Understanding the Impact of Climate Change on Abortion Access in Florida Using System Dynamics Modeling

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I. Background

Reproductive-age people in Florida face unique obstacles in obtaining safe abortions due to the socio-political climate in the state.[1] Women in Florida are uninsured at a higher rate compared to the national average for women (18% compared to 11.7% nationally).[2] Further, Floridian people often live in 'contraceptive deserts' at disproportionately higher rates compared to their counterparts.[2] In 2017, of the 85 facilities providing abortions, 65 of them were abortion clinics, demonstrating how important abortion clinics are to reproductive access for people in Florida.[3] Approximately one in every four people are required to travel outside of their county to receive an abortion; 73% of counties in Florida do not have abortion clinics.[4] Abortion legislation in Florida continues to become increasingly restrictive, making access to abortions even more difficult. At the same time, Florida is also the US state with the highest rate of Hurricanes.[5] Increasing rates of extreme climate events threaten to hinder access to abortions in Florida due to clinic closures, transportation disruptions, and delays in appointment times.

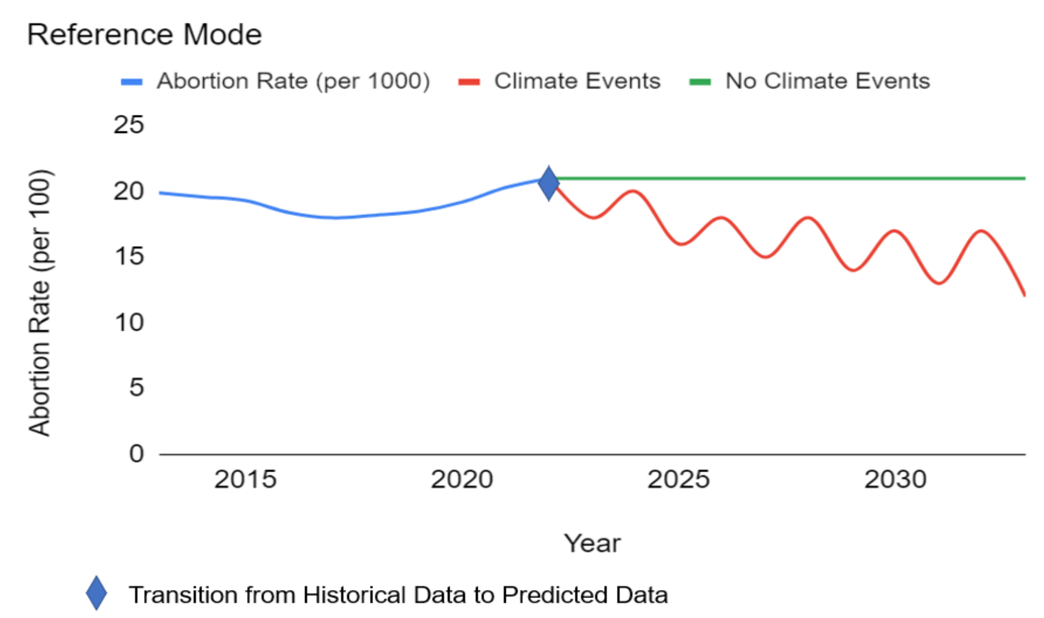
There is a substantial gap in the literature exploring how climate change events impact access to reproductive healthcare in the United States.[6] Recent severe climate events in the United States, such as hurricanes, have demonstrated how natural disasters fueled by climate change can limit access to abortion — especially when abortion procedures require precise timing due to legal restrictions. Climate events and climate disasters interrupt travel, childcare, employment, and clinic access for people seeking abortions.[6] One study of people seeking abortion services in Texas at the time of Hurricane Harvey found that climate events limited abortion access by creating challenges in accessing abortion funds and clinics that closed temporarily.[6] Restrictions on late-term abortions, such as Florida's 15-week abortion ban mean that people seeking abortions must receive care within a critical, limited time period during early pregnancy.[7] Extreme weather events can delay an individual's ability to make and attend appointments for abortion services, further constricting the critical period during which a pregnant person can legally receive an abortion. Despite these potential consequences, the connection between reproductive justice and climate disasters in the US has been largely overlooked. In this study, we aimed to create a model demonstrating how safe abortion access is threatened by the growing number of annual climate events (such as hurricanes, tropical storms, and excessive flooding) and how these natural disasters may influence pregnant peoples' access to abortion services.

