Why the Aztecs Fell

🟩 Abstract

Why did the Aztec Empire fall? This article uses system dynamics modeling to explore the deep structural causes behind one of history's most striking collapses. Moving beyond conventional narratives of conquest and technological superiority, we uncover the underlying feedback loops, delays, and internal tensions that shaped the trajectory of Aztec society leading up to its fall in 1521. Using systemic thinking, we simulate historical patterns to test hypotheses and bring clarity to how internal complexity, environmental stress, and political fragility interacted to create a tipping point. By revisiting this collapse through a systems lens, we gain new insight not only into the Aztecs, but into the hidden dynamics behind the failure of powerful civilizations.

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Jun 6, 2025

Keywords

Aztecs, Collapse, System Dynamics, History, Feedback Loops, Simulation, Empire Decline, Structural Causes, Thought Models, Sustainability.


CERRO DEL PEÑON
ALBARRADA DE NETZAHUALCOYOTL
ALBARRADA DE NETZAHUALCOYOTL
CALZADA AL TEPEYAC
CENTRO CEREMONIAL
CALZADA A IXTAPALAPA
Y XOCHIMILCO
LA GRAN TENOCHTITLAN
CALZADA A TACUBA
Y CHAPULTEPEC

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Introduction

The fall of the Aztec Empire is often told as a tale of European conquest, superior weaponry, and divine prophecy. While compelling, this narrative overlooks critical internal dynamics that left the Aztec system vulnerable long before Hernán Cortés arrived. In this article, we ask: *what if we could simulate history to test alternative explanations?*

Using system dynamics, a methodology developed to understand complex systems through models, we reconstruct the conditions that preceded the fall. We identify patterns of accumulation, delayed feedback, structural imbalances, and unintended consequences that gradually undermined the empire from within. This is not a story of heroes and villains—it is a story of systems, limits, and collapse.

Case Description

The Aztec Empire, with Tenochtitlán as its radiant capital, dominated Mesoamerica through a vast network of tribute, war, and political control. But this strength masked vulnerabilities: resource exhaustion, overcentralization, growing inequality, and systemic rigidity. As the empire expanded, it stretched its social and ecological systems beyond sustainable thresholds.

In this study, we build a simulation model based on stocks and flows, feedback loops, and external pressures (like drought, war, and resistance). The model reveals how short-term gains from expansion produced long-term fragility. Cortés's arrival was the spark—but the fuel for collapse was already in place.

This analysis enables students, leaders, and decision-makers to reflect on the relevance of systemic thinking in avoiding collapse in our own time.

The Epidemic That Conquered Before the Swords: A Systemic Dynamics View of Smallpox in Tenochtitlan

Introduction

During the conquest of Mexico, smallpox played a silent yet devastating role. From a **systems dynamics perspective**, this epidemic was not just a biological event, but a structural phenomenon that deeply influenced the social, military, and demographic behavior of the Mexica empire. Relying on testimonies such as those of **Bernal Díaz del Castillo**[1] and on

[1] *The letters and chronicles of Bernal Díaz del Castillo, a soldier in the conquest of Mexico and author of* The True History of the Conquest of New Spain, *are preserved in the General Archive of the Nation, located in the former*

quantifiable historical data, we can model this event to better understand its patterns and systemic implications.

📊 Table 1. Historical Parameters and Assumptions for the System Dynamics Model

Parameter / Variable	Estimated Value / Explanation
Original population of Tenochtitlan	250,000 inhabitants. Estimate based on historical accounts and pre-Hispanic urban density.
Initial immune fraction (virgin-soil epidemic)	10% immune, 90% susceptible. A virgin-soil epidemic occurs in populations with no prior exposure or immunity.
Incubation period	14 days. Time between infection and the onset of visible symptoms. Infected individuals are contagious but not visibly sick.
Recovery time	14 days. Period during which visible symptoms persist until recovery and acquired immunity.
Number of Spanish conquistadors	1,000 soldiers. Based on historical records of Cortés' expedition.
Number of Aztec warriors	80,000. Conservative estimate of the active military force defending the city.
Daily contact rate per infected person	19 contacts. Based on dense urban living conditions and typical social interactions.
Infection probability per contact	20%. Assumption based on known transmission dynamics of smallpox in immunologically naive populations.
Estimated mortality rate	30%. Midpoint of the 25–50% range reported for virgin-soil epidemics.
First visible symptoms recorded	Day 50. Historical sources report 100 visibly ill individuals and 5 deaths by this time.
Visible deaths by day 50	5 people. Based on direct observations described in historical chronicles.
Estimated date of Aztec defeat	Day 120. Approximately 70 days after the onset of visible symptoms.
Surviving Aztec population by day 120	~125,000. Represents a 50% population loss, supported by historical estimates.

Lecumberri Palace in Mexico City. This archive is part of Mexico's national historical heritage and safeguards essential documents from the colonial period.

Initial Systemic Analysis

This system can be represented as an **SIR model** (Susceptible – Infected – Recovered), reinforced by population density and the complete lack of medical knowledge. Key elements include:

- **Invisible Delay:** During the first 14 days of infection, symptoms were not visible. This enabled mass transmission before any containment measures could be taken.
- **Positive Feedback:** As more individuals became infected, the number of infectious contacts grew, **accelerating the spread exponentially**.
- **Population Collapse:** In just **70 days from the first visible symptoms**, half of the population was lost. This led to the collapse of Aztec **military capacity, economic activity, and social structure**.

