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# From Epidemic to Declining Threat: Mapping Rabies Trends in South Asia, 1990-2019

Bhupendra Meena<sup>1\*</sup>, Bhagchand Meena<sup>2#</sup>, Rahul Shukla<sup>3\*</sup>, Anuj Kumar<sup>4\*</sup>, Shivendra Pratap Singh<sup>5\*@</sup>

\*Department of Statistics

Babasaheb Bhimrao Ambedkar University (A Central University)

Lucknow, U.P., 226025

#Department of Statistics, Central University of Rajasthan , Ajmer, Rajasthan,305817

Authors Email- <sup>1</sup>bhupendrakm57@gmail.com

<sup>2</sup>kkstbjp01@gmail.com

<sup>3</sup>rahul.shukla.stats@gmail.com

<sup>4</sup>anujkmsmath2016@gmail.com

<sup>5</sup>shivendra15.07@gmail.com (@ Corresponding Author)

## Abstract

This study examines rabies prevalence and impact in South Asia from 1990 to 2019, focusing on India as a global epicenter. Despite worldwide public health advancements, rabies persisted as a significant threat, primarily transmitted by stray dogs. Our research utilized a multifaceted approach, analyzing infection rates, mortality figures, and control measure effectiveness to provide a comprehensive understanding of the rabies landscape in South Asia. Key findings reveal the persistent challenge of rabies control in the region, particularly in India, and highlight the critical role of stray dogs in disease transmission. Notably, the study identifies a cautiously optimistic trend: a decline in the rabies death rate across South Asia over the study period. This downward trajectory represents a significant milestone, reflecting the cumulative impact of sustained interventions by health workers, policymakers, and communities. While rabies remains a formidable public health challenge, the declining death rates offer hope for the future. The research concludes that this progress not only highlights the effectiveness of current strategies but also provides valuable insights for rabies control and prevention in other developing regions. These findings underscore the importance of continued efforts and offer a roadmap for further reducing the impact of this deadly disease in South Asia and beyond.

**Keywords:** South ASIA, Joint Point Software, Annual Percent change(APC), Rabies Trend



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## INTRODUCTION

The most common way that rabies is spread by the bite of a rabid animal. Rabies is a preventable viral disease. Rabies is an acute progressive encephalomyelitis caused by any of the viruses from the genus *Lyssavirus*, family *Rhabdoviridae*[6] The rabies virus affects mammal's central nervous systems, which ultimately results in brain disease and death. Although any mammal can contract rabies, the vast majority of cases that are reported to the Centres for Disease Control and Prevention (CDC) each year involve wild animals including bats, raccoons, skunks, and foxes. More than 150 countries and territories are affected by the viral disease rabies,[7][10].which can be prevented through vaccination. Every year, it kills tens of thousands of people, mostly in Asia and Africa, and 40% of them are youngsters under the age of 15. In up to 99% of cases, dogs are responsible for rabies virus transmission to humans. The incidence of rabies in the world is decreasing due to the development of pre- and post-prophylactic vaccines [1]. South Asia comprises the countries of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Depending on the number of cases rabies endemic countries can be categorized into three groups; high (India, Pakistan and Bangladesh), medium (Bhutan, Nepal and Sri Lanka) and low (Afghanistan). Maldives is completely free of rabies[5]. The majority of SA nations are developing nations with modest health budgets. Because of this, the World Health Organisation (WHO) has already emphasised the need for a coordinated and multi-sectoral collaborative approach to reduce rabies in this region while taking into account the economic impact on meeting the Millennium Development Goal (MDG) target. South Asia is regarded as the hot spot for the tourist and travelers. Unfortunately, three big countries (India, Pakistan and Bangladesh) of this region belong to top five rabies endemic countries of the world. Around 55,000 people die of rabies every year globally and 45% of them belong to South and South East Asia[2]. India alone accounts for nearly 60% of rabies deaths in Asia and 35% of deaths globally. Section 2 provides an overview of the global rabies problem. In Section 3, we focus on the specific challenges faced in Southeast Asia. The research methodology is detailed in Section 4, followed by a comprehensive data analysis in Section 5. Section 6 presents the results of our study, while Section 7 offers the final conclusions and implications of our findings.