II. Reference Mode and the Design Problem

The scope of this model is abortion access among reproductive-age people capable of pregnancy in Florida with unintended pregnancy from 2023-2033. Reproductive healthcare services are largely provided at abortion and community health clinics, so we utilized abortion rates as a proxy for sexual and reproductive health services and outcomes.

In 2017, 71,050 abortions were provided in Florida.[8] As shown in Figure 1 below, between 2014 and 2017 abortion rates declined in Florida from 20.6 to 18.6 abortions per 1000 people of reproductive age.[2] However, in 2018 the abortion rate began to increase with 82,851 abortions provided in 2022.[9] In our Reference Mode, the 'feared state' represents not meeting the population's demand for abortion and the 'goal state' represents meeting demand over the next 10 years, until 2033. The fear of not meeting demand indicates that the rate of abortion could slowly fall over time in an oscillatory pattern due to extreme climate events caused by climate change and consequent abortion clinic closures, assuming no further legislative restrictions are passed. Because some clinic closures are permanent, the compounding effect of these closures demonstrates that abortion demand will not be met at the same rate that it was prior to the climate events. Since Florida law prohibits abortion after 15 weeks of pregnancy, the increasing number of clinic closures and subsequent restrictions to reproductive and sexual health services create an unmet need for abortion in Florida.[7] In our goal state, we hypothesize that the oscillatory declining abortion rate may be mitigated by implementing resiliency measures that make abortion clinics less vulnerable to climate events.

Figure 1: *Reference Mode for Rate of Abortions in Florida*



III. Model Structure

Abortion clinics in Florida are facing temporary and permanent closures due to climate change events; clinics close temporarily if damage is minimal, or permanently if they suffer excessive infrastructure damage due to flooding or do not have the funds to restart operations. As clinics close, fewer people with unintended pregnancies will be able to access safe abortion services in Florida, leading to a higher incidence of unsafe abortions that may cause health complications.

In our model, we define standard (safe) abortions as abortions carried out by a trained medical provider, and nonstandard (unsafe) abortions as those using “a procedure for terminating an unintended pregnancy carried out either by persons lacking the necessary skills or in an environment that does not conform to minimal medical standards, or both” based on the World Health Organization’s (WHO) definition.[10]

Our model attempts to capture the dynamics of abortion access and service delivery within a sample population of 1000 individuals who begin in the stock of [*People of reproductive age (15-44) capable of getting pregnant*]. The model is composed of two distinct stock and flow structures - one captures the demand for abortion services by individuals becoming pregnant and seeking reproductive services, and the other captures the supply of abortion services through open clinics (Figure 3 and Figure 4). These structures are connected on the fractional rate of people getting an abortion, highlighted in red in Figure 3 and Figure 4. The model is simulated using a time step of one month, and a time frame of 10 years (120 months).

Climate events were modeled using a switch variable, represented in the model as 'switch climate change.' When this variable is set to zero, the model simulates the scenario in which there are no climate events and no clinical closures. When this variable is set to one, a lookup table with climate event data is triggered, and the model simulates a scenario in which the effect of past and future climate events on clinic closures is considered.

Abortion clinic closures due to hurricanes, tropical storms, and other severe weather can cause delays for people with unknown pregnancies detecting their pregnancies. On average, people detect pregnancy at six weeks.[12] We theorized that in the event of a climate event, there is an additional two-day delay for every event that occurs. This additional time delay is considered by adding two additional days to the *average time delay of pregnancy detection* when the climate events scenario is switched on. Once a pregnant person knows they are pregnant, they either flow into the stock of [*Pregnant people who decide to get a standard abortion*] or the stock of [*Pregnant people who do not get a standard abortion*]. In the scenario of severe climate events, those who decide to get an abortion may face additional delays to receiving a safe and standard abortion if there are clinic closures and appointment cancellations.