Understanding the Logic of Contagion: The SIR Model

Before addressing the specific case of the smallpox epidemic among the Aztecs, it is important to introduce the basic epidemiological model known as **SIR** (Susceptible – Infected – Recovered). This model helps explain how an infection spreads through a population over time by classifying people into three main categories:

- **Susceptible (S):** Individuals who have not yet been infected but are at risk.
- **Infected (I):** Individuals who have contracted the disease and can transmit it.
- **Recovered (R):** Individuals who are no longer contagious, either because they have developed immunity or have died.

This structure will serve as a starting point for building a more detailed model that incorporates the unique characteristics of the smallpox outbreak in the Aztec world, including incubation, visible symptoms, and mortality rates.

Full Model - Basic SIR Infection Model.

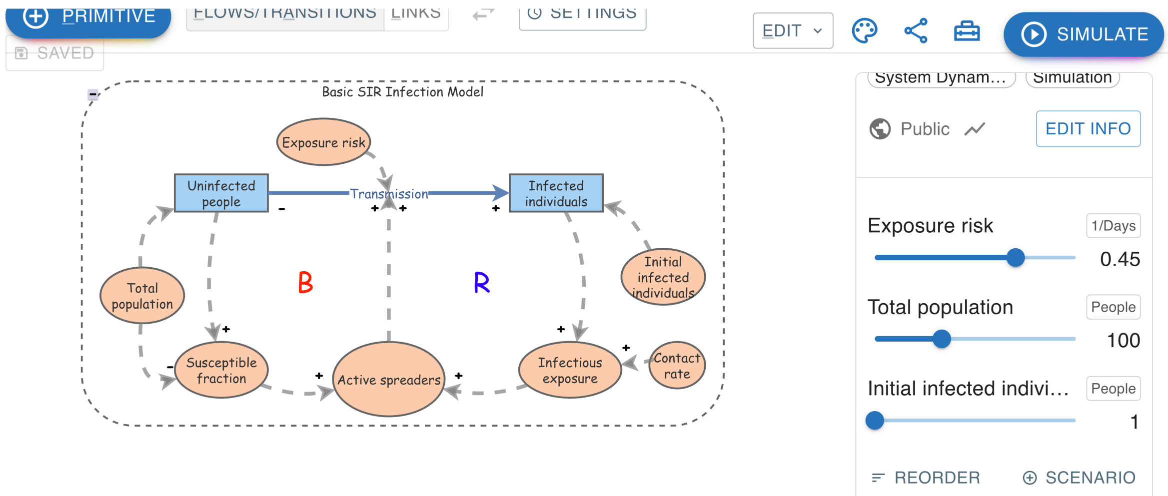

Figure 1: Basic SIR Infection Model.

SIR Model Documentation

Model Table

Type	**Name**	**Formula / Value**	**Units**
Stock	Uninfected people	Initial value: [Total population]	People
Stock	Infected individuals	Initial value: [Initial infected individuals]	People
Flow	Transmission	[Active spreaders]*[Exposure risk]	People/ Days
Variable	Exposure risk	0.45	1/Days
Variable	Total population	100	People
Variable	Susceptible fraction	[Uninfected people]/[Total population]	Unitless
Variable	Active spreaders	[Infectious exposure]*[Susceptible fraction]	People
Variable	Infectious exposure	[Infected individuals]*[Contact rate]	People
Variable	Initial infected individuals	1	People
Variable	Contact rate	1	Unitless

Graphical results of the SIR model

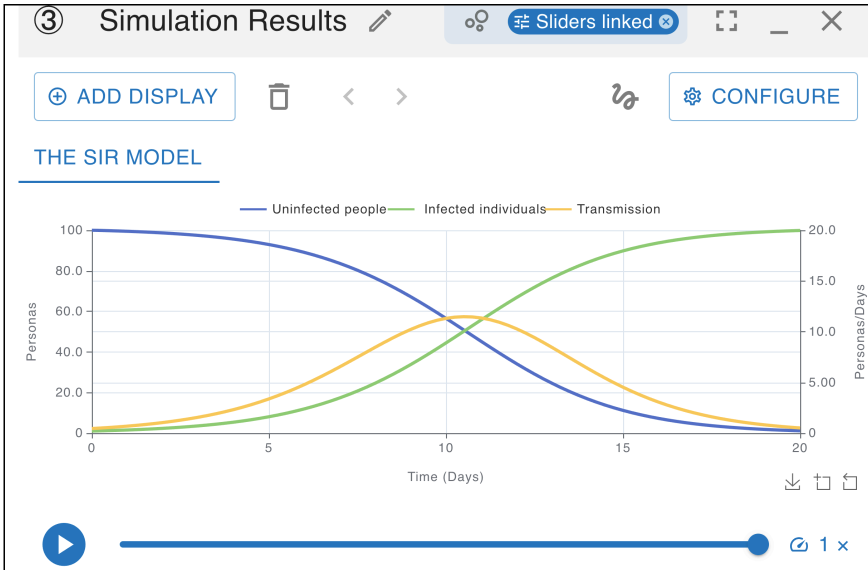

Figure 2: Graphical results of the basic infection model (SIR).