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## 1. GLOBAL BURDEN OF RABIES

Except for Antarctica, all continents have rabies, with Asia and Africa accounting for more than 95% of all fatalities. However, rabies cases are infrequently recorded, and the registered numbers are far lower than the burden estimate. One of the NTDs, rabies primarily affects populations who are already marginalised, underprivileged, and vulnerable. Although there are effective human rabies vaccines and immunoglobulins, they are frequently difficult to obtain or reach by individuals who need them. With the average cost of rabies post-exposure prophylaxis (PEP) estimated to be US\$ 108 (plus travel expenses and lost income), managing a rabies exposure can be a crippling financial burden for impacted families, whose average daily income may be as low as US\$ 1-2 per person. PEP is given to more than 29 million people annually worldwide[4][9]. According to estimates, this will stop hundreds of thousands of rabies deaths each year. Rabies spread by dogs is projected to cost the world \$8.6 billion a year in economic costs, not to mention the untold psychological agony it causes to people and communities.

## 2. DISEASES BURDEN IN SOUTH ASIA

Rabies is a disease of public health and economic importance in southeast Asia. The annual expenditure due to rabies has been estimated to be more than US\$ 563 million in Asia[8]. Despite rabies being 100% preventable, and despite the South-East Asia Region's substantial progress in driving down the disease's burden in recent years, it remains an issue: More than 26 000 people in the Region succumb to it annually. Eight of the Region's 11 countries account for around 45% of the world's rabies burden[3], with over 1.5 billion people at risk of rabies exposure. More than 6 million patients receive at least one dose of rabies vaccine every year.

### 2.1. MISSION POSSIBLE: REACHING ZERO HUMAN RABIES DEATHS IN SOUTH ASIA AND SOUTH EAST ASIA REGION

An exceptionally deadly virus is rabies. After an incubation period of anywhere between a week and a year, the victim will develop the disease's signature symptoms, including fever, headache, nausea, and death, after just one bite or scratch from an infected animal, which is 99 % of the time a dog. All will be well; no symptoms will appear if prompt post-exposure action is done, including thorough cleaning and wound care, as well as multiple doses of WHO-approved rabies vaccine. However, more intensive

action is required, including improved access to PEP tools, to fulfil the Sustainable Development Goal aim of achieving zero human rabies deaths by 2030. In order to facilitate that, the World Health Organisation (WHO) has organised a meeting in Kathmandu, Nepal, in early May. Participants from rabies-endemic nations from the WHO South-East Asia, WHO Western Pacific, and WHO Africa regions will be present, as well as representatives from organisations that support global health initiatives like Gavi, the Vaccine Alliance, the Food and Agriculture Organisation of the United Nations (FAO), and the World Organisation for Animal Health (OIE). Together, they will examine how to improve access to PEP and speed up the fight against rabies. That requires implementing a variety of straightforward yet very effective strategies, as the Global Strategic Plan to End Human Deaths from Dog-Mediated Rabies by 2030 and as the South-East Asia Region's own Strategic Framework has long stressed, that means implementing a range of simple though highly effective policies.

**Table 1. Distribution of human rabies cases per year in South Asia region[2]**

country	Estimated No. of Human Rabies cases
Afghanistan	30-35
Pakistan	2500-5000
Bangladesh	2200-2500
India	18000-20000
Bhutan	17-20
Nepal	10-100
Sri Lanka	20-30
Maldives	0 (free from Rabies)

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### **3. MATERIALS AND METHODS**

#### **3.1. SOURCE OF DATA**

Data for the disease burden of rabies were derived from the online data source tool, the Global Health Data Exchange query tool (<http://ghdx.healthdata.org/gbd-results-tool>), which is an ongoing global collaboration that uses all available epidemiological data to provide a comparative assessment of health loss from 369 diseases across 204 countries and territories (GBD 2019 Diseases and Injuries Collaborators, 2020). We acquired data on the incidence, death, prevalence and DALYS and the estimated annual percentage change of rabies from 1990 to 2019 from GBD 2019 database.