From the stock of [*Pregnant people who decide to get a standard abortion*] the *rate of getting a safe abortion* and the *rate of people not able to get abortions* are multiplied by the *fractional rate of people getting an abortion*. This fractional rate is dependent on the number of operating clinics and connects the separate abortion and climate events stock and flow structures together (Figure 3 and Figure 4). When clinics close, and the stock of [*Accessible abortion clinics running*] decreases, which in turn depletes the stock of [*People receiving standard abortions*] through the *fractional rate of people getting abortions*. The *fractional rate of people getting an abortion* is determined by a lookup table. We assume among those who have already decided to get an abortion, if 100% clinics are open, 70% of this population will get an abortion. If 50% of clinics are open, 30% of people will get an abortion, and if 10% of clinics are open, only 10% of those who have decided to get an abortion will actually get one. This assumed relationship is completely theoretical due to the lack of available research and data exploring this dynamic. In the follow-up to an extreme weather event, a higher proportion of individuals who originally decided to get a standard abortion either have give birth or elect to receive nonstandard (unsafe) abortions.

Individuals in the stock of [*Pregnant people who do not get a standard abortion*] can flow into the stock of [*People receiving nonstandard abortions*] or [*People giving birth*]. From these stocks, we assume 99% of people will flow back into the initial stock of people susceptible to pregnancy. A small proportion of people (1%) who were not able to receive a standard safe abortion will develop health complications that lead may to maternal morbidity, mortality, infertility or psychological distress.[13]

Figure 3: *Stock and Flow Modeling the Effect of Climate (Change) Events on Population Receiving Abortions*

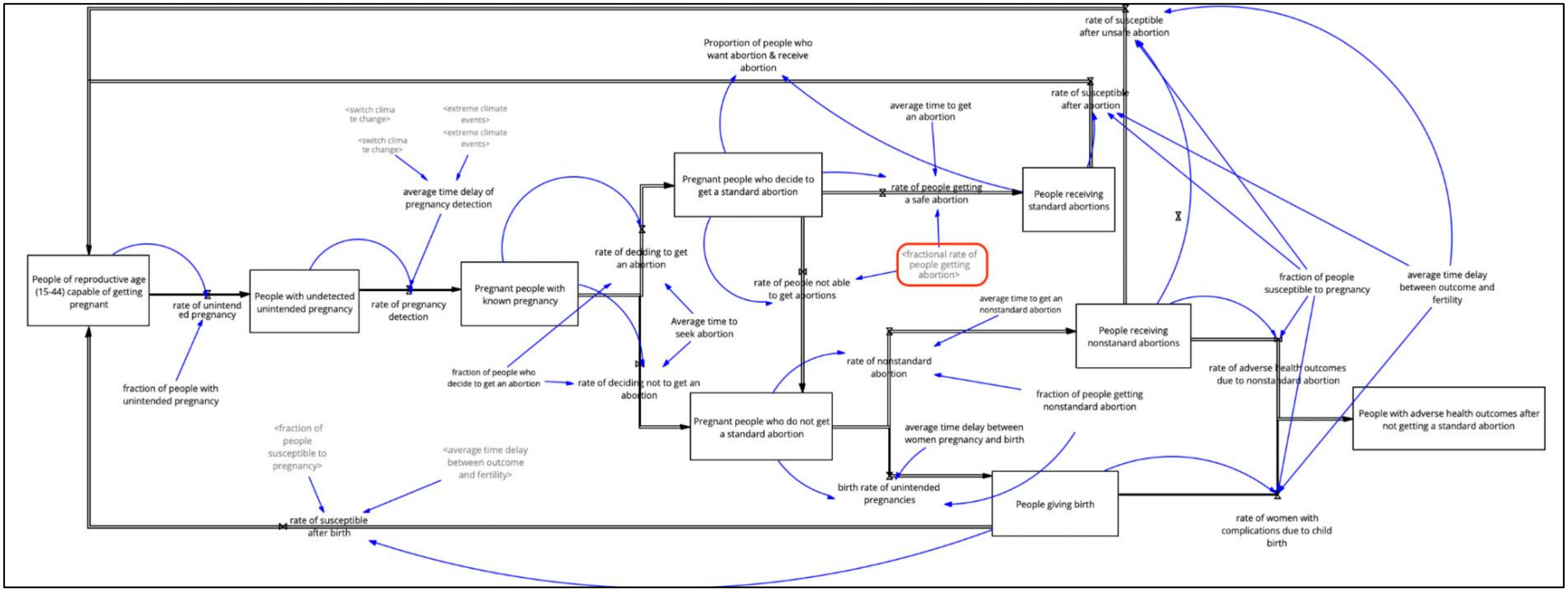
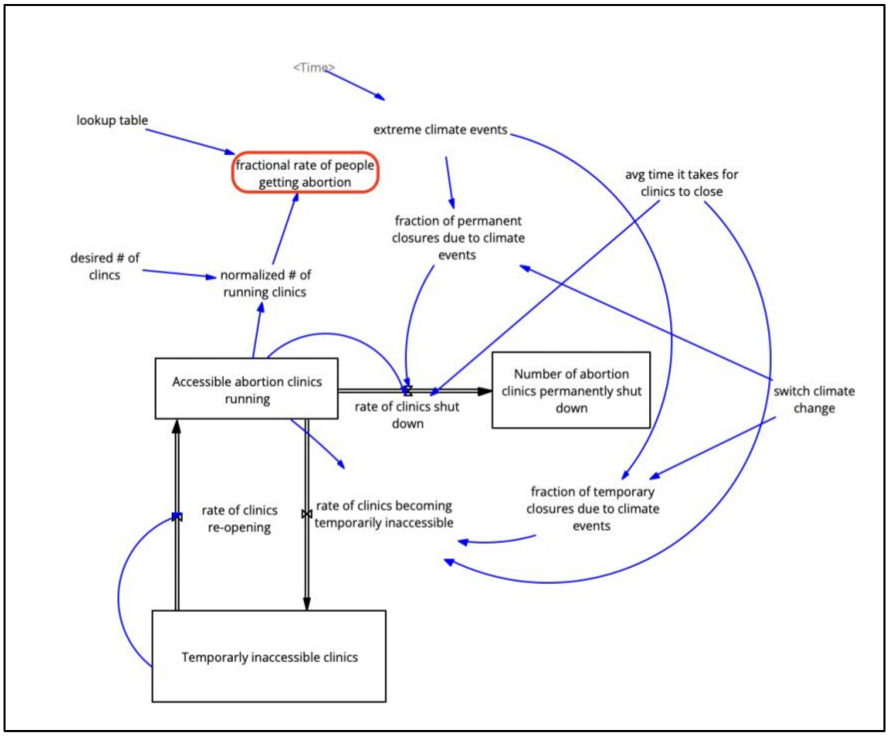