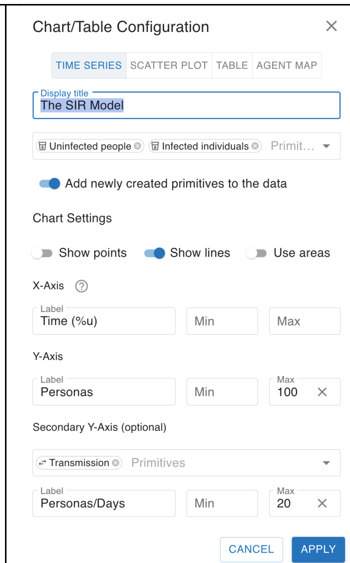

Figure 3: Graph settings of the SIR model.

Model registration & settings (SIR)

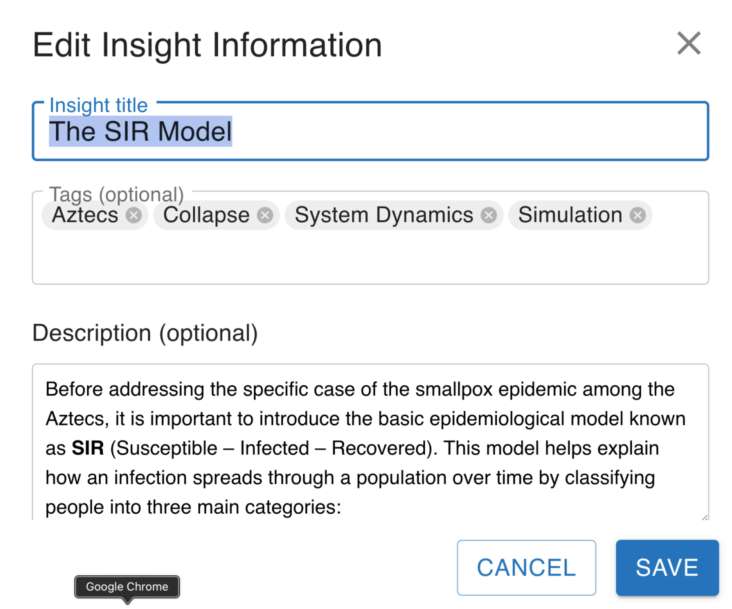

Figure 4: Model registration

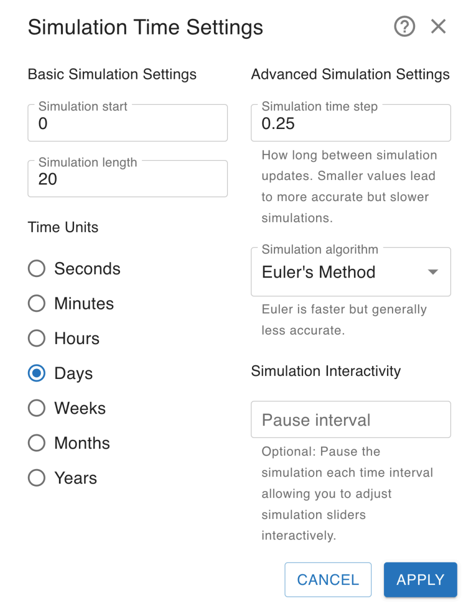

Figure 5: Model settings

Simulating the Spread of Smallpox among the Aztecs: Model Visualization, Structure, and Analysis

This section presents how the simulation model was visualized and structured to represent the impact of smallpox on the Aztec population. Starting from the basic SIR model, it was expanded conceptually and structurally to better reflect the specific dynamics of the disease in a context with no prior immunity. The resulting model allows for simulation of the virus's spread, analysis of key system flows, and comparison of its outcomes with available historical data. Since many figures from the time are uncertain, some variables had to be inferred using current scientific knowledge about smallpox behavior in previously unexposed populations. This provides a more accurate understanding of the epidemic's devastating role in the fall of the Aztec Empire.

Model Storytelling: Structure, Dynamics, and Logic Behind the Smallpox Impact

This section tells the step-by-step story of how the simulation model of smallpox spread among the Aztecs was designed and visualized. Using a storytelling approach, it presents three key phases: first, the structural expansion of the basic SIR model to capture the epidemiological process of smallpox in a population with no prior exposure; second, the identification of feedback loops that determine the system's behavior; and third, the underlying logic that defines how infected individuals either die or recover and become immune. This narrative not only explains how the model was built, but also why it credibly represents the historical unfolding of the epidemic.

Step 1: Smallpox Spread Structure

This first step of the model simulates the progression of smallpox starting from its initial case in the Aztec population. It is represented by a stock structure with five key stages: uninfected people, in incubation, infected individuals, smallpox deaths, and immunes. From day one, the first case enters incubation for 14 days, then becomes visibly infected for another 14 days. Due to the visible symptoms of smallpox (skin lesions), the progression was observed and recorded. This structure mirrors the timeline reported by Bernal Díaz del Castillo, who documented the appearance of visibly ill individuals shortly after Hernán Cortés entered Tenochtitlan. The model translates this chronology into a clear and measurable dynamic.

