

# Educational Emergency Treatment Model: An Adaptive Response To Education And Multivariate HMM Model To Latent Crisis State In Rural Rajasthan During COVID-19

Soorya Surendran<sup>1\*</sup>, Neeraja S<sup>2</sup>, Dr. Georg Gutjahr<sup>3</sup>, Radhika Menon<sup>4</sup>, Dr. Prema Nedungadi<sup>5</sup>

<sup>1</sup>PhD Scholar, School of Computing, Amritapuri, Amrita Vishwa Vidyapeetham Kerala, India. [sooryas@am.amrita.edu](mailto:sooryas@am.amrita.edu)

<sup>2</sup>Department of Mathematics Amrita Vishwa Vidyapeetham Kerala, India. [amritarite.neerajats@gmail.com](mailto:amritarite.neerajats@gmail.com)

<sup>3</sup>Amrita CREATE, Amrita Vishwa Vidyapeetham Kerala, India. [georg.gutjahr@gmail.com](mailto:georg.gutjahr@gmail.com)

<sup>4</sup>Amrita CREATE, Amrita Vishwa Vidyapeetham Kerala, India. [amritarite.rmenon@gmail.com](mailto:amritarite.rmenon@gmail.com)

<sup>5</sup>Amrita CREATE, Amrita Vishwa Vidyapeetham Kerala, India. [prema@amrita.edu](mailto:prema@amrita.edu)

\*Corresponding Author: Soorya Surendran

[sooryas@am.amrita.edu](mailto:sooryas@am.amrita.edu) +91-9947234430

**Citation:** Soorya Surendran et al. (2024), Educational Emergency Treatment Model: An Adaptive Response To Education And Multivariate HMM Model To Latent Crisis State In Rural Rajasthan During COVID-19, *Educational Administration: Theory and Practice*, 30(5), 10855-10865

Doi: 10.53555/kuey.v30i5.4850

## ARTICLE INFO ABSTRACT

In this study, we propose an emergency education model that utilizes adaptive decision-making to navigate different intervention states. The model was implemented in an afterschool program in Harirampura, India, which transitioned from in-person teaching to various forms of remote and distance learning during the COVID-19 pandemic. To assess the effectiveness of this adaptive approach, the study employs a multivariate Hidden Markov Model to compare the latent crisis states caused by COVID-19. This analysis expands on Karalis' original Effective Educational Emergency and Treatment (MEET) model. Additionally, the study evaluates the impact of the adaptive approach by comparing standardized Annual Status of Education Report scores in Harirampura with those in other rural areas of Rajasthan before and after the pandemic. The results of the analysis demonstrate a strong correlation between the intervention states implemented and the observed latent crisis states during the pandemic. This study indicates that the adaptive MEET model effectively mitigated the negative effects of the COVID crisis on education outcomes in Harirampura. Furthermore, these results support the applicability of the model to the address of other educational disruptions stemming from natural or manmade disasters.

**Keywords:** Adaptive MEET model, Elementary education, multivariate Hidden Markov Model

## Introduction

The COVID-19 pandemic caused widespread school closures, disrupting global education systems and depriving millions of students of learning opportunities (Simulating the Potential Impacts of COVID-19, 2020). The pandemic has had severe consequences, calling for exigent, transformative educational systems at all levels that prioritize learning outcomes and the well-being of students. According to UNESCO's ministries of education (UNESCO, 2023), over 600 million children and adolescents worldwide lack basic skills in reading and math, underscoring the importance of literacy for personal development and socio-economic progress.

The Global Proficiency Framework (GPF) was established to address educational challenges, outlining minimum proficiency levels in reading and mathematics for grades one through nine (USAID, 2019). GPF serves as a universal metric for the assessment of learner's achievements across countries, facilitating comparative assessments and the appraisal of key parameters like the United Nations' Sustainable Development Goal (SDG) 4 (USAID, 2019). The SDG 4 indicator measures the percentage of students meeting global proficiency standards (able to build their literacy and numeracy skills) and enables the identification of

areas for educational improvement. Aligned with SDG 4, GPF plays a central role in the promotion of quality higher education worldwide, intended to provide inclusive and equitable education.

India has integrated the GPF into its education system through the National Achievement Survey (NAS) (Pandey, 2018), which facilitates global proficiency in education and the identification of areas for improvement. Furthermore, India has launched initiatives, such as Sarva Shiksha Abhiyan (SSA), Rashtriya Madhyamik Shiksha Abhiyan (RMSA), Padhe Bharat Badhe Bharat (PBBB), Beti Bachao, Beti Padhao (BBBP), Rashtriya Avishkar Abhiyan (RAA), and the National Education Policy (NEP) 2020, to achieve SDG 4 and ensure quality education for all children in the country. All these programs are geared to guarantee equitable access to education and promote inclusive learning environments (Pandey, 2018).

### **The emergence of the COVID-19 pandemic**

The emergence of COVID-19 in Wuhan, China, in December 2019 posed a formidable global challenge, affecting people's health and well-being and disrupting various sectors of life, including social, economic, and education. COVID-19 has wrought disruptions across the globe - travel restrictions (Chinazzi et al., 2020), school closures (Viner et al., 2020), economic recession (Fernandes, 2020), political upheavals (Barrios, 2020), lurking discriminatory policies (Habbat et al., 2022), besides disinformation and conspiracy campaigns (Enitan et al., 2020). Education was the most unsettled sector. The pandemic triggered closures of educational institutions and the proliferation of online learning options (Joseph et al., 2020). Unfortunately, it also revealed underlying disparities in ensuring equitable access to education, disproportionately affecting students from marginalized communities and low-income households. UNESCO reported (UNESCO, 2023) that the education of over 1.5 billion students across 165 countries was derailed by COVID-19-triggered school closures. The pandemic underscored the need to address global disparities prevalent in health and education.

