

# Foot-and-mouth disease (FMD)

## Introduction:

**FMD** is one of the world's most economically important viral diseases of livestock. The infection results in vesicular lesions in and around the mouth and on the feet, resulting in the reluctance of an animal to eat or move. It is a highly transmissible disease caused by infection with genus *Aphthovirus*, a member of the family *Picornaviridae*.

According to **NADRES**, from 2001 to 2024, there have been a total of **33,655** outbreaks of FMD disease in India, resulting in **797,541** attacks and **39,311** deaths.

## Host characteristics:

The virus primarily affects **cloven-hoofed animals** of the order *Artiodactyla*, including livestock hosts like **cattle** and **buffaloes** (**primary species** affected by FMD in India: They exhibit **severe symptoms** and are crucial for the **dairy** and **meat industry**), **pigs** (act as **amplifiers**: highly susceptible to the virus, **spreading it rapidly**), **sheep** and **goats** (**susceptible**, they often exhibit **milder symptoms**, making **detection** and **control more challenging**), as well as **many cloven-hoofed wildlife species**.

**Clinical signs:** Fever, Vesicles and Blisters, Drooling, Lameness, and Decreased productivity.

## Pathogen characteristics:

**Virus Structure:** Small, non-enveloped, positive-sense, single stranded, non-segmented RNA virus surrounded by an icosahedral capsid composed of four structural viral proteins (VP1, VP2, VP3, and VP4)

**Minimal infectious dose** ~10-100 particles are enough to start the infection.

**Serotypes:** Seven types of FMD virus are A, O, C, Southern African Territories (SAT)- 1, 2, and 3 and Asia 1.

Only types O, A and Asia1 are seen in India.

**Mean [95% Confidence Interval (CI)] durations** of serotype disease phases in cattle: **Incubation** (2.7–4.8 days); **Latent** (1.1–2.1 days); **Subclinical infectious** (1.5–3.5 days); **Clinical infectious** (6.2–11.6 days); **Total infectious phase** (8.2–14.2 days).

## Environmental factors:

**Transmissibility:** Air-borne-can travel long distances.

**Persistence:** Can stay in the hots for months.

**Temperature:** Virus survives in cooler temperatures (4°C to 50°C)

**Humidity:** Facilitate the survival and transmission of virus.

**Wind:** Spread over long distances in the form of aerosol.

**Soil and Water:** Contaminated soil and water can harbor the virus.

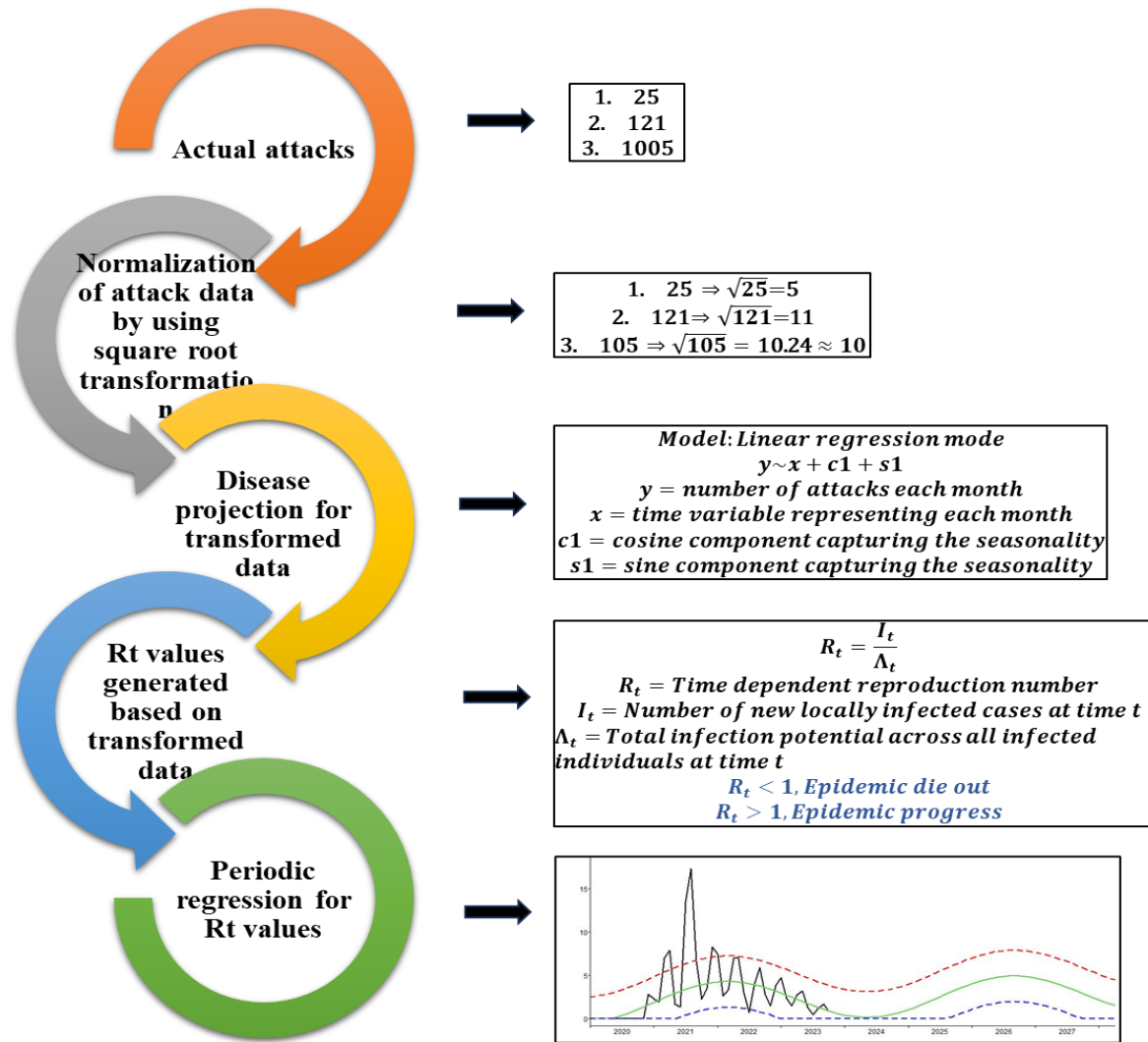
**Animal density:** High animal density increases the likelihood of virus transmission.