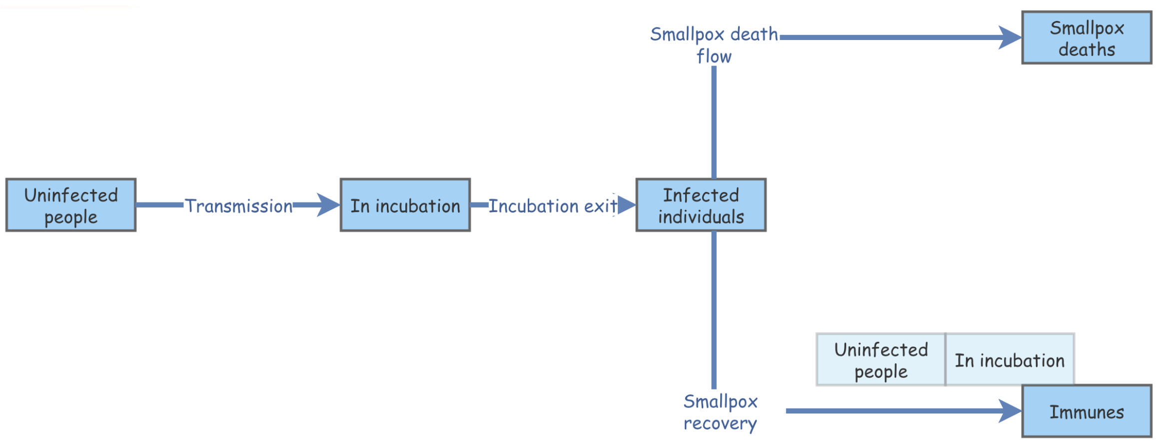

Figure 6: Stock structure representing the stages of smallpox progression in the Aztec population: uninfected people, in incubation, infected individuals, smallpox deaths, and immunes. The sequence follows historical chronology based on the documented observations of Bernal Díaz del Castillo after Hernán Cortés entered Tenochtitlan.

🌀 Step 2: Embedding feedback loops in the extended stock structure

From the basic SIR model, we learned that the epidemic is governed by two feedback loops: a **reinforcing loop** (infection spread) and a **balancing loop** (depletion of susceptibles). When expanding the model to represent the smallpox epidemic among the Aztecs, these loops are embedded into the new stock structure, which now includes more detailed stages (incubation, immunity, and death). In addition, **new balancing loops** emerge between the stocks, helping to regulate the course of the epidemic.

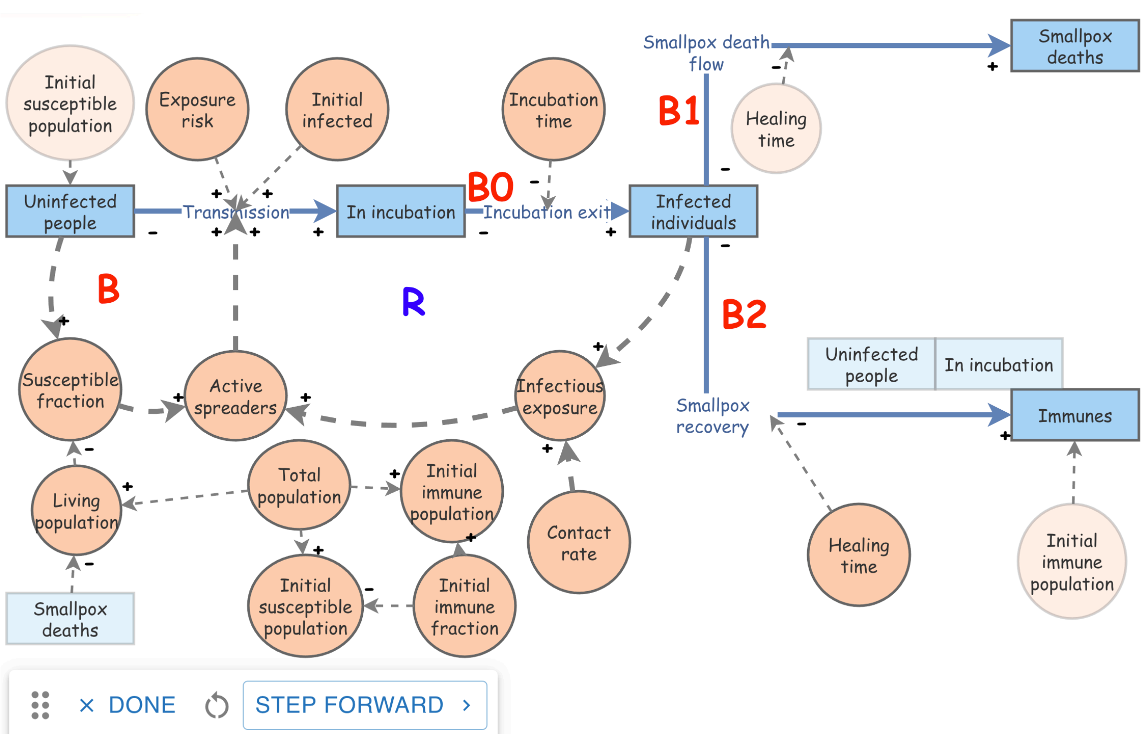

Figure 7º. Feedback loops embedded in the extended smallpox model structure.

Step 3 – Mortality and Immunity Logic

This stage of the model defines the outflows from the infected population: those who die and those who survive and become immune. A corrected fatality rate is used, combining the base lethality of smallpox with an added mortality index due to poor disease management. Their sum determines the death flow; the remainder accounts for those who recover and gain immunity.

