrator or apprehension by the authorities. An agent enters the busted state when they are apprehended by the authorities before conducting a mass killing.

The following assumptions are made in this model: an agent who is currently non-vulnerable can either progress to become inception vulnerable or stay non-vulnerable. An agent in the inception vulnerable stage can maintain their current state, regress to the non-vulnerable state, or progress to the inception state. Agents in states inception and planning can progress to the next state, maintain their current state, or regress as far back as inception vulnerable in a single transition. Agents in the executing state can transition to any state except non-vulnerable. Agents in the planning or execution state can transition to the busted state. Agents in the executed or busted state will never return to any other state of the model. The state transition diagram for agent progression is illustrated in Figure 4.

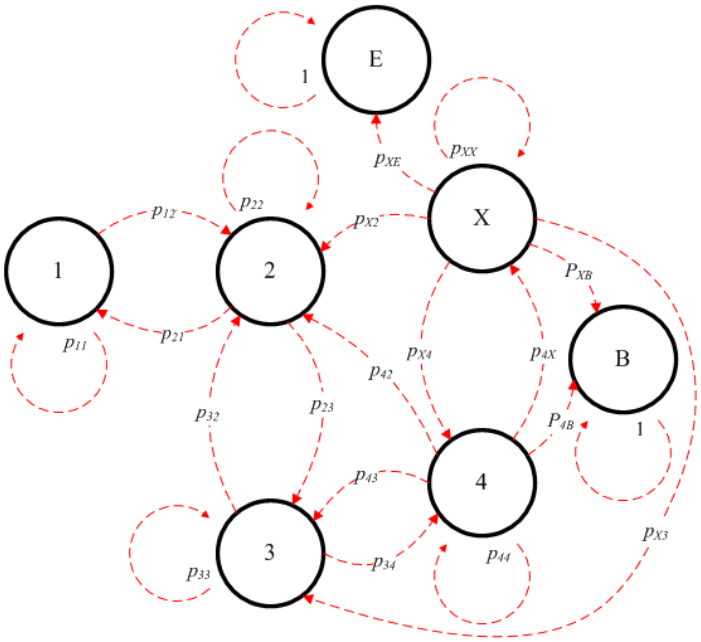

Figure 4. State Transition Diagram for Agent Progression

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Based on the state transition diagram, the probability transition matrix can be written as follows:

$$\mathbf{P} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ X \\ E \\ B \end{array} \begin{array}{c} \begin{array}{ccccccc} 1 & 2 & 3 & 4 & X & E & B \end{array} \\ \left(\begin{array}{ccccc|cc} p_{11} & p_{12} & 0 & 0 & 0 & 0 & 0 \\ p_{21} & p_{22} & p_{23} & 0 & 0 & 0 & 0 \\ 0 & p_{32} & p_{33} & p_{34} & 0 & 0 & 0 \\ 0 & p_{42} & p_{43} & p_{44} & p_{4X} & 0 & p_{4B} \\ 0 & p_{X2} & p_{X3} & p_{X4} & p_{XX} & p_{XE} & p_{XB} \\ \hline 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{array}\right) \end{array} \quad \begin{array}{l} \mathbf{Q} \\ \\ \\ \\ \\ \mathbf{R} \end{array} \tag{4}$$

It is evident from Figure 4 and the transition probability matrix (4) that the states {1, 2, 3, 4, X} are transient and the states {E, B} are absorbing. In the transition matrix **P** the sub-matrices **Q** and **R** are marked. To understand the probability transition matrix **P**, consider a random agent who is currently in the inception vulnerable state {2}. The probability that the agent will transition to the non-vulnerable state {1} is given from the matrix **P** and is equal to p_{21}. The relationships between the other states in **P** can be determined similarly. An indicator of future mass killings is the fraction of agents who progress further along the timeline of a killer. The fraction of agents who progress from non-vulnerable, inception vulnerable, inception, or planning to the next stage of the timeline can be obtained from the matrix **P** as p_{12}, p_{23}, p_{34}, and p_{4X}.