**Trade:** Movement and trade of livestock can introduce the virus to new areas.

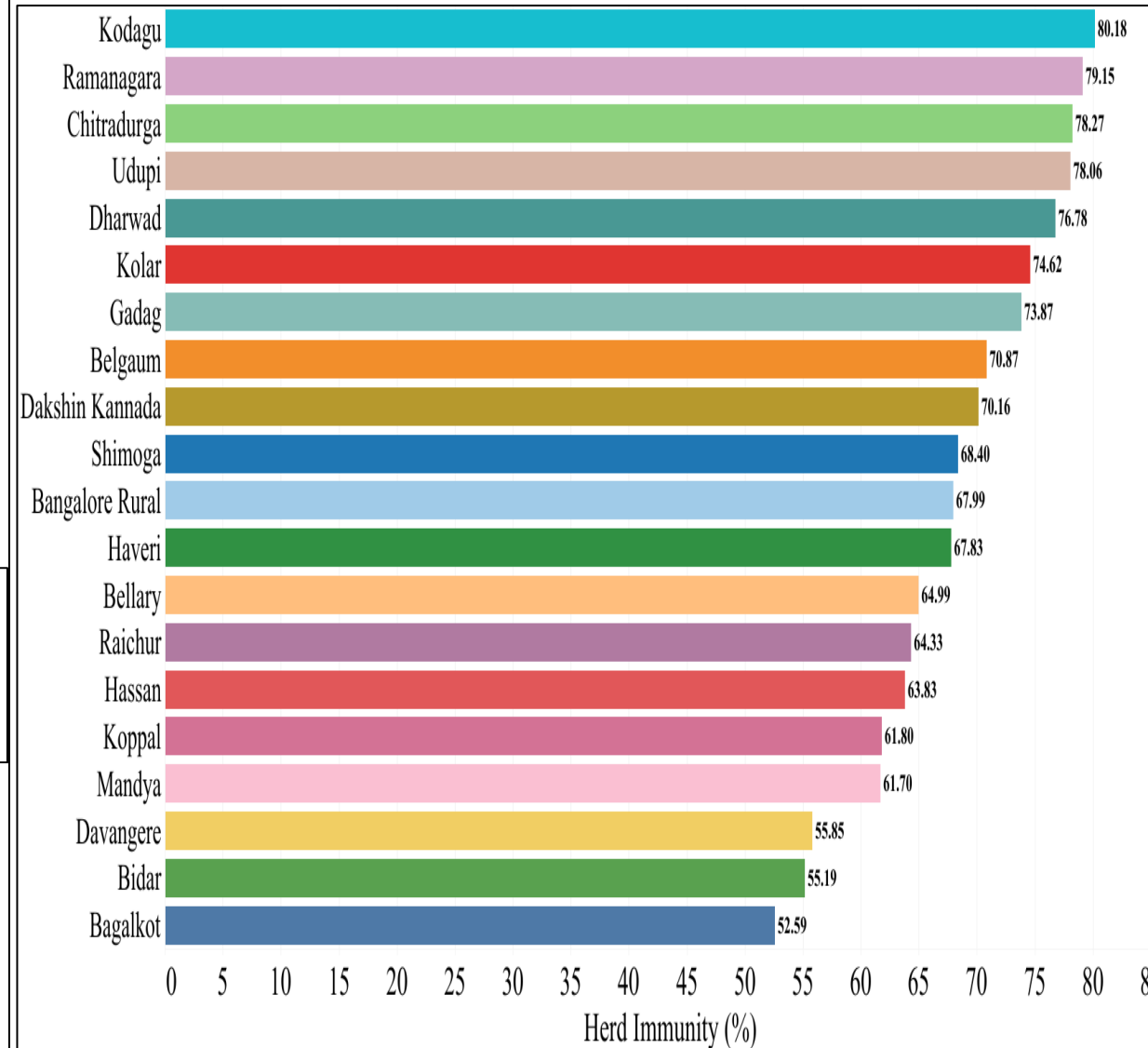
**Grazing:** Areas where animals graze can be sites of virus transmission, especially if shared by infected and susceptible animals. etc..