Figure 4: *Abortion Clinic & Climate Event Stock and Flow Model Close Up*



IV. Model Simulations

The model was simulated with an initial value of 1000 people in the first stock, [*People of reproductive age (15-44) capable of getting pregnant*]. For the remaining stock, initial values were determined based on parameters that established dynamic equilibrium within the model. For the model run "No Climate Events" (blue), the switch variable that triggers the climate events lookup table was set to zero. Conversely, the switch variable was set to one for the model run titled "Climate Events" (red). Figures 6 – 9 show the output of the final simulation.

In Figure 6, we attempted to reproduce our reference mode for the rate of the population receiving abortions. Because our reference mode accounts for demand for services, we modeled the proportion of people who receive a standard abortion among the total population of people who decide to get an abortion. In our reference mode, we hypothesized that over time we would expect to observe a reduction in the rate of meeting abortion demand due to clinic closures. Figure 6 displays a similar pattern as our Reference Mode. The model simulation depicts a far more drastic difference in the proportion of people who want and receive an abortion under the two scenarios, with a notable decline in the rate of abortions due to climate events compared to no climate events. While demand is consistently met under the no climate change scenario, the climate events scenario depicts the oscillatory behavior fueled by climate change and the compounded effect of delays in access to standard abortions and pregnancy detection on the rate of people receiving standard abortions. To note, this decline is partially caused by a depletion in the population at risk over time. Every month, one percent of people who give birth or get nonstandard abortions flow into the [*People with adverse health outcomes after not getting a standard abortion*] stock, and do not flow back into the susceptible population. Since we developed our model using a static sample population of 1,000 people, a simplification for demonstration purposes, our scale is different from that of our reference mode, and what we might expect to see among the entire population of Florida.