The executed or busted probability can be determined using the probability of absorption, which is calculated according to (3) using the fundamental matrix **N** and the matrix **R** from (4). The result is the matrix **f**:

$$\mathbf{f} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ X \end{array} \begin{array}{c} \begin{array}{cc} E & B \end{array} \\ \begin{pmatrix} f_{1E} & f_{1B} \\ f_{2E} & f_{2B} \\ f_{3E} & f_{3B} \\ f_{4E} & f_{4B} \\ f_{XE} & f_{XB} \end{pmatrix} \end{array} \tag{5}$$

The values f_{iE} in the first column of (5) represent the fraction of agents, currently at the i^{th} stage, who will successfully conduct a mass killing. However, the values in the second column of (5), f_{iB}, represent the fraction of agents, currently at the i^{th} stage, who will be apprehended by authorities prior to conducting a mass killing.

4. Informing Policy Design

4.1 Conventional Policy Design

Analyzing the system and agents with these techniques provides a means to inform policy in a way that conventional models do not. Conventional policy design focuses on reactively constructed policies designed around the planning and execution phases. Examples include policies that seek to make an environment safer by controlling a population's access to weapons, introducing deterrents, or increasing the level of government scrutiny on individual agents within society. In matrix **f**, these policies attempt to decrease f_{4E} and f_{XE} and increase f_{4B} and f_{XB}. It is understandable that conventional policy design introduces policies reactively because of the connection between emotion and policy. The intensified emotions resulting from events of mass violence make an ideal situation for an availability cascade to occur via sensationalized media coverage. The result is described by Kahneman (2011, p142):

> An availability cascade is a self-sustaining chain of events, which may start from media reports or a relatively minor event and lead up to public panic and large-scale government action. On some occasions, a media story

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> about a risk catches the attention of a segment of the public, which becomes aroused and worried. This emotional reaction becomes a story in itself, prompting additional coverage in the media, which in turn produces greater concern and involvement. The cycle is sometimes sped along deliberately by "availability entrepreneurs," individuals or organizations who work to ensure a continuous flow of worrying news. The danger is increasingly exaggerated as the media compete for attention-grabbing headlines. Scientists and others who try to dampen the increasing fear and revulsion attract little attention, most of it hostile: anyone who claims that the danger is overstated is suspected of association with a "heinous cover-up." The issue becomes politically important because it is on everyone's mind, and the response of the political system is guided by the intensity of public sentiment. The availability cascade has now reset priorities. Other risks, and other ways that resources could be applied for the public good, all have faded into the background.

Conventional polices seek to ease the emotional burden that leads to the increased societal instability by targeting aspects of the events that are most easily sensationalized, most notably the deadliness of the event. By attempting to decrease the deadliness of future mass killings, mitigation strategies seek to show societal support for the physical and emotional wounds. This is a well-intended reaction to provide support to communities and victims. However, the alternative perspective on this is the interplay between media coverage and desensitization to the occurrence of mass violence events.

4.2 Acceptable Level of Violence

In every society, there exists a level of violence which is deemed acceptable. Individual acts of violence are criminalized and seen as harmful to society, but policies designed to mitigate this violence are less effective when the occurrence of violence is not seen as an issue to mainstream public opinion (Sedmak & Kralj, 2014). Lower sensitivity to violence leads to a higher tolerance for similar future violent acts (Sedmak & Kralj, 2014). Continual exposure to violence leads to increased acceptance, both as individuals and as a society (Willis & Silovsky, 1998). The societal acceptable level of violence acts like a bubble that grows larger as the frequency and deadliness of the acts increase. If the frequency and deadliness of a new violent act is within this bubble of acceptability, the society will not be interested in mitigating the violence.

To the media, who tailors what information they provide based on the wants of their readers, the acceptable level of violence helps to shape what is reported and how the events are reported. Events that exceed the acceptable level of violence are more likely to be sensationalized in order to increase viewership as the society seeks information. Individuals who seek to use violence to communicate a message via the media see this acceptable level of violence differently. To a would-be killer, this reflects the minimum violence they need to inflict in order to make their voice heard.