# Disease data processing

## Periodic regression process

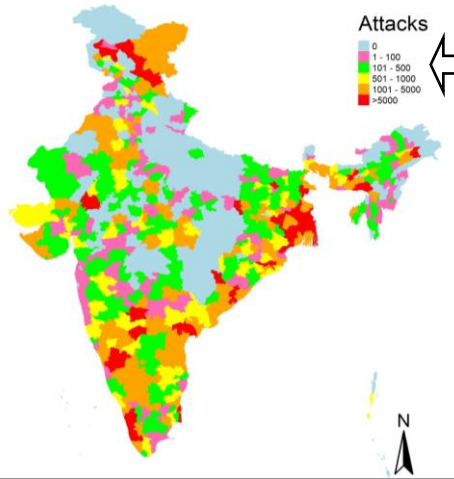


## Herd - level threshold of districts in Karnataka based on seromonitoring (2022-23)



## Disease map of FMD

During 2001-2019



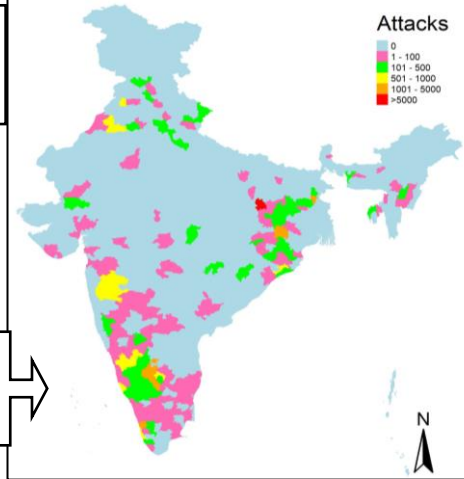
Attacks

Total districts : 441  
Affected/Lakh cattle pop: 545  
Affected/Lakh total pop: 202

Intensity of  
attack has  
reduced

Total districts : 153  
Affected/Lakh cattle pop: 66  
Affected/Lakh total pop: 26