### **Large-scale learning assessments Household survey – ASER**

The Annual Status of Education Report (ASER) (ASER, 2018) is an annual audit of a large-scale household survey conducted across Indian states to assess the status of education and learning progress among children in rural areas. The survey, covering children aged (3-16) years, assesses their skills in reading, writing, and basic arithmetic.

ASER appraises the ability of children to read English and a regional language through a simple four-task reading test that includes identification of commonly used letters as the first task, familiar words as the second task, and words containing in short paragraphs as Standard-I level and Standard-II level text containing the ability to read short stories. In the assessment of arithmetic skills, four tasks cover child recognition of numerals from 1 to 9, number recognition from 10 to 99, solving two-digit numerical subtraction problems, and 3-digit by 1-digit numerical division problems (ASER, 2018). The child is marked at the highest level when they attain all eight tasks comfortably.

Prior to the onset of COVID-19, ASER tests were conducted at home rather than in schools, including children who attended private schools, those who were not enrolled in school, and those who happened to be absent from school on the day of the assessment (ASER, 2018). During the COVID-19 pandemic, ASER conducted its tests by phone surveys (Kumar, 2020). The ASER 2022 study (ASER, 2022) reported a major decline for most grades in children's basic reading and arithmetic skills compared to the ASER 2018. This downturn can be attributed to the sudden shift from traditional classroom settings to online or remote learning sessions. Many rural areas in India lack the required infrastructure to support online education, and the detrimental effects of COVID-19 on rural education in India are vividly demonstrated in ASER reports from 2020 to 2022. The survey of 2020 indicated that 20 % of rural children had no textbooks at home, and 27 % of children with smartphones could reliably access the internet for their studies at the national level (ASER, 2020; ASER, 2021).

### **Rajasthan**

Rajasthan is a densely populated state, with about three-fourths of its residents living in rural settlements. The state faces numerous challenges of poverty, illiteracy, and outdated healthcare infrastructure. Along with Bihar, Madhya Pradesh, and Uttar Pradesh, Rajasthan is a BIMARU state (Pingale et al., 2014; Som et al., 2014) that lags in economic growth, healthcare, and education. One of the main reasons for Rajasthan's membership in the BIMARU group is its low educational standards and poor literacy. Studies (Som and Mishra, 2014) reveal that the Government of Rajasthan has been unable to deliver primary education to disadvantaged sections of the society, including the scheduled tribes (ST), scheduled caste (SC), women, and communities settled in remote areas (Som, 2014; Bhasin, 2017; Kumar, 2023).

The state has a tribal population of over 9 million. Tribal communities in Rajasthan are distinguished by their customs, culture, festivals, and trades. Bhils and Minas are the two major tribes in Rajasthan. Education is not a priority for these tribal communities; about 47.8 % of the Mina people are illiterate, and families rely heavily on their children's supplemental income to support the household (Misra and Kapoor, 2002).

### **COVID-19 Pandemic in Rajasthan**

The pandemic has affected educational institutions and students in multiple ways since the spread of COVID-19 in March 2020 in the state. The closures of educational institutions were repeatedly extended many times,

which superseded online learning as the new educational norm. The abrupt change in learning format drastically affected students and teachers alike, primarily in rural Rajasthan. Studies (Luhach et al., 2022) reported that rural schools were more disrupted than urban schools, hamstrung by outdated infrastructure and the inability of legacy facilities to sustain web-based learning. The digital divide has been consequential; not all teachers felt at ease with the precipitous transition from face-to-face learning to virtual or web-based learning (Panakaje et al., 2022).

### **Educational Crisis**

When it comes to calamitous health crises, COVID-19 is the most recent example; other pandemics have had a serious impact on education systems, which include the influenza outbreak (McGuire L., 2007) and the Ebola outbreak (Haogen et al., 2021). Armed conflicts often lead to crises in education. Armed conflicts in Nepal (Silwal, 2016), abject poverty and violence against educational opportunities for younger girls and women in the war-torn areas of Afghanistan by Burde and Khan (Burde and Khan, 2016), and chaotic education of Syrian refugees at schools in Istanbul by (Aydin and Kaya, 2017) are some examples of educational crises caused by armed conflicts.

Another form of educational crisis evolves from natural calamities. Australia endured numerous natural disasters, including Victorian bushfires in 2009, Queensland floods in 2010-2011, and cyclone Yasi in 2011. (LeBrocque et al., 2017) discussed the consequential burden that descended on educational systems and pinpointed the exigence of trauma-informed teacher training. In early August 2018, Kerala witnessed an unprecedented deluge of rainfall triggered by a low-pressure system followed by a monsoonal depression a few days later, which resulted in catastrophic floods causing 400 human deaths, displacing 1.4 million people, and devastating over 75 % of the 1,259 out of 1,664 villages (Hunt and Menon, 2020). The floods wreaked substantial structural damage to civic infrastructure, including schools, and month-long closures of schools ensured 25,000 children were out of gear.