Figure 6: *Simulation of Meeting Abortion Demand*

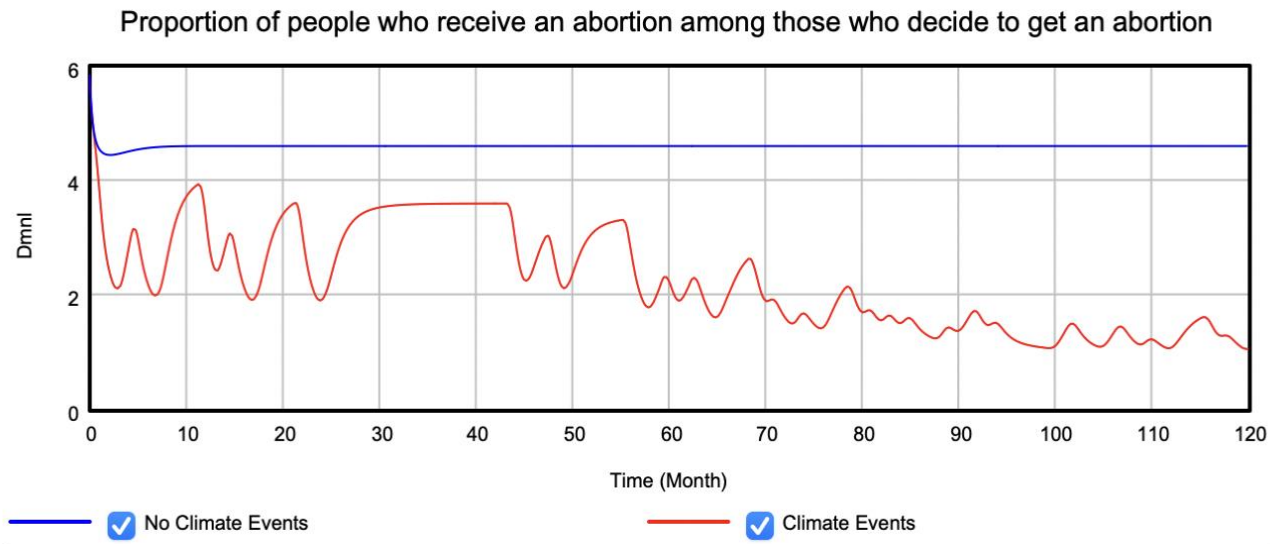


Figure 7 displays how climate events impact the stock of the *People receiving nonstandard abortions*. In extreme climate events, the population of people receiving nonstandard abortions steadily grows due to delays in accessing and receiving abortion services and pregnancy detection. Similarly to Figure 6, the behavior in Figure 7 oscillates with extreme climate events. Under normal circumstances, the population of people receiving nonstandard abortions remains relatively stable. This simulated behavior shows how extreme climate events can drastically impact health decisions and behaviors among this population, leading to adverse health outcomes.