#### **3.2. JOINTPOINT REGRESSION SOFTWARE:**

With the help of joinpoint regression analyze the rabies trend in south Asia. The joinpoint Regression is a free software developed by the National Cancer Institute (NCI) in the United States. It provides a user-friendly interface for performing joinpoint regression analysis and offers options to estimate the number of joinpoint, calculate annual percentage change, and visualize the results.

### **4. DATA ANALYSIS**

A secondary systematic descriptive analysis was conducted regarding the burdens of rabies in South Asia from 1990 to 2019, and the findings were further investigated. The incidence, deaths, prevalence and DALYs of rabies in both sexes and different age groups were also compared. Uncertainty intervals were defined as the 2.5th and 97.5th values of posterior distributions.

All data management was performed using the join point regression software and using Microsoft Excel. A p value of less than 0.05 was regarded as statistically significant.

### **5. RESULTS**

#### **5.1. RABIES DEATHS BURDEN IN SOUTH ASIA**

##### **5.1.1. Trend of overall crude death rate for both gender of circulatory diseases rabies in South Asia from 1990 to 2019**

Trend of crude death rate for both gender for the period 1990 to 2019 shown in the given figure 1

Figure 1

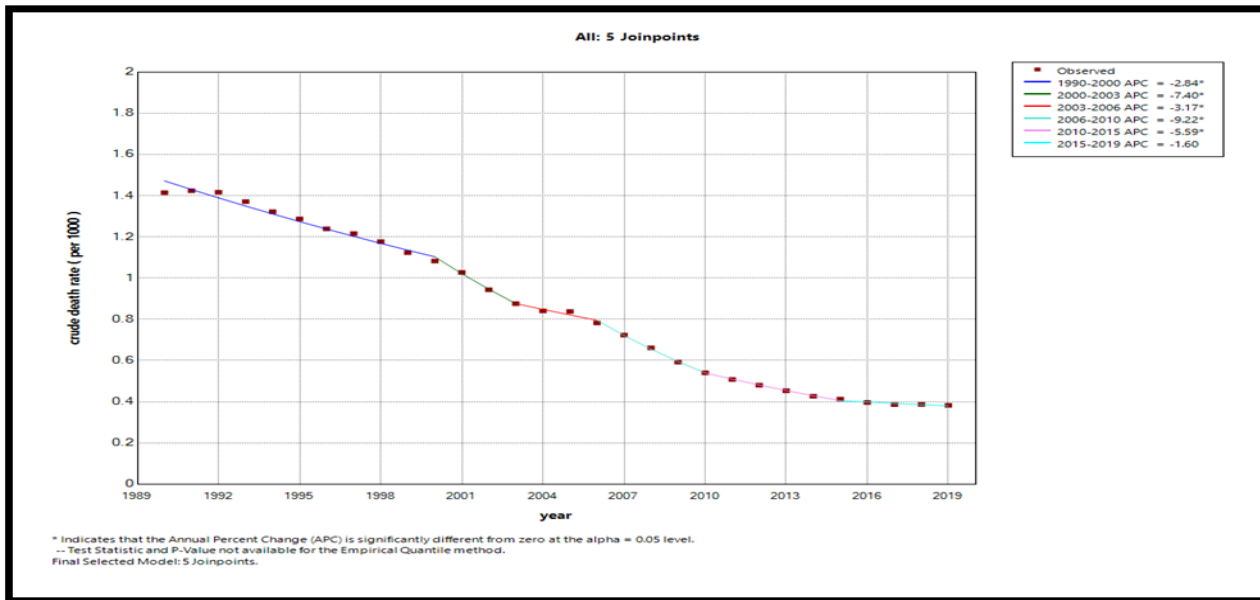


Figure 1 shows the trend of the crude death rate for both sexes for circulatory diseases rabies in South Asia from 1990 to 2019. From the figure a downward trend can be clearly observed in both gender cases during the period 1990 to 2019. It is also observed that from 2016 to 2019 crude death rate for both genders shown constant in nature. The chronological trend in both gender cases revealed that there is a significant decrease in crude death rate of circulatory diseases between 1990 to 2019. The Annual percentage change of crude death rate for both genders shown in the given table as follows-