In order to alleviate pressure on healthcare systems inflicted by COVID-19, many countries opted to temporarily shut down schools, enabling the enforcement of social distancing measures (Mian A, and Khan S, 2020) and obligated educational institutions to adopt alternative methods for learning in digital platforms such as Emergency Remote Teaching (ERT) and Virtual Learning (VL) in schools, colleges, and universities (Anthony and Noel, 2021).

In India, various Crisis Management Teams operate at different levels under different administrative sectors. The National Crisis Management Committee (Das P, 2012) is responsible for managing and responding to national-level emergencies and disasters, State Disaster Management Authority and the District Disaster Management Authority (National Disaster Management Authority, 2009) are responsible for managing and responding to disasters at the state and district levels, respectively. Their primary function is the preparation and implementation of disaster management plans, identifying potential risks, and coordinating with agencies and stakeholders for effective disaster management.

### **MEET – A Model for Educational Emergency Treatment**

A crisis management model is a conceptual framework that includes all aspects of preparation, prevention, coping, and rescue recovery from a crisis. A comprehensive review of events from an educational perspective reveals that a few crisis managements models have been developed specifically for education. The Model for Effective Educational Emergency and Treatment (MEET), which Karalis introduced in 2020, is an illustration of such a model. Karalis's model deals with the restoration of educational functions during post-emergency periods, comprised of the following phases: Setup of a Response Team, Situation and Context Analysis, Shaping the Response, Implementation, Communication, and Evaluation.

Managing a crisis obligates the involvement of domain experts; it is expected that the response team (RT) members have similar fields and levels of specialization; their overall levels of expertise, to a large extent, determine the success of the plan drawn to address the crisis. The 'Setup of an RT' phase emphasizes the domains of expertise required for the composition of the RT. The 'Situation and context analysis' phase underlines the significance of conducting a comprehensive evaluation of a crisis incident. The 'Shaping the response' phase discusses the relevance of determining the components of the proposed solution for rescue and recovery from a crisis. The 'Implementation' mechanism is reasonable for any educational organization, as this phase demands improvements and corrective interventions.

The actions involved in the implementation phase are not always serial and are often required to be repeated or implemented concurrently. This phase includes the conduct of courses for a representative set of teachers (pilot tests), the training of teaching staff, the development of training materials, monitoring mechanisms, and support infrastructure.

Karalis's proposed scheme for the crisis management model includes two essential entities: communication and evaluation. Communication is crucial in crisis management, which involves the construction of meaning, sharing an interpretation of the lead or consistent understanding between information senders/receivers, audiences, the public, and stakeholders. The 'Evaluation' phase requires an effective feedback channel between the implementation and evaluation teams.

This paper aims to analyze the impact of COVID-19 on child education at Harirampura, a rural village in the state of Rajasthan, during the pandemic and extend Karalis's MEET model by allowing the adaptive selection of interventions. Against the backdrop descriptions in the preceding sections, the paper outlines; Materials and Methods, Results, Discussion, and Conclusion.

### **Materials and Methods**

This study examined the academic achievements of school-going children in Grades - I, II, and III in Harirampura village, Sawai Madhopur district, Rajasthan, during the COVID-19 lockdown period, January 2020 through April 2022. The population is tribal and belongs to the Mina community.

For each test subject (i.e., a child in school) involved in this study, demographic characteristics such as sex, age, and school grade were collected. Other parameters explored in the study included the actual severity of COVID-19-affected victims, their perceived severity, and their social behaviour in the study area. COVID death cases were considered an indicator of the actual severity; re-tweet counts of Twitter posts as a measure of perceived severity, attendance counts of children as a measure of social behavior; and government orders (directives) as a measure of external restrictions imposed to contain the spread of coronavirus. The Hidden Markov model was used to find the hidden states during the pandemic, and finally, educational outcomes for the children were assessed before and after the pandemic.

### **Formulation of the Adaptive MEET Model**

The Amrita Rural India Technology-aided Education [RITE] (Gutjahr et al., 2019) is a technology-based educational outreach drive by the Amrita Center of Research in Analytics, Technology, and Education [CREATE] (Nedungadi et al., 2018) of Amrita Vishwa Vidyapeetham. The RITE program was formally launched in September 2013, with the aim of providing quality inclusive education and promoting awareness of health, nutrition, sanitation, and gender equality in the rural communities of India. Amrita RITE offers free tablet-based after-school tutoring for school-going students, Grades 1 to 12, and adult literacy training to residents in isolated, rural areas of India. These tablets contain apps that focus on reading and writing and improve math skill ability for the younger grades.

In order to formulate our adaptive MEET model, the first two steps of Karalis's MEET model, namely the setup of a RT (Response Team) and the situation and context analysis, are performed as in the original MEET model and the next two steps were modified :

### **Set up of the Response Team**

RITE recommends the inclusion of skilled persons in education planning, evaluation, and e-learning to address the educational crisis. The response team of RITE took further action by considering the government-issued order during the pandemic and conducted the online class.

### **Situation and Context Analysis**

Even amidst the educational crisis, the goal was to ensure that all students received an uninterrupted education. This program's overarching objective was to engage and include as many students as possible and ensure that the crisis did not derail their education. This called for a comprehensive analysis of the prevalent situation and context analysis, probing the impact of the pandemic on the village's study area.

### **Shaping the Response**

To address the need for urgent solutions during the pandemic, judicious determination of the components of the solution being proposed was imperative (Karalis, 2020). In the case of the COVID-19 crisis, the remedies pertained to optional teaching styles, where a set of solutions was chosen rather than a single solution, one for each crisis state of the Multivariate Hidden Markov Model.