Figure 7: *Simulation of people receiving nonstandard abortions*

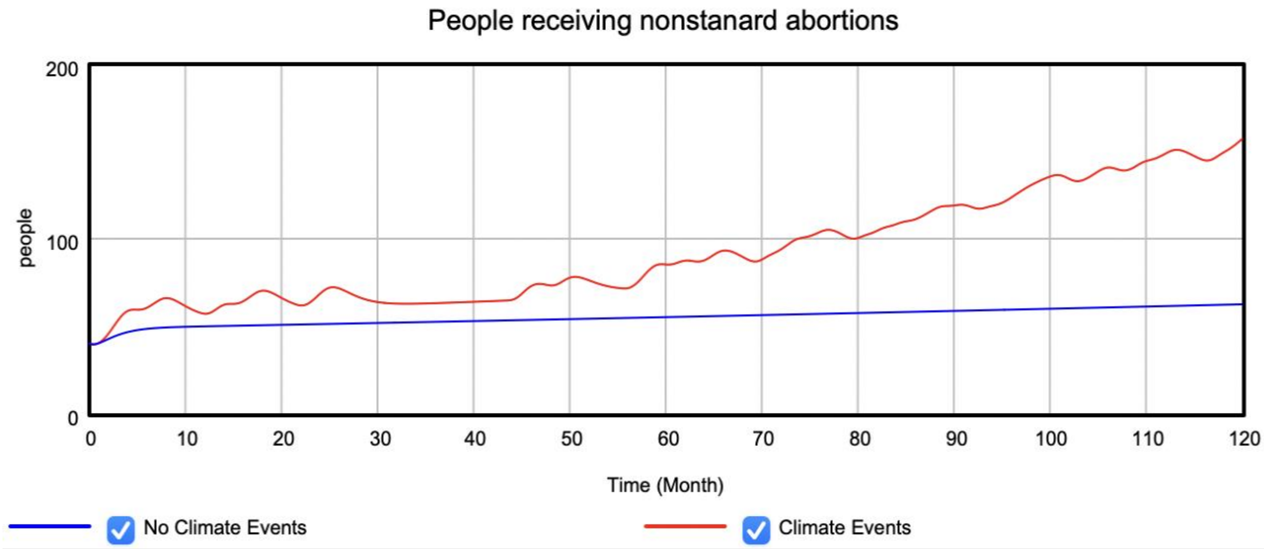
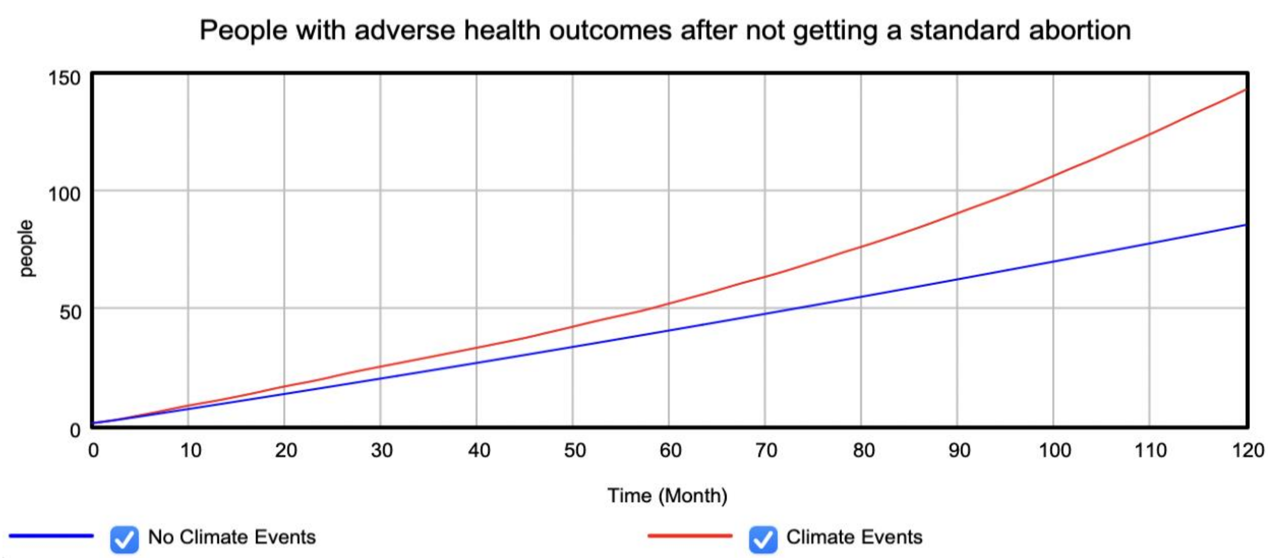