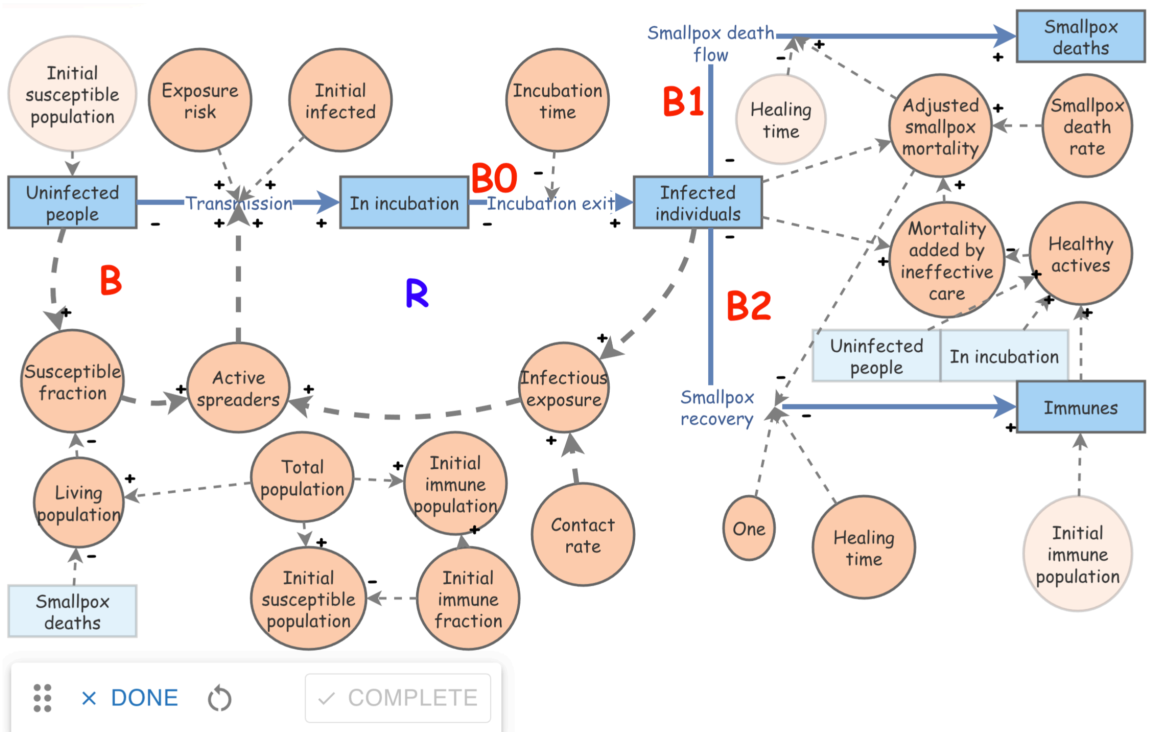

Figure 8: Mortality and immunity flows driven by smallpox severity and disease mismanagement.

Systemic Collapse of Tenochtitlan: Feedback Dynamics of the Smallpox Epidemic and Its Role in the Conquest

This model simulates the spread of smallpox after Hernán Cortés withdrew from Tenochtitlan and later returned allied with the Mexicas' enemies. The system's behavior is driven by reinforcing and balancing feedback loops that reveal how an invisible disease undermined an entire civilization. With simulation results presented through graphs and data tables, users can examine whether the model aligns with historical accounts documented by the chroniclers of the conquest.

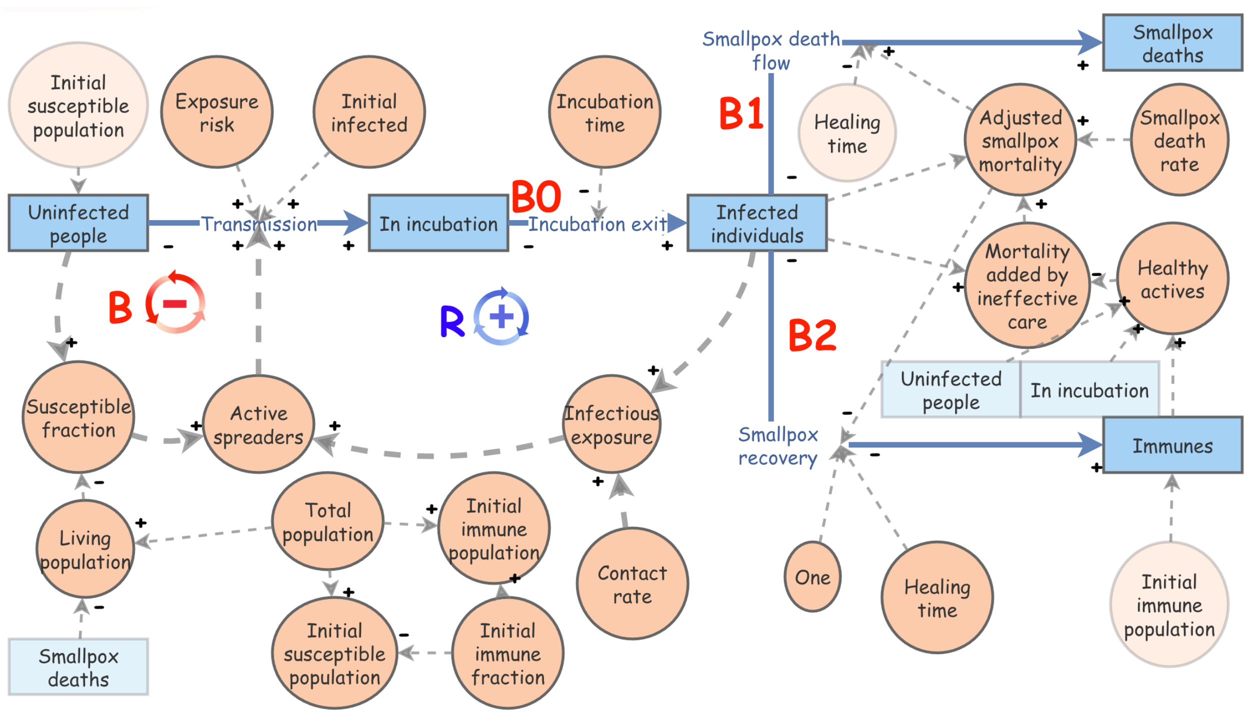

Figure 9: (Full model) Diagram of the full model showing feedback loops governing smallpox spread, mortality, and immunity.