RITE had already made available alternative solutions: remote teaching, door-to-door tutoring, face-to-face teaching, and regular in-class teaching (which could be resumed when the crisis was over). RITE carried out a needs analysis to ascertain the knowledge, abilities, and behavioral attitudes that students and teaching staff would require to achieve a particular set of learning outcomes. RITE persistently monitored the needs of students and teachers, so that they were well-equipped to address the situational challenges posed by the pandemic. Daily monitoring was performed through direct communications between teachers and headquarters program coordinators, where the former turned in updates on the progress of their students and the effectiveness of the adopted teaching methods.

### **Implementation**

A distinctive feature of RITE's implementation was its context-specific adaptability and endowment with online teaching materials that provide training to teaching staff on the conduct of online classes. Daily audits of learning analytics, class attendance (online registration verified through verbal confirmation), teaching hours, and courses taught were recorded to track progress, and highlight areas that needed improvement.

The two phases hereunder operate in conjunction with the preceding 4 phases:

*Communication:* Parent-teacher meetings, regularly conducted before COVID-19, continued to be in vogue during the pandemic. Daily communications between the RITE Headquarters program coordinators and local teachers in the study area were maintained through mobile phone calls and messages via WhatsApp.

*Evaluation:* To appraise the effectiveness of teaching methods, RITE employed a textbook-based evaluation system, along with weekly and quarterly assessments. The regular teachers drew up question papers for weekly assessments; RITE subject matter experts designed the question papers for quarterly assessments. Constrained by the COVID-19 lockdowns and the consequent shift to alternative teaching styles, door-to-door and online, the RITE team was unable to conduct weekly and quarterly assessments, as they could not marshal all students in a timely fashion.

Based on the evaluation done, RITE had to adapt its assessment methods during the coronavirus crisis. The focus shifted to continuous monitoring of learning analytics, class attendance, and teaching hours, to ensure students' steady progress toward their learning outcomes. This was supplemented by regular communications between teachers and students, to address any concerns and provide feedback. Although the traditional assessments were not feasible during the crisis, RITE was able to implement alternative methods to ensure that the students were still receiving the needed support.

### **Multivariate Hidden Markov Model**

To figure out what the village's hidden crisis states were after the fact, we used a multivariate Hidden Markov model (Felix et al., 2022). The three emissions that were seen were:

1. The daily attendance is modeled as conditionally Poisson distributed
2. The number of COVID-19 death cases is modeled as conditionally log-Normal distributed
3. Social media posts (retweets from Twitter) are modeled as conditionally log-Normal distributed.

Akaike Information Criterion (AIC) (Wagenmakers and Farrell, 2004; Farrell, 2004) and Bayesian Information Criterion (BIC) (Chakrabarti and Ghosh, 2011) were used to select the number of hidden states. AIC estimates the quality among models, and BIC uses the likelihood function to find the best model. Our models were fitted using an EM algorithm (Felix et al., 2022).

The estimated latent crisis states were compared with the observed intervention states that were adaptively used in the village. The RITE interventions in Harirampura involved the implementation of different teaching styles, which were grouped into four states.

1. Lockdown: When the village was in a complete lockdown, students received online classes.
2. Major severity: In this intervention, teachers residing in the localities provided door-to-door classes to the students at their homes.
3. Minor severity: In this intervention, restricted face-to-face classes were allowed to be conducted, but only for students above the third grade, and with restrictions such as social distancing. The Sarpanch of the village provided permission to conduct classes. In centers with more than 10 students, classes were conducted in shifts to adhere to social distancing measures.
4. Lack of severity: In this intervention, students received regular in-person classes.

### **Design and plan of study**

#### **The following data were collected:**

##### **Students attendance**

The social behavior during the four states of the pandemic was measured by the weekly attendance of the children in Hariampura village, Rajasthan. The relative count of attendance of students gave a good indicator of the willingness of people to go outside their homes and meet other people in the village.

##### **ASER reports [13-15]**

Standardized ASER assessments, before and after the pandemic, were used to evaluate the overall effectiveness of the RITE interventions in Harirampura. The student's performance in the village and ASER reports were compared; the levels of significance were determined via p-values.

##### **COVID deaths**

The number of COVID cases and COVID deaths in the study area from June 2020 to April 2022 were retrieved from the Johns Hopkins University (JHU) (CSSEGISandData, 2023) repository. Since the data prior to June 2020 was unavailable from the JHU repository, information on COVID-19 transmission spanning the months of March, April and May 2020 related to Rajasthan was retrieved from local sources, since the number of cases before May was small.

##### **Twitter-Posts**

Social media posts were probed to infer the perceived severity of the pandemic in Rajasthan; specifically, the numbers of tweets, re-tweets, and 'liked' were used. Twitter application programming interfaces (Barrie C and Chun-ting Ho J, 2021) were used to obtain the tweet geocode apropos of COVID-19 in Rajasthan, from March 1, 2020 through 5 November 2022.

## Results

**Table 1:** Comparison of the Amrita RITE intervention program in Harirampura and ASER reports of other villages in the State of Rajasthan for the years 2018- 2019 and 2022 and the distribution of children mastering arithmetic skills.