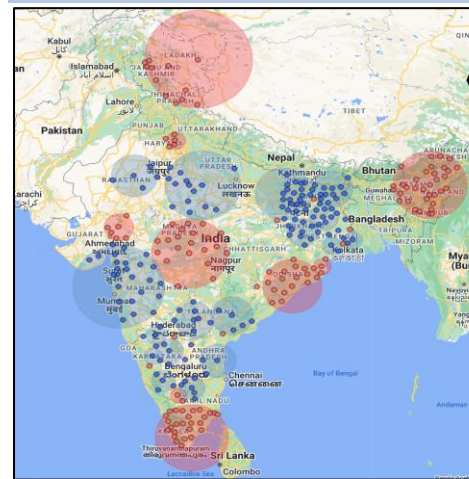
During 2020-2024



Attacks

## Hotspot map of FMD

During 2001-2019

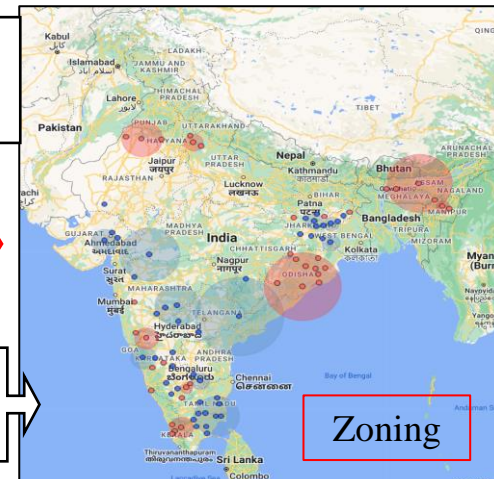


No of high clusters: 17  
No of low clusters : 25  
Maximum radius: 329.06  
Minimum radius: 62.21

Number and  
spread of  
clusters  
reduced

No of high clusters: 16  
No of low clusters : 20  
Maximum radius: 296.24  
Minimum radius: 41.16

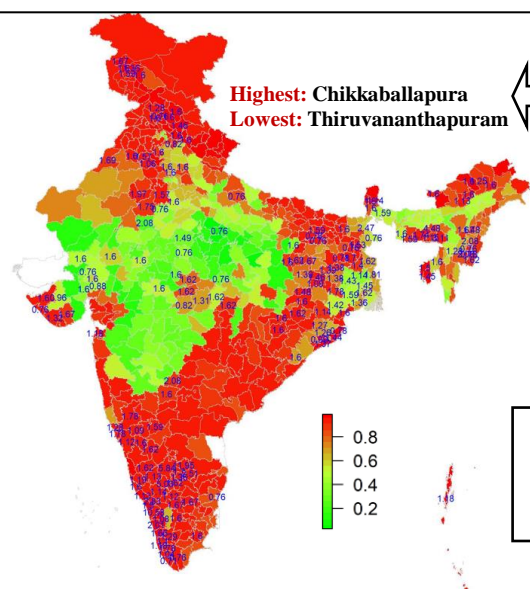
During 2020-2024



Zoning

## Risk map of FMD

During 2001-2019



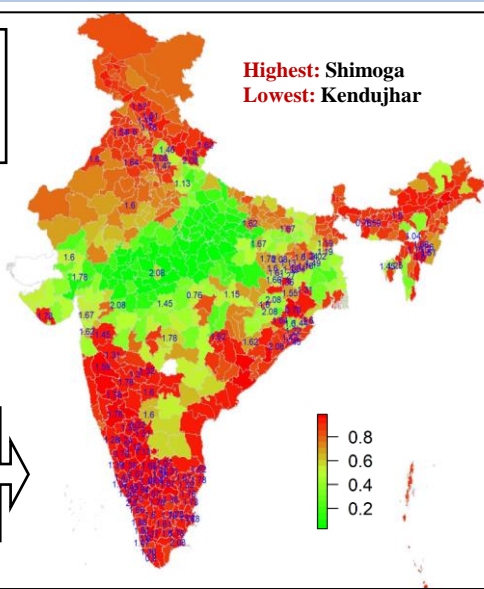
Highest: Chikkaballapura  
Lowest: Thiruvananthapuram