Model Table

Type	Name	Formula / Value	Units
Stock	Uninfected people	Initial value: [Initial susceptible population]	People
Stock	In incubation	Initial value: 0	People
Stock	Infected individuals	Initial value: 0	People
Stock	Smallpox deaths	Initial value: 0	People
Stock	Immunes	Initial value: [Initial immune population]	People
Flow	Transmission	[Exposure risk]*[Active spreaders]+[Initial infected]	People/ Days
Flow	Incubation exit	[In incubation]/[Incubation time]	People/ Days
Flow	Smallpox death flow	[Adjusted smallpox mortality]*([Infected individuals]/[Healing time])	People/ Days
Flow	Smallpox recovery	([Infected individuals]/[Healing time])*([One]-[Adjusted smallpox mortality])	People/ Days
Variable	Exposure risk	0.20	1/Days
Variable	Initial infected	IfThenElse(Days() =1,1,0)	People/ Days
Variable	Incubation time	14	Days
Variable	Healing time	14	Days
Variable	One	1	Unitless
Variable	Contact rate	19	Unitless
Variable	Infectious exposure	[Infected individuals]*[Contact rate]	People
Variable	Susceptible fraction	[Uninfected people]/[Living population]	Unitless
Variable	Active spreaders	[Infectious exposure]*[Susceptible fraction]	People
Variable	Total population	250000	People
Variable	Initial immune fraction	0.1	Unitless
Variable	Initial immune population	[Initial immune fraction]*[Total population]	People
Variable	Initial susceptible population	[Total population]*(1-[Initial immune fraction])	People
Variable	Living population	[Total population]-[Smallpox deaths]	People
Variable	Smallpox death rate	0.50	Unitless
Variable	Healthy actives	[In incubation]+[Uninfected people]+[Immunes]	People
Variable	Mortality added by ineffective care	if ([Infected individuals]>[Healthy actives]) then ([Infected individuals]/[Healthy actives])-1	Unitless

		else
		0
		End If	

Variable	Adjusted smallpox mortality	If ([Infected individuals]>{0 People}) Then
		[Mortality added by ineffective care]+[Smallpox death rate]
		Else
		0
		End If
			Unitless

Simulation Results and Parameter Analysis

This section displays the complete simulation's graphs and data table. The model features eight parameters that the user may modify: smallpox fatality rate, contagion rate, probability of infection, initial immune fraction, incubation period, and recovery time, among other settings. While all parameters are editable, for the specific case of smallpox the values for incubation and recovery times are based on the disease's characteristics and should remain fixed. They remain unlocked only to enable adapting the model to other epidemics. For example, when adjusting the fatality rate from 30 % to 56 %, the simulation produces a value close to 50 % deaths by the end of the run—matching historical records. The data table documents these values, confirming how closely the model aligns with what happened during the conquest.