Standard	Year	< 10		(10 – 99)		Subtraction		Division		Chi-square test for trend (P-value)
		Others (%)	Harirampura (%)	Others (%)	Harirampura (%)	Others (%)	Harirampura (%)	Others (%)	Harirampura (%)	
Grade- 1	2018	43.4	100	12.7	71.5	2.3	14.4	0.5	0	< 0.0001
	2019	49.9	100	21	100	2	80	NA*	30	< 0.0001
	2022	42.7	100	12.2	93.8	1.5	37.6	0.4	6.4	< 0.0001
Grade- 2	2018	78.2	100	31.6	100	7.5	68.8	1.9	18.8	< 0.0001
	2019	73.9	100	28.4	90.7	5	54.4	NA*	27.2	< 0.0001
	2022	72.7	99.7	26.5	85.5	4.5	28.4	0.9	14.2	0
Grade- 3	2018	92	83	51.2	75.2	17.4	67.6	5	13.8	< 0.0001
	2019	99	100	48.9	92.3	12.4	53.8	NA*	15.3	< 0.0001
	2022	84.8	100	44.8	100	11.8	93.8	3	31.3	< 0.0001

Notes: NA\*- No assessment done

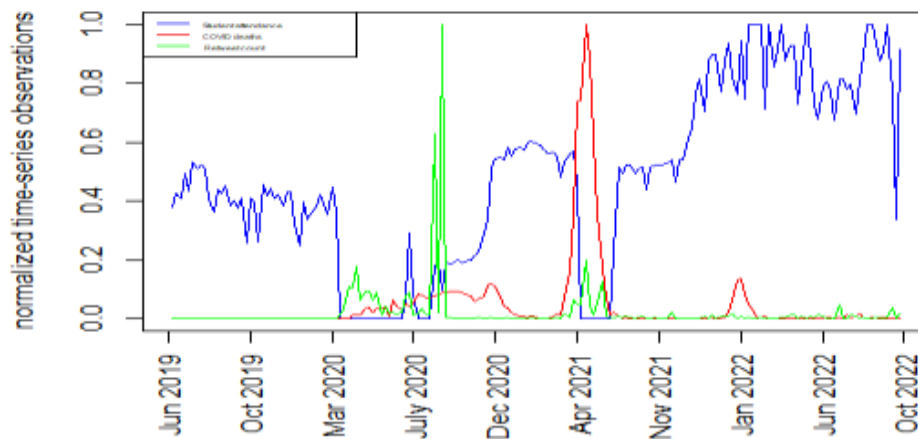
**Table 2:** Comparison of Amrita RITE intervention program in Harirampura and ASER reports of other villages in the State of Rajasthan for the years 2018- 2019 and 2022 and the distribution of children mastering English reading skills.

Standard	Year	Letters		Words		Paragraph		Story		Chi-square test for trend
		Others (%)	Harirampura (%)	Others (%)	Harirampura (%)	Others (%)	Harirampura (%)	Others (%)	Harirampura (%)	
Grade- 1	2018	36.2	100	11.5	100	6	28.6	3.1	0	0.048
	2019	41	74	12.1	74	7.6	14	NA*	14	< 0.0001
	2022	37.3	100	8.4	68.8	3.6	31.3	1.9	0	0
Grade- 2	2018	69.4	100	31.7	100	17.2	25	8.5	6.3	< 0.0001
	2019	55.1	100	23.9	91	14.8	63.7	NA*	27.2	< 0.0001
	2022	64.9	100	23.2	71.5	11.4	43	5.7	28.5	0.028
Grade- 3	2018	85.9	100	55	100	36.7	30.6	20.4	15.3	0.635
	2019	75.1	82.7	38.2	67.4	29.8	53.7	NA*	15.3	0.019

	2022	78	100	41.2	87.5	25.3	31.3	14.2	18.8	0.240
--	------	----	-----	------	------	------	------	------	------	-------

Notes: NA \* No assessment done NA – Not applicable

Fig. 1 Illustrates three-year time series data from June-2019 to October-2022. The figure shows plots of the normalized values of three different observations: COVID-19 death cases, Student attendance, and retweet counts, during the COVID-19 period.



**Fig 1:** Trends in COVID-19 Deaths, Student Attendance, and Retweet Count during the Pandemic in Rajasthan

Fig.1 shows that during the period of March-2020 to June-2020 and from May-2021 to June-2021 student attendance was zero which indicates complete lockdown in Rajasthan. After the second wave (i.e., May-June 2021) of COVID-19 in India, attendance at schools increased significantly as the situation improved, and lockdown restrictions were rescinded step by step, with ameliorative measures of the Government. This paper used two criteria to examine the performance of HMM with multiple variables: AIC and BIC with number of states from one to six. To understand model complexity, goodness of fit and model selection we computed the AIC and BIC statistical measures.

**Table 3:** Values of AIC and BIC of HMM model

Model	Degrees of freedom	AIC	BIC
One-state HMM	5	18824	18840
Two-state HMM	13	8917	8959
Three-state HMM	23	5437	5511
Four-state HMM	35	4789	4901
Five-state HMM	49	3875	4031
Six-state HMM	65	4159	4366

Table 3 shows the values for AIC and BIC obtained for different HMM are analyzed herein. Computed AIC and BIC statistics show the lowest values for the 5-state multivariate HMM. Since AIC and BIC tend to overestimate the number of hidden states, a model with four states was chosen to analyze the data, as explained by (Pohle J et al.,2017).