**Table 2: Crude death rate for both genders during 1990 to 2019 with APC**

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	P-Value
1	1990	2000	-2.8408*	-3.0686	-2.5398	< 0.000001
2	2000	2003	-7.3997*	-8.1680	-6.0766	< 0.000001
3	2003	2006	-3.1721*	-4.5482	-2.2578	0.000156
4	2006	2010	-9.2236*	-10.4686	-8.4277	< 0.000001
5	2010	2015	-5.5861*	-6.8826	-4.3088	0.000001
6	2015	2019	-1.5978	-2.7214	0.4421	0.051413

The crude death rate for both genders during 1990 to 2019 with APC shown in table 2. The chronological trend in both gender cases revealed that there is a significant decrease in crude death rate of circulatory diseases between 1990 to 2019, reflected in APC for 2006 to 2010 APC -9.2236 (95%CI -10.46 to -8.42), for 2010 to 2015 APC -5.9(95%CI -7.1 to -4.7), for 2000 to 2003 -7.39 (95%CI -8.16 to -6.07).

### 6.1.2 Trend of crude death rate for male genders of circulatory diseases rabies in India from 1990 to 2019

Trend of crude death rate for male gender for the period 1990 to 2019 shown in the given figure 2

Figure 2

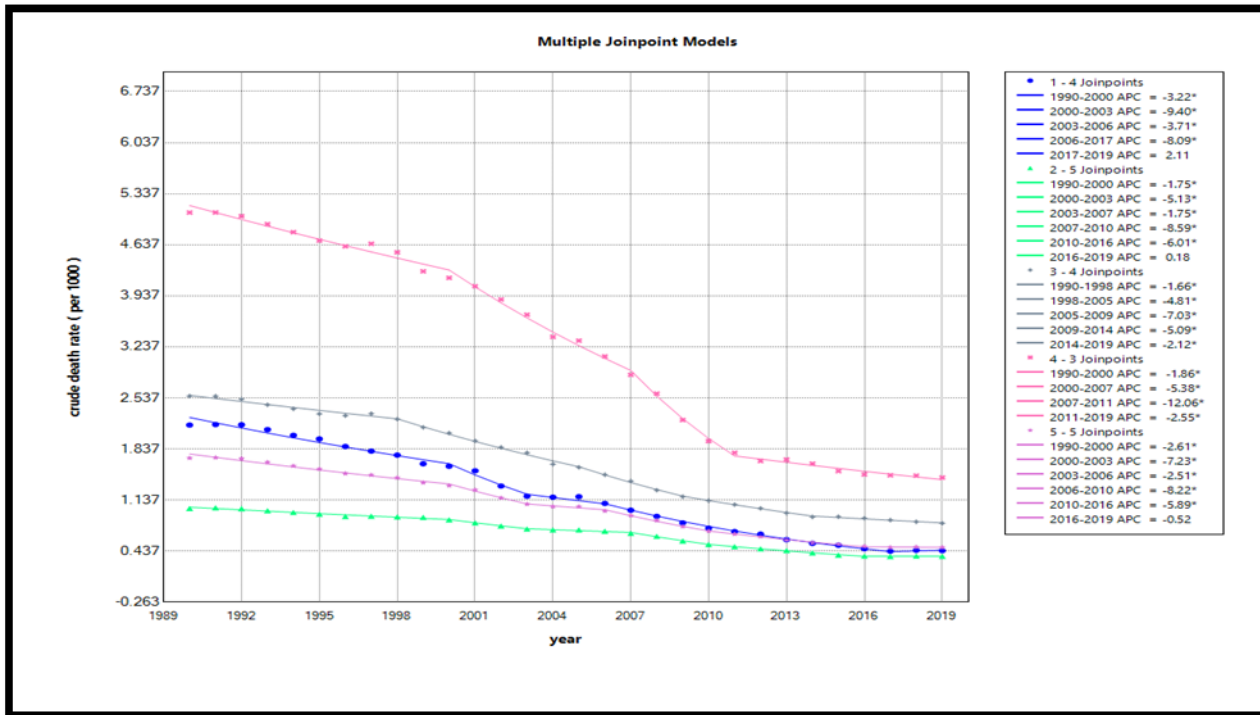


Figure 2 shows the trend of the overall crude death rate for male for circulatory diseases rabies in South Asia from 1990 to 2019. From the figure a downward trend can be clearly observed in male gender cases during the period 1990 to 2019. It shows multiple join points in male cases of crude death rate of circulatory diseases rabies. The chronological trend in male there is a significant decrease in overall crude death rate of circulatory diseases rabies from 1990 to 2019 reflected in APC. The Annual percentage change of crude death rate for male gender shown in the given table as follows-

**Table 3 :Crude death rate for male gender during 1990 to 2019 with APC**

Cohort	Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	P-Value
1 - 4 Joinpoints	1	1990	2000	-3.2239*	-3.7252	-2.5563	0.000022