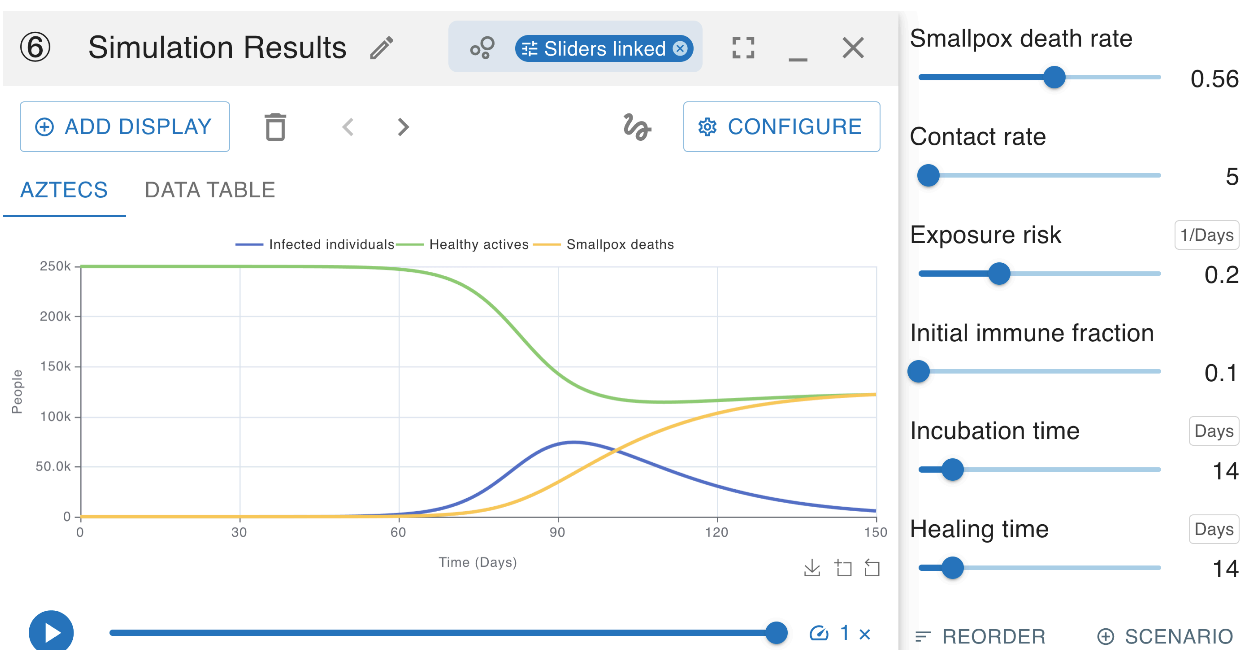

Figure 10: Simulation results graph displaying smallpox death progression compared with historical values.

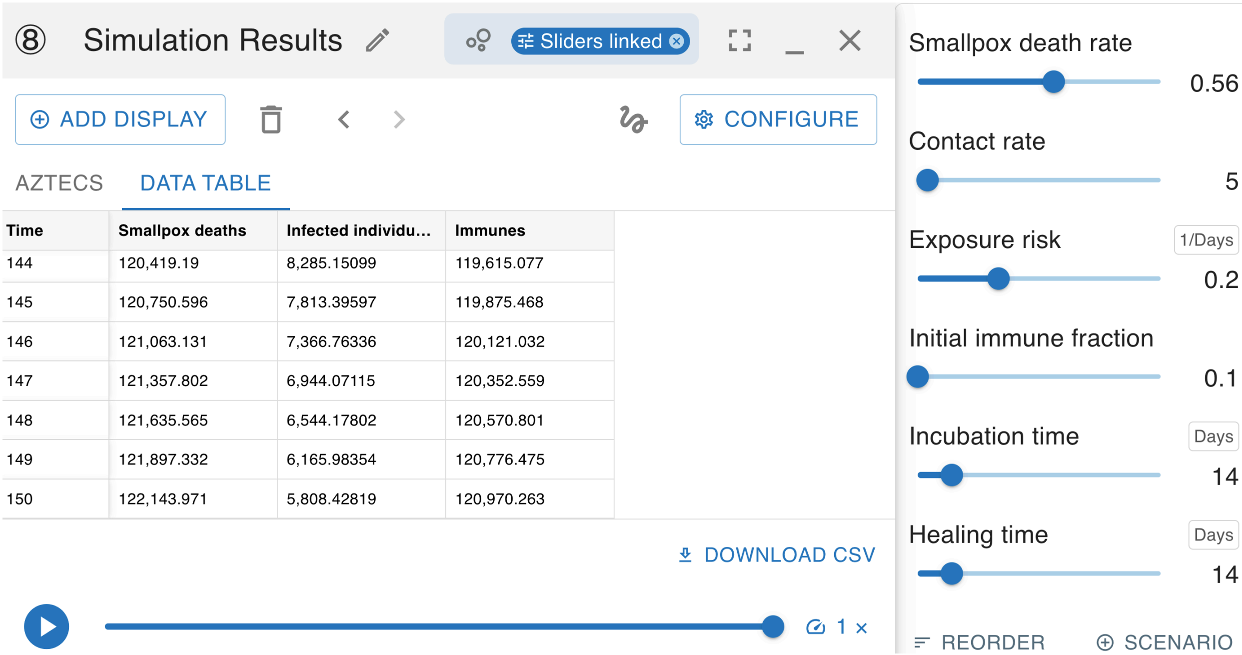

Figure 11; Table of simulated numerical outcomes versus historical smallpox records.

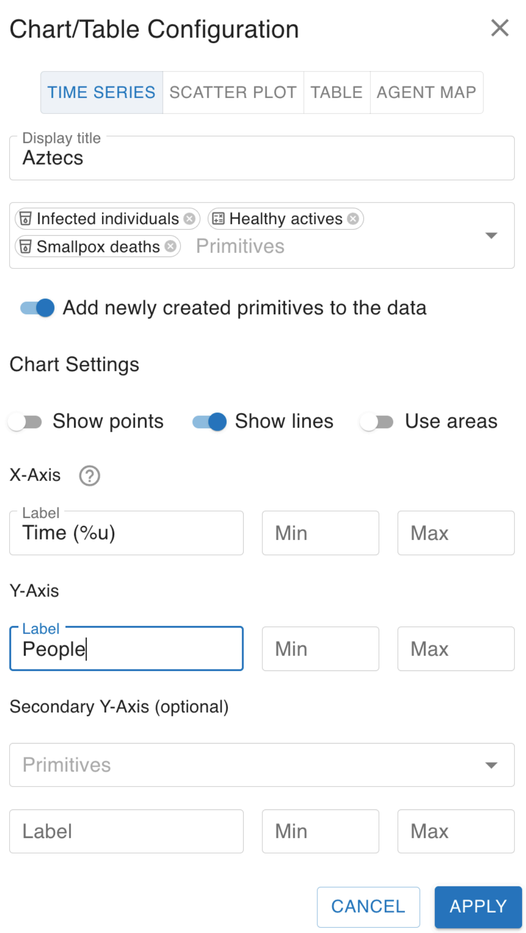

Figure 12: Graph settings: axes and ranges defined to display the epidemic's progression.