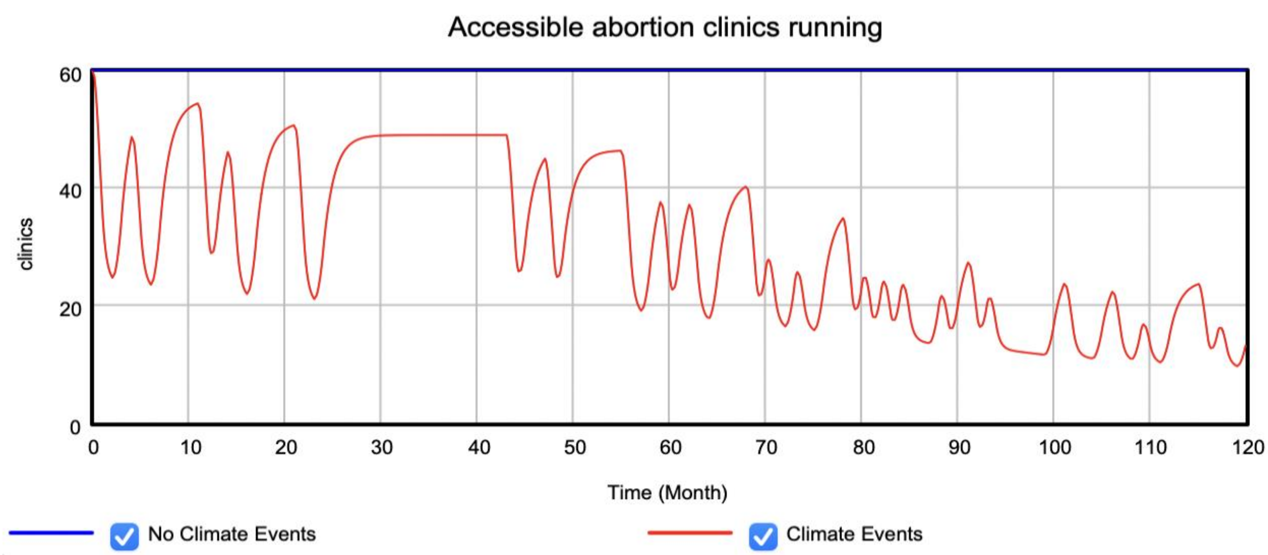
Figure 8 displays the simulated change in the number of people with adverse health outcomes from childbirth or nonstandard abortions over time. Unsurprisingly, this output closely follows the trend of people receiving a nonstandard abortion. As the number of individuals who receive a abortion grows, adverse health outcomes among this population do too.

Figure 8: *Simulation of People with adverse health outcomes after not getting a standard abortion*



In the model, the impact of climate change events on abortion access is operationalized through clinic closures. The simulated output depicts that under the no climate events scenario, clinics remain open. When there are climate events triggered by the switch variable, clinics close in an oscillatory pattern, with the total number of open clinics decreasing over time due to the compounded effect of permanent closures (Figure 9). This oscillatory behavior is consistent with the incidence of climate change events over the 10 years (2023-2033) we are modeling. Thus, model simulations demonstrate how increased incidence of climate events have a direct impact on the number of abortion clinics that can provide care for pregnant people in Florida.

Figure 9: *Simulation of Abortion Clinics Running*



V. Discussion

As a result of insufficient research exploring the dynamic between climate change and abortion access, this model was constrained by data limitations. We assumed multiple rates of change within the model, notably the rate of receiving safe abortions as it relates to the proportion of operating abortion clinics. We also used a constant population of 1000 individuals, assuming the model to be in dynamic equilibrium of people aging into and out of the model at the same rate. However, the model fails to capture people seeking and receiving abortions in Florida from out of state. Since Florida is one of the only southern states where abortion remains legal, many southern pregnant people travel to Florida to receive an abortion.[14] Since we could not find sufficient statistics on out-of-state residents seeking abortion services in Florida, we excluded the inflow of out-of-state residents in our model. Due to the aggregate nature of system dynamics modeling, we were not able to capture, at the individual-level, the consequences of delays due to climate events which would render a person legally unable to receive an abortion after 15 weeks of pregnancy. The issue of modeling the precise effect of the 15-week abortion ban on individual outcomes may be better addressed using a discrete event, agent-based, or hybrid modeling approach. In furthering this model we'd like to develop a time variable that captures the accumulation of time (both due to average time delays and additional delays from climate events) that captures how people's decision-making is affected by the abortion ban time constraint. Additionally, the model does not capture the unique socio-political landscape in Florida. By stratifying on race and ethnicity and developing a model structure that captures soft variables like social influence and stigma, we believe the model could better capture the nuances associated with people’s abortion access. Despite these limitations, this model has important implications for future public health interventions and policies that protect reproductive-aged people's already restricted access to abortions in Florida.