1 - 4 Joinpoints	2	2000	2003	-9.3950*	-10.6771	-5.9328	0.000006
1 - 4 Joinpoints	3	2003	2006	-3.7149*	-6.5908	-2.2702	0.005900
1 - 4 Joinpoints	4	2006	2017	-8.0892*	-9.0674	-7.7391	< 0.000001
1 - 4 Joinpoints	5	2017	2019	2.1094	-3.2272	5.1292	0.321023
2 - 5 Joinpoints	1	1990	2000	-1.7536*	-1.9580	-1.4758	< 0.000001
2 - 5 Joinpoints	2	2000	2003	-5.1273*	-5.7545	-3.9454	< 0.000001
2 - 5 Joinpoints	3	2003	2007	-1.7460*	-2.4036	-0.6686	0.002815
2 - 5 Joinpoints	4	2007	2010	-8.5915*	-9.2600	-7.3269	< 0.000001
2 - 5 Joinpoints	5	2010	2016	-6.0053*	-6.4201	-5.1539	< 0.000001
2 - 5 Joinpoints	6	2016	2019	0.1840	-0.9467	2.3045	0.789819
3 - 4 Joinpoints	1	1990	1998	-1.6602*	-2.0884	-1.1966	0.000022
3 - 4 Joinpoints	2	1998	2005	-4.8133*	-5.2071	-3.8945	< 0.000001
3 - 4 Joinpoints	3	2005	2009	-7.0349*	-7.9575	-5.2533	< 0.000001
3 - 4 Joinpoints	4	2009	2014	-5.0861*	-6.0638	-3.6385	< 0.000001
3 - 4 Joinpoints	5	2014	2019	-2.1170*	-2.7750	-0.8843	0.000414
4 - 3 Joinpoints	1	1990	2000	-1.8555*	-2.3291	-1.1934	0.000010
4 - 3 Joinpoints	2	2000	2007	-5.3836*	-6.2446	-4.6517	< 0.000001
4 - 3 Joinpoints	3	2007	2011	-12.0649*	-14.0936	-10.6956	< 0.000001
4 - 3 Joinpoints	4	2011	2019	-2.5527*	-3.1405	-1.7613	< 0.000001
5 - 5 Joinpoints	1	1990	2000	-2.6145*	-2.8533	-2.2939	< 0.000001
5 - 5 Joinpoints	2	2000	2003	-7.2304*	-8.0022	-5.8656	< 0.000001
5 - 5 Joinpoints	3	2003	2006	-2.5128*	-3.9522	-1.5926	0.002159
5 - 5 Joinpoints	4	2006	2010	-8.2196*	-9.2873	-7.4227	< 0.000001
5 - 5 Joinpoints	5	2010	2016	-5.8888*	-6.6189	-4.6600	< 0.000001
5 - 5 Joinpoints	6	2016	2019	-0.5233	-2.0169	2.1394	0.560419

The crude death rate for male gender during 1990 to 2019 with APC shown in Table 3. The chronological trend in male gender cases revealed that there is a significant decrease in the crude death rate of circulatory diseases between 1990 to 2019, reflected in APC for 2007 to 2011 APC -12.06 (95% CI -14.09 to -10.69).