Model Registration & Settings

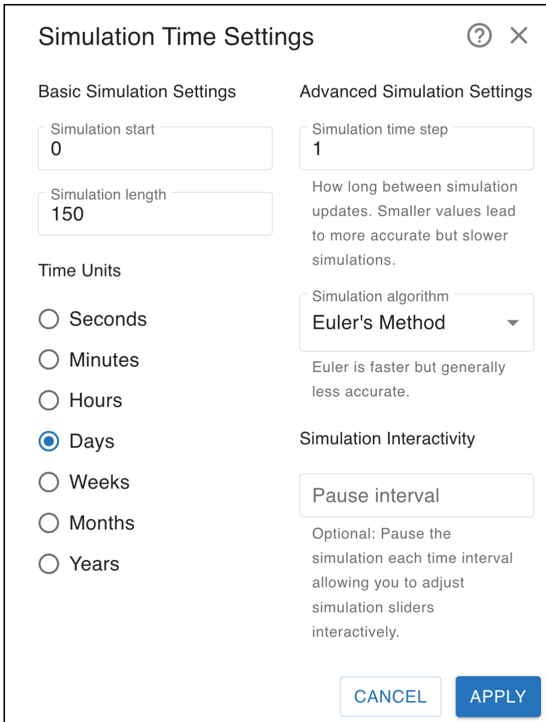

Figure 13: Model settings: Temporal and simulation parameters (duration, time steps, and interactivity options) that govern the run.

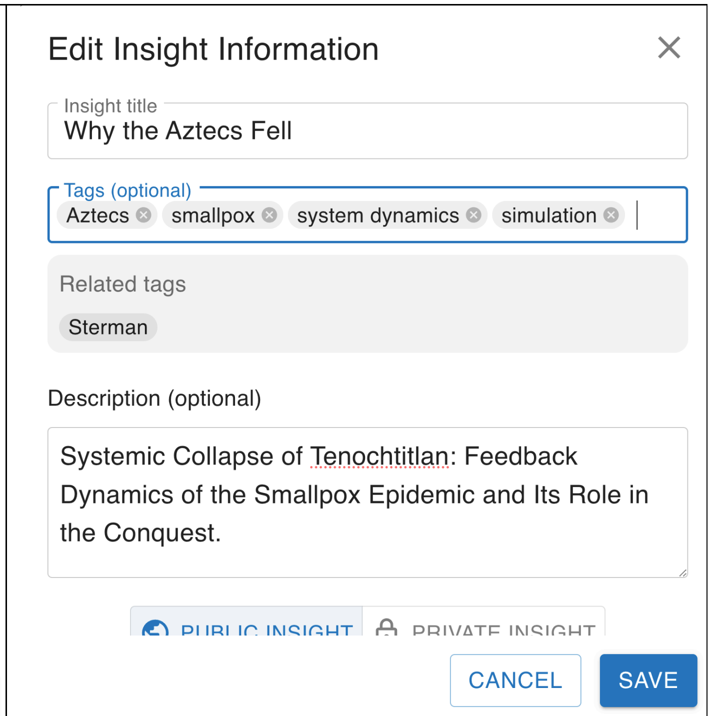

Figure 14:Model registration: Key metadata (title, author, date, and keywords) to categorize and locate the model.

Conclusion

Modeling and simulation are extraordinarily powerful tools for testing hypotheses about historical events. In this case, the model produces numbers and curves that closely mirror recorded reality: roughly 50 % smallpox fatalities by day 120, the resulting demographic collapse, and the Aztecs' inability to sustain military resistance. This makes it evident that it was not only superior weaponry but an "invisible weapon" —smallpox—propagating through reinforcing feedback loops, which dismantled social and political networks before the conquest was complete.

This intellectual and educational exercise teaches us to narrate history with one foot in the future: by simulating the epidemic, we can explore alternative paths, examine numerical discrepancies, and dispel doubts about why things happened. Beyond explaining the past, this model offers a kaleidoscope of possibilities to understand how small changes in parameters—fatality rate, contagion rate, immune fraction—can completely alter an empire's trajectory. In doing so, we learn to apply systems thinking to historical events and glimpse clear avenues to investigate other complex episodes that still seek precise answers.

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📘 Glossary of Key Concepts (English)

Virgin Soil Epidemic
A disease outbreak in a population with no previous exposure or immunity, often resulting in extremely high mortality rates. The smallpox epidemic in the Aztec Empire is one of the most cited historical examples.

Susceptible Population
Refers to individuals who are vulnerable to infection due to lack of immunity. In the Aztec case, approximately 90% of the population was considered susceptible.

Infection Rate
The probability that a contact between an infected and a healthy person will lead to transmission. This value helps model the spread of disease in simulations.

System Collapse
A rapid degradation of the structure and functioning of a system, often triggered by internal fragility or external shocks. In this context, disease, warfare, and sociopolitical instability interacted to collapse the Aztec system.

Feedback Loops
Core structures in system dynamics. Reinforcing loops amplify changes (e.g., rapid spread of disease), while balancing loops resist change (e.g., immunity acquisition).

Dynamic Modeling
A simulation technique used to understand and test how complex systems evolve over time. Used here to reconstruct how disease and conquest may have unfolded together.

Recovery Time
Time needed for an infected individual to recover and become immune, influencing the speed at which herd immunity can develop in a population.