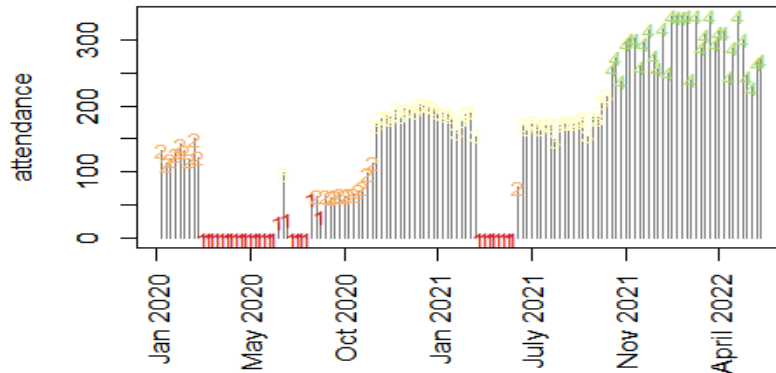
Fig. 2 shows the state transition diagram of 4-state HMM. The directed graph showing the state transitions indicates state 1 is the complete lockdown, the fourth state is normal, second and third states were transitioned from moderate lockdown to near normal state.



**Fig.2:** The latent state transition diagram for a four-state multivariate HMM (Vertices represent different crisis states, and the arrows represent the possible transition between the states)

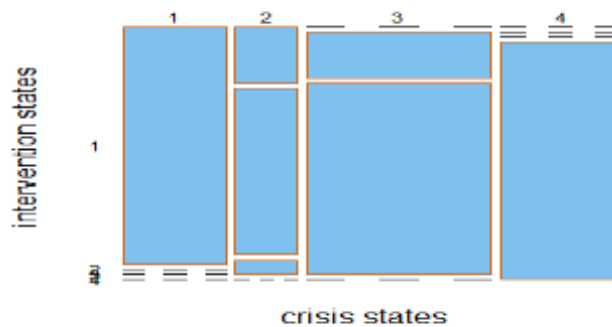
Fig. 3 represents the specific hidden states of HMM obtained from our fitted model, i.e., the four different educational crisis states of the Harirampura village during pandemic that is corresponding to four hidden factors namely State1: Lockdown, State 2: Major severity, State 3: Minor Severity and State 4: Lack of severity.

When the village was in HMM State 1, which was a complete lockdown state, students received online education. In State 2, teachers residing in the localities provided door-to-door classes to the students at their homes. In State3, conducted face-to-face classes. Student attendance was monitored closely, and any student who was absent for at least a week was checked and inquired about the reason for their absence. While at crisis state 4, students were received regular classes. The teachers who had a deeper understanding of the village culture were hired locally so that they could address and teach students in the local dialect.



**Figure 3:** State distributions under 4-state multivariate HMM

The dimensions were plotted as the crisis state at the bottom and the intervention state at the left of the Mosaic plot in Fig. 4. The mosaic plot captures the relationships between crisis and intervention states, on all the days of the study (from June 2020 to April 2022). The number of observations in each level of the variable represented on the X-axis (crisis state) directly relates to the width of the column. The number of observations in the second variable (intervention states), within each level of the first variable, is reflected in the vertical length of the bars. The mosaic plot showed that in crisis state-1 (lockdown) and 4 (normal), there is a perfect agreement with the intervention states.



**Fig. 4:** Mosaic plot of crisis and intervention states



## Discussion

The COVID-19 crisis was a major event, with negative impacts that even threatened the survival and existential core of a system or organization (Pauchant and Mitroff,1992). The pandemic-engendered chaos of COVID-19 has affected the educational sectors, across the world.

The primary urgent priority in mitigating the effects of COVID-19 was to respond to and manage the crisis effectively, followed by efforts towards rehabilitation and recovery. The RITE program offers effective interventions to address the questions during the educational crisis, ensuring quality education during and after the crisis.

Karalis's MEET model for managing educational crises explained how the model contributes to a set of specific outcomes, through a series of intermediates for effective crisis management. However, the proffered model deviates from the sequential structure in two key components: communication and evaluation which are longitudinal and run through other crucial components of the MEET model. Amrita RITE stepped up to tackle the COVID-19 pandemic's impact on schoolchildren's learning, by implementing intelligent interventions to ensure the uninterrupted education of village students and the adoption of well-coordinated educational plans and programs.

The remedial measures adopted by RITE included online access to educational content for students, and teacher's door-to-door visits to students at their homes, to deliver educational materials and conduct classes to the students of Harirampura village.

After India's second COVID-19 wave (May-June 2021), attendance at schools in Harirampura increased significantly (Fig. 1); as the situation improved, lockdown restrictions were rescinded step by step, lest inadvertent interference with the remedies underwritten by the State and Central governments. Analysis of the data parameters (COVID death cases, attendance of students and re-tweet counts) by the application of multivariate HMMs, variation of the number of states from two to six, and the AIC/BIC statistics (Table 3), advocated a five-state HMM model.

According to (Pohle J et al.,2017), AIC/BIC parameters tend to overestimate the number of hidden states; hence, the selection of an HMM with four states was used for analysis (Pohle J et al.,2017). The hidden states correspond to different crisis situations in the village. The lowest attendance of children, observed in the First State of HMM, is suggestive of strict lockdown measures imposed by the government. The rate of attendance suddenly increased after the second wave, (observed in state 3 and state 4), indicative of decreased COVID cases, or no restrictions in place, followed by relaxed lockdown restrictions decreed by the government (Fig.3). The findings suggest that the COVID-19 situation and related government policies heavily influenced school attendance in Harirampura village. The mosaic plot illustrates the relationship between crisis and intervention states (Fig. 4).