### 6.1.3 Trend of overall crude death rate for female gender of circulatory diseases rabies in India from 1990 to 2019

Trend of crude death rate for femlae gender for the period 1990 to 2019 shown in the given figure



Figure 3

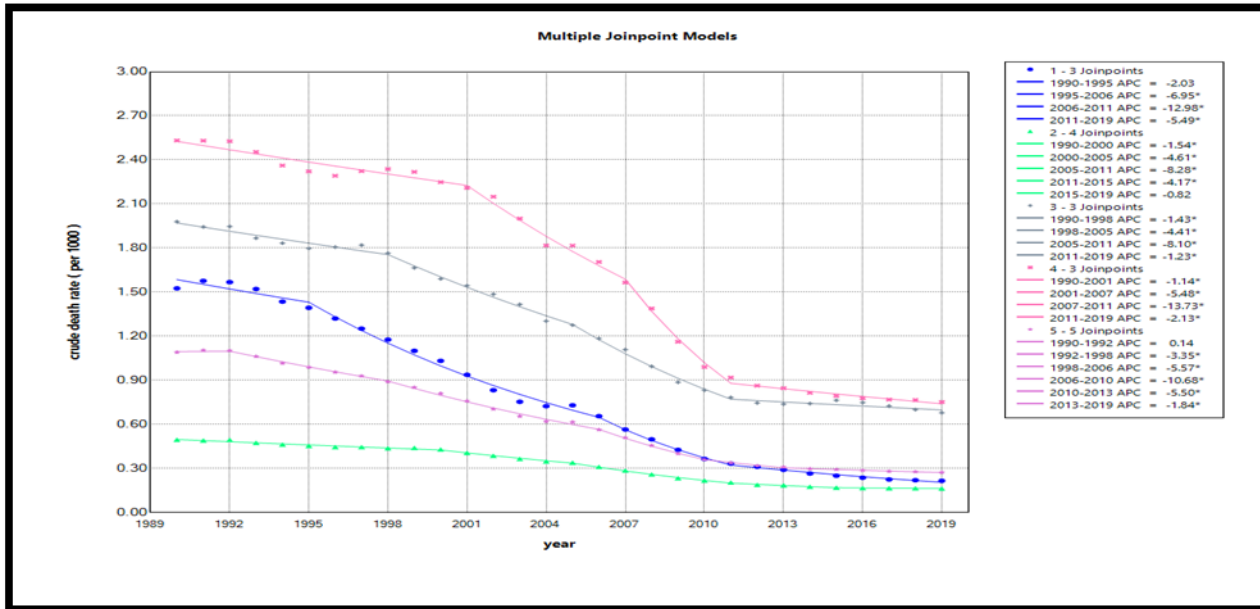


Figure 3.1.2 shows the trend of the overall crude death rate for female for circulatory diseases rabies in South Asia from 1990 to 2019. From the figure a downward trend can be clearly observed in female gender cases during the period 1990 to 2019. It shows multiple join points in male cases of crude death rate of circulatory diseases rabies. The chronological trend in male there is a significant decrease in overall crude death rate of circulatory diseases rabies from 1990 to 2019 reflected in APC. The Annual percentage change of crude death rate for male gender shown in the given table as follows-