Highest  $R_0$  : 11.9  
Lowest  $R_0$  : 0.71  
Risk area (>0.6): 457

Risk has  
reduced

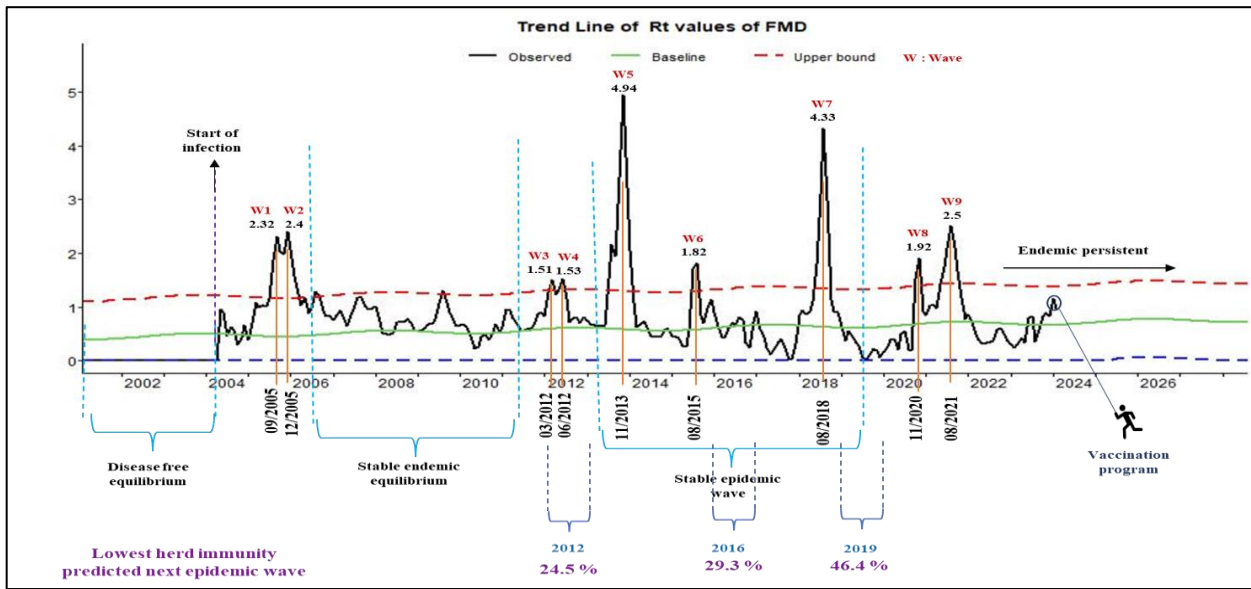
Highest  $R_0$  : 3.79  
Lowest  $R_0$  : 0.76  
Risk area (>0.6): 416

During 2020-2024

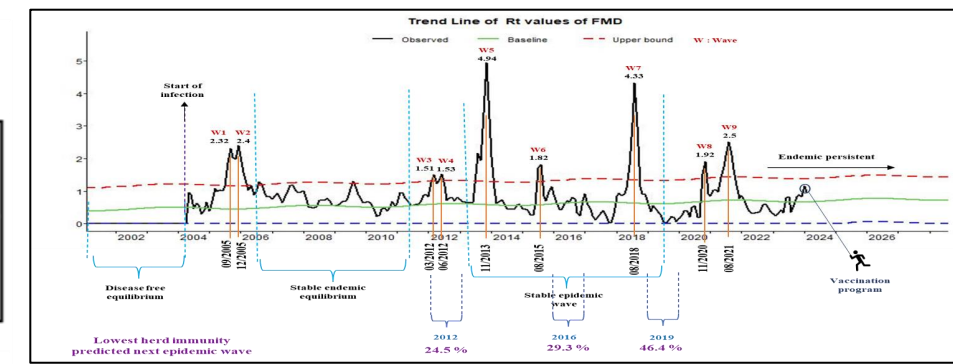
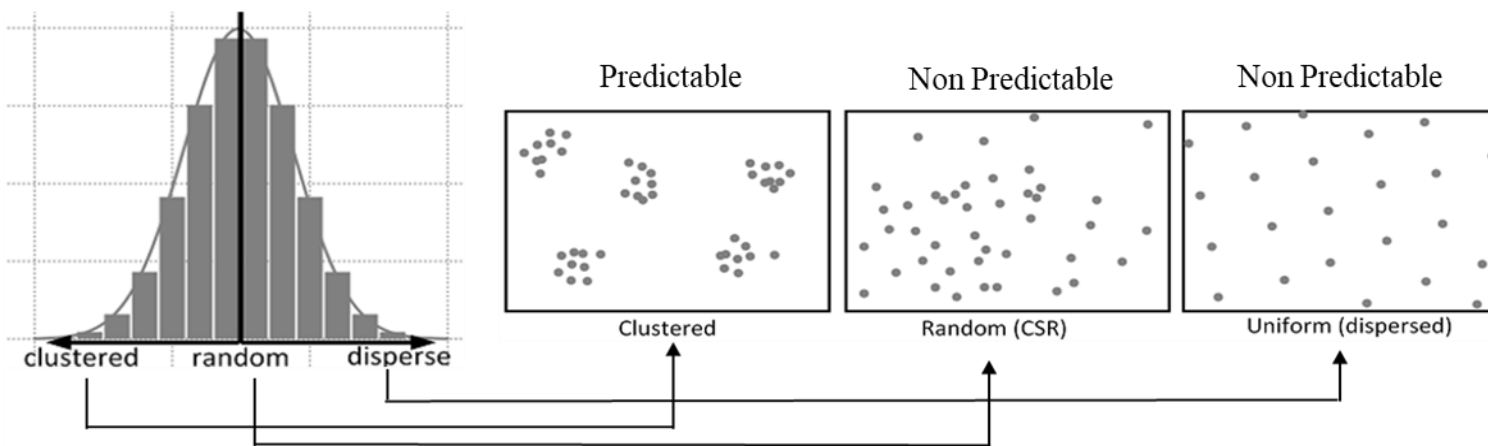