The multivariate HMM provided a good fit with the inferred states as well as the mosaic plot (Fig. 3). The mosaic plot showed that in crisis states 1 (lockdown) and 4 (normal), there was a perfect agreement with the intervention states. The HMM model displayed multiple variables and concurrently captured the complex relationships amongst them, which provide an accurate representation of the hidden variables. Table 1 and Table 2 portray the impact of RITE intervention compared to ASER. These tables show that RITE interventions significantly reduced the effects of the pandemic on education. The adaptive MEET model applied to a real-world education crisis state was found to be effective in addressing the crises.

The results of this study demonstrated that RITE interventions were effective in addressing the challenges confronted by rural communities in Rajasthan, by providing students access to education during the epidemic, as well as furnishing the students with educational materials. Further, the rural educational system of Rajasthan was resilient to a vicissitude of changes during the COVID-19 pandemic, enabling the incorporation of traditional and modern teaching methods, while prioritizing the safety of students and staff.

## Conclusion

This research highlighted the significant disruptions caused by the COVID-19 pandemic on elementary education in Harirampura, a rural village in Rajasthan. This paper introduced an innovative adaptive emergency education model (adaptive MEET) that enabled decision-making and showcased its effectiveness in minimizing the aftermath of the COVID-19 pandemic on elementary education. The study's implications extend beyond Harirampura, emphasizing the promising potential of the adaptive MEET model to address educational challenges arising from multiple crises in diverse settings. The RITE intervention relied heavily on a technology-based approach to verify whether the gains achieved during the coronavirus pandemic in Harirampura are sustainable and whether the model effectively addressed the educational challenges of government schools in this region are to be ascertained.

## References

1. Simulating the Potential Impacts of COVID-19 School Closures on Schooling and Learning Outcomes: A Set of Global Estimates.

2. UNESCO (2023). UNESCO's education response to COVID-19. Retrieved from <https://www.unesco.org/en/covid-19/education-response/initiatives>
3. USAID, UNESCO Institute for Statistics (UIS), UK's Foreign, Commonwealth, and Development Office (FCDO), The Bill and Melinda Gates Foundation, Australian Council for Education Research (ACER), World Bank(2019). Global Proficiency Framework: Reading and Mathematics. Report retrieved from: <https://gaml.uis.unesco.org/wp-content/uploads/sites/2/2019/05/GAML6-REF-16-GLOBALPROFICIENCY- \FRAMEWORK>
4. Pandey B. (2018). Achieving SDG 4 in India: moving from quantity to quality education for all. Research and Information System for Developing Countries. <https://www.ris.org.in/>
5. Chinazzi M, Davis JT, Ajelli M.et.al.(2020).The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*, 368(6489):395-400. doi: 10.1126/science.aba9757
6. Viner RM, Russell SJ, Croker H.et.al.(2020). School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *The Lancet Child & Adolescent Health*,4(5):397-404. doi: 10.1016/S2352-4642(20)30095-X
7. Fernandes N. (2020). Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy. IESE Business School Working Paper No. WP-1240-E, doi.org/10.2139/ssrn.3557504.
8. Barrios JM, and Hochberg Y. (2020). Risk perception through the lens of politics in the time of the COVID-19 pandemic. No. w27008. National Bureau of Economic Research. Doi 10.3386/w27008
9. Habbat N, Anoun H, Hassouni L.(2022). Sentiment analysis and topic modeling on Arabic twitter data during covid-19 pandemic. *Indonesian Journal of Innovation and Applied Sciences (IJIAS)*, 2(1):60-67. doi.10.47540/ijias.v2i1.432
10. Enitan SS, Ibeh IN, Oluremi AS.et.al.(2020).The 2019 Novel Coronavirus outbreak: current crises, controversies and global strategies to prevent a pandemic. *International Journal of Pathogen Research*, 4(1):1-16. doi.10.9734/ijpr/2020/v4i130099
11. Joseph C, Kerryn BH, Rudolph J. (2020).COVID-19: 20 countries' higher education intra-period digital pedagogy responses. *Journal of Applied Learning and Teaching*, 3(1):1-20. doi.10.37074/jalt.2020.3.1.7
12. ASER Centre. (2018). Annual Status of Education Report (Rural) 2017. New Delhi: ASER Centre. Report retrieved from: <https://img.asercentre.org/docs/ASER%202018/Release%20Material/aserreport2018.pdf>
13. Kumar JP. (2020). Impact of Pandemic COVID-19 on Education in India. *International Journal of Current Research*,12(07):12582-86. doi.10.24941/ijcr.39209.07.2020
14. ASER Centre. (2022). Annual Status of Education Report (Rural) 2021. New Delhi: ASER Centre Report retrieved from: <https://img.asercentre.org/docs/ASER%202022 %20report%20pdfs/All%20India%20documents/aserreport2022>
15. ASER Centre. (2021). Annual Status of Education Report (Rural) 2020. New Delhi: ASER Centre. Report retrieved from: [https://img.asercentre.org/docs/aser2021 finalreport\\_16.116.54pm1.pdf](https://img.asercentre.org/docs/aser2021 finalreport_16.116.54pm1.pdf)
16. ASER Centre. (2020). Annual Status of Education Report (Rural)2019. New Delhi: ASER Centre. Report retrieved from: <https://img.asercentre.org/docs/ASER%202021 /ASER%202020%20wave%201%20-%20v2/nationalfindings.pdf>
17. Pingale SM, Khare D, Jat MK.et.al.(2014). Spatial and temporal trends of mean and extreme rainfall and temperature for the 33 urban centers of the arid and semi-arid state of Rajasthan, India. *Atmospheric Research* 138:73-90. doi.10.1016/j.atmosres.2013.10.024
18. Som, K. S, Mishra, R. P.(2014). BIMARU states: Need a rethinking. *IOSR Journal of Humanities and Social Science*, 19(7):34-41. doi.10.9790/0837-19713441
19. Bhasin MK, Nag S. (2017). Demography of the Tribal Groups of Rajasthan: 1. Population Structure. *The Anthropologist* 9(1):1-37. <https://doi.org/10.1080/09720073.2007.11890977>
20. Kumar, C.J.(2023). Tribal Education in Rajasthan: A Policy Analysis. In *Politics of Education in India* (pp. 75-86). Routledge India. eBook ISBN: 9780429285523
21. Misra P and Kapoor, A. K. (2002). Ecology, Economy, and Culture: An anthropological profile of the Meena, a Scheduled Tribe of Rajasthan. *Social Change*, 32(1-2):1-26. doi:10.1177/004908570203200201
22. Luhach S, Lata P and Singh K.(2022).Emergency Remote Teaching and Technology Comfort: Mapping Perceptions of English Teachers from Schools in Rural Areas of Rajasthan during COVID-19 Crisis. *Proceedings of the International Conference on Best Innovative Teaching Strategies (ICON-BITS 2021)*.doi.10.2139/ssrn.4027472
23. Panakaje N, Rahiman HU, Rabbani MR.(2022).COVID-19 and its impact on educational environment in India. *Environmental Science and Pollution Research*, 29:27788-804.doi.10.1007/s11356-021-15306-2
24. McGuire L.(2007). Planning for a pandemic influenza outbreak: Roles for librarian liaisons in emergency delivery of educational programs, medical reference services quarterly 26(4): 1-13.doi.10.1300/J115v26n04\_01
25. Haogen Y, Asif Saeed M, Diogo A.(2021). Public health emergencies and school attendance: What the Ebola crisis can teach us about the coming post-COVID education landscape. *International Journal of Educational Development* 85:102457, doi: 10.1016/j.ijedudev.2021.102457