**Table 4: Crude death rate for male gender during 1990 to 2019 with APC**

Cohort	Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	P-Value
1 - 3 Joinpoints	1	1990	1995	-2.0261	-3.7696	1.0196	0.112372
1 - 3 Joinpoints	2	1995	2006	-6.9541*	-7.6379	-6.3602	< 0.000001
1 - 3 Joinpoints	3	2006	2011	-12.9760*	-16.0720	-11.3889	< 0.000001
1 - 3 Joinpoints	4	2011	2019	-5.4943*	-6.3998	-4.2817	< 0.000001
2 - 4 Joinpoints	1	1990	2000	-1.5435*	-1.8157	-1.2404	0.000001
2 - 4 Joinpoints	2	2000	2005	-4.6090*	-5.5185	-3.5436	< 0.000001
2 - 4 Joinpoints	3	2005	2011	-8.2785*	-9.3246	-7.6342	< 0.000001
2 - 4 Joinpoints	4	2011	2015	-4.1724*	-7.0618	-2.7953	0.000508
2 - 4 Joinpoints	5	2015	2019	-0.8160	-1.8772	1.1153	0.270518
3 - 3 Joinpoints	1	1990	1998	-1.4339*	-1.9472	-0.7177	0.000369
3 - 3 Joinpoints	2	1998	2005	-4.4142*	-5.2491	-3.6418	< 0.000001
3 - 3 Joinpoints	3	2005	2011	-8.0958*	-9.8862	-7.2895	< 0.000001
3 - 3 Joinpoints	4	2011	2019	-1.2350*	-1.8417	-0.4266	0.002071
4 - 3 Joinpoints	1	1990	2001	-1.1436*	-1.5045	-0.7241	0.000013
4 - 3 Joinpoints	2	2001	2007	-5.4774*	-6.5059	-4.5787	< 0.000001
4 - 3 Joinpoints	3	2007	2011	-13.7284*	-15.7267	-12.1484	< 0.000001
4 - 3 Joinpoints	4	2011	2019	-2.1335*	-2.7860	-1.3289	0.000009
5 - 5 Joinpoints	1	1990	1992	0.1386	-2.4307	1.9813	0.895314
5 - 5 Joinpoints	2	1992	1998	-3.3538*	-5.3568	-2.8354	0.000044
5 - 5 Joinpoints	3	1998	2006	-5.5703*	-6.3991	-5.1638	0.000004
5 - 5 Joinpoints	4	2006	2010	-10.6754*	-11.7287	-6.9963	< 0.000001
5 - 5 Joinpoints	5	2010	2013	-5.4956*	-8.3275	-2.8364	0.000864
5 - 5 Joinpoints	6	2013	2019	-1.8420*	-2.3813	-0.9095	0.000442

The crude death rate for male gender during 1990 to 2019 with APC shown in Table 4. The chronological trend in female gender cases revealed that there is a significant decrease in the crude death rate of circulatory diseases between 1990 to 2019, reflected in APC for 2007 to 2011 APC - 13.72 (95%CI -15.72 to -12.14).

## 6. Conclusion

In the shadow of progress, a silent killer stalked the streets of South Asia from 1990 to 2019. Rabies, a merciless virus that ravages the nervous system, found its primary vector in the region's ubiquitous stray dogs. As nations around the world made strides in public health, India grappled with its unenviable position as a global epicenter for this ancient scourge. Unraveling the true impact of rabies required a multifaceted approach. Researchers delved into a trove of data, piecing together a complex puzzle of infection rates, mortality figures, and the efficacy of control measures. Their findings painted a nuanced picture of a public health battlefield where small victories were hard-won. Yet, amidst the grim statistics, a beacon of hope emerged. The study's conclusion revealed an encouraging trend: the



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tide of rabies deaths across South Asia appeared to be receding. This downward trajectory in the rabies death rate, while cautiously optimistic, serves as a testament to the relentless efforts of health workers, policymakers, and communities united in their fight against this formidable foe.

The discovery that South Asia's rabies death rate is trending downward marks a significant milestone in the region's public health journey. It suggests that despite the enormous challenges, the concerted efforts to combat this deadly disease are beginning to bear fruit. This trend not only offers hope for the future but also provides valuable insights into effective strategies for rabies control and prevention across the developing world.

**Conflict of Interest:**No author have conflict of Interest

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