Highest: Shimoga  
Lowest: Kendujhar

## The periodic regression graph of FMD plotted using time-dependent $R_0$ ( $R_t$ ) values

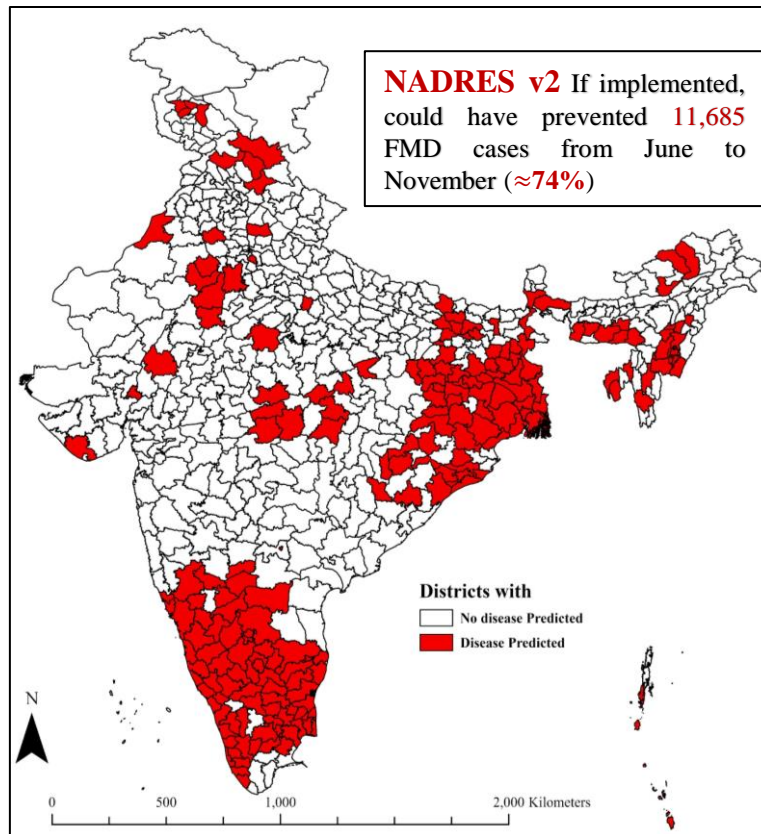




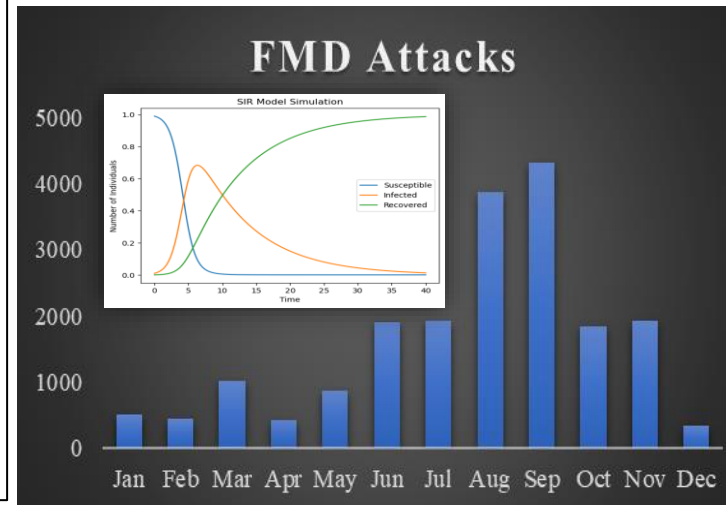


Lowest herd immunity predicted next epidemic wave	2012	2016	2019
	24.5 %	29.3 %	46.4 %

## FMD prediction during 2021



- Total attacks during 2021 : **19363**
- Spreads in : **116** districts
- NADRES v2 predicted : **82** districts (**≈71%**)
- Majority of attacks : **June to November**
- Total attacks in June–Nov : **15791**
- During June–Nov percentage of attacks : **81.5 %**
- Spreads in : **104** districts (Jun–Nov)
- NADRES v2 predicted : **77** districts (**≈74%**)



## Spatial autocorrelation results