4.3 Profiling Killers & Cohorts of Perpetrators

Just as tolerance levels of mass killings are dynamic, so too are the cultural norms which shape the profile of a killer. It is difficult to give rational reasons for acts of mass violence, and often times the perpetrator dies during the execution of the event, making it impossible to question their motives. However, the information-seeking society is not content without an explanation. Therefore, sensational media often assumes attributes and the causes of the mass killer. Some of these attributes and causes may have been correct at one time for a previous cohort, but they are not necessarily true for the next generation. Assuming attributes is dangerous because it delays updates to our understanding of the root causes of the current cohort of perpetrators.

Profiling a mass killer is significantly more difficult than profiling agents of other forms of violence. Mass killings are low likelihood/ high impact (LL/HI) events. Suicides are an example of a high likelihood/ low impact (HL/LI) event. HL/LI events are relatively easy to research because of the large amount of data available both in time and location. Conversely, LL/HI events are difficult to research because of the relatively limited number of cases. Because of this limitation, it is nearly impossible to generalize the influences of these events. Even if the geographic area and/or the timespan for data collection were greatly expanded, changes in social attitudes over such a period would render any findings reductive at best.

The changing culture of the world leads to different cohorts of mass killers being influenced differently. A study by Gill, Horgan, Corner, and Silver (2016) compared two cohorts of mass killers, one from 1990-2005 and another from 2006-2013. The more recent cohort was more likely to have used the internet in their planning, and significantly less likely to have "had previous military experience, made verbal statements to family/friends/wider audiences about their intent and beliefs, socialized face to face with members of a wider network, experienced being degraded or the target of an act of prejudice or unfairness, experienced a recent stressor, and interacted face-to-face with others holding a similar grievance" (Gill et al., 2016). The earlier cohort "was more heavily influenced by negative life events," and the later cohort "was more influenced by delinquent peer association" (Gill et al., 2016). The influences behind the cohorts are constantly changing.

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Because of the complexity among cohorts of perpetrators and individual profiles, policies that make assumptions about the profile of a killer come at the expense of understanding the true influencers of the next cohort of potential killers.

4.4 Policy Recommendation

In order to understand which policies will be most effective in decreasing mass killing, it is important to recognize the effects of the critical transition probabilities from (1) on the executed and busted probabilities in **f**. Figure 5 shows a transition probability table where very high likelihood (VHL), high likelihood (HL), medium likelihood (ML), low likelihood (LL), and very low likelihood (VLL) qualitatively represent the probabilities for state transitions. Agents in the planning and executing states have significantly higher probabilities for progressing to the next stage than agents in the three earlier states. The largest filter for potential killers occurs early in their development and the number of agents occupying the states {2, 3} is significantly larger than the number of agents occupying the later, more volatile states {4, X}.

Our policies should reflect this by shifting the focus from the conventional approach of late stage reaction to earlier stage prevention. Conventional policies attempt to decrease f_{4E} and f_{XE} and increase f_{4B} and f_{XB}, which are the planning and execution phase absorption probabilities. The focus in these phases does not address the process of becoming a potential killer; whereas, attempts to decrease f_{iE} would address this. These earlier stage transitions account for a much larger quantity of the total state transitions of agents, which greatly reduces the probability of agents transitioning to later states. This represents not only a more efficient application of policy resources, but over time may reduce the total resource requirements in these later stages.

		1	2	3	4	X	E	B
Non-Vulnerable	1	VHL	VLL	-	-	-	-	-
Inception Vulnerable	2	LL	VHL	VLL	-	-	-	-
Inception	3	-	ML	HL	LL	-	-	-
Planning	4	-	LL	LL	ML	HL	-	LL
Executing	X	-	VLL	LL	LL	LL	HL	LL

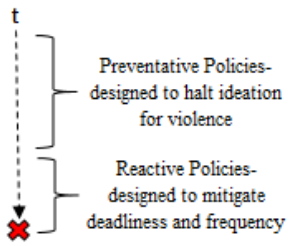

Figure 5. Policy Analysis based on Qualitatively Described Transitional Probabilities

The motivation for societies to offer emotional support for victims can serve as a more active prevention by extending emotional support that humanizes those in the inception vulnerable or inception population. Putting into action and normalizing guidelines such as those developed by Suicide Awareness Voices of Education (Suicide Awareness Voices of Education, 2017) will more significantly decrease the f_{iE} probabilities in matrix **f** of agents committing mass killings than conventional policies that focus on reacting to an already developed agent determined to enact violence.

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