Preliminary simulations of this model helped inform initial recommendations that may strengthen the resiliency of abortion clinics. Hospitals across the country are encouraged to use predictive climate models to set structural design criteria that lessen their reliance on external safeguards and reinforce power and water systems to protect them from the impacts of extreme weather.[15] We suggest similar measures be applied to abortion clinics to better prepare for climate events and reduce operational disruption due to extreme weather. Since hospitals have the capacity and technology to remain open during extreme weather events, we believe they may be able to function as ‘annex’ locations when abortion clinics temporarily close. A system of clinical partnership could minimize care disruptions by providing timely care to patients, and reduce the need for non-standard, unsafe abortions. The model also illustrates how scheduling delays and back-ups due to climate events can be extremely disruptive to care. Creating a robust multi-clinic, user-friendly scheduling system that merges appointment data for local clinics may allow faster re-scheduling time in the wake of appointment cancellations. Allowing patients whose abortion appointments were impacted by climate events to easily access available appointments at alternative operating clinics may reduce the adverse health outcomes associated with not receiving a safe, standard abortion. Although this model is conceptual in nature, we hope that this work propels future research that explores the connection between climate change and reproductive healthcare access, and inspires interventions that address these disparities.

VI. Conclusion

In this paper we aimed to understand how extreme climate events due to climate change impact access to abortion by inducing abortion clinic closures and limiting access to reproductive care in an already overburdened healthcare system in Florida. Understanding how climate change and consequent climate events contribute to restricted sexual and reproductive healthcare access is crucial to maintaining population health, yet is largely under-researched. Despite the limited existing data on abortion rates and extreme climate events in Florida, there is currently no data to support how these public health phenomena are interdependent. As a result, this model is largely theoretical, and should be used as a conceptual model to understand how reproductive healthcare and climate change are interconnected, rather than as quantitative evidence. We hope this model will motivate future research that explores this topic further using evidence-based quantitative and qualitative methods.

Appendix

Variable Name	Equations or Constant Value	Units
average time delay between outcome and fertility[16]	*2*	Months
average time delay of pregnancy detection[12]	*1.5 + ((2/30)*extreme climate events*switch climate change)*	Dimensionless
average time delay between pregnancy and birth[17]	*8*	Months
avg time it takes for clinics to close	*0.25*	Months
average time to get an abortion[18]	*0.25*	Months
average time to get a nonstandard abortion	*0.25*	Months
average time to seek an abortion	*0.25*	Months
fraction of people getting a nonstandard abortion	*0.4*	Dimensionless
fraction of people susceptible to pregnancy	*0.999*	Dimensionless
fraction of people with unintended pregnancy[19]	*0.48/12*	Dimensionless
fraction of people who decide to get an abortion[20]	*0.5*	Dimensionless
fraction of permanent closures due to climate events	*0.01*extreme climate events*switch climate change*	Dimensionless
fraction of temporary closures due to climate events	*0.3*extreme climate events*switch climate change*	Dimensionless
pregnant people with known pregnancy	*=INTEG(rate of pregnancy detection-rate of deciding not to get an abortion-rate of deciding to get an abortion)*	People

pregnant people who decide to get a standard abortion	*=INTEG(rate of deciding to get an abortion-rate of people not able to get abortions-rate of people getting a safe abortion)*	People
population receiving standard abortion	*=INTEG(rate of people getting a safe abortion-rate of susceptible after abortion)*	People
pregnant people who do not get a standard abortion	*=INTEG(rate of people not able to get abortions+rate of deciding not to get an abortion+rate of people not able to get abortions-birth rate of unintended pregnancies-rate of nonstandard abortion)*	People
people receiving nonstandard abortions	*=INTEG(rate of nonstandard abortion-rate of susceptible after unsafe abortion-rate of adverse health outcomes due to nonstandard abortion)*	People
people giving birth	*=INTEG(birth rate of unintended pregnancies-rate of susceptible after birth-rate of people with complications due to childbirth)*	People
people with adverse health outcomes after not getting a standard abortion	*=INTEG(rate of adverse health outcomes due to nonstandard abortion+rate of people with complications due to childbirth)*	People
accessible abortion clinics running	*=INTEG("rate of clinics re-opening"-rate of clinics becoming temporarily inaccessible-rate of clinics shut down)*	Clinics
temporarily inaccessible clinics	*=INTEG(rate of clinics becoming temporarily inaccessible-"rate of clinics re-opening")*	Clinics

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