26. Silwal S.(2016). Resilience amidst conflict? The effect of civil war exposure on secondary education. *International Journal of Development and Conflict* 6(2):97-120. Retrieved from: <http://www.ijdc.org.in/uploads/1/7/5/7/17570463/dec2016art2v1.pdf>
27. Burde D and Khan, J. (2016). Will you send your daughter to school? Norms, violence, and girls' education in Uruzgan, Afghanistan. *Journal on Education in Emergencies*, 2(1): 42-80. Retrieved from <http://hdl.handle.net/2451/39648>
28. Aydin H and Kaya Y. (2017). The educational needs of and barriers faced by Syrian refugee students in Turkey: A qualitative case study. *Intercultural Education*, 28(5): 456-73. doi:10.1080/14675986.2017.1336373
29. Le Brocque R, De Young, AC, Montague G.et.al. (2017). Schools and natural disaster recovery: The unique and vital role that teachers and education professionals play in ensuring the mental health of students following natural disasters. *Journal of Psychologists and Counsellors in Schools*, 27(1):1-23. doi:10.1017/jgc.2016.17
30. Hunt KMR and Menon. A.(2020). The 2018 Kerala floods: a climate change perspective. *Climate Dynamics*.54:2433-46. doi.10.1007/s00382-020-05123-7
31. Mian A, and Khan S. (2020). Medical education during pandemics: a UK perspective, *BMC Medicine* 18(100): 1-2. doi: 10.1186/s12916-020-01577-y
32. Anthony B and Noel S.(2021). Examining the adoption of emergency remote teaching and virtual learning during and after COVID-19 pandemic. *International Journal of Educational Management* 35(6): 1136-50. doi.10.1108/IJEM-08-2020-0370
33. Das P.(2012). Disaster management in India: policy review and institutional structure. *Asia pacific Journal of Social Sciences*. IV(1):37-52.
34. National disaster management authority.(2009).National Policy on disaster management 2009. Report retrieved from: [https://nidm.gov.in/PDF/policies/ndm\\_policy2009.pdf](https://nidm.gov.in/PDF/policies/ndm_policy2009.pdf)
35. Karalis T.(2020). Planning and evaluation during educational disruption: Lessons learned from COVID-19 pandemic for treatment of emergencies in education. *European Journal of Education Studies*. doi:10.5281/zenodo.3789021.
36. Gutjahr G, Nair A, Menon R.et.al.(2019) Technology for monitoring and coordinating an after-school program in remote areas of India. *IEEE Tenth International Conference on Technology for Education (T4E)*. doi: 10.1109/T4E.2019.00-57.
37. Nedungadi P, Menon R, Gutjahr G.et.al.(2018). Towards an inclusive digital literacy framework for digital India. *Education and Training*, 60(6):516-528. doi.10.1108/ET-03-2018-0061
38. Felix EFO, Buhat CAH and Mamplata JB. (2022). Poisson hidden Markov model on earthquake occurrences in metro Manila, Philippines, *Earth Science Informatics*, 15:1635-45. doi.10.1007/s12145-022-00810-x
39. Wagenmakers E and Farrell S. (2004). AIC model selection using Akaike weights. *Psychonomic bulletin & review*, 11:192-196. doi.10.3758/BF03206482
40. Chakrabarti A, Ghosh JK.(2011).AIC, BIC and recent advances in model selection. *Philosophy of statistics*.7:583-605. doi.10.1016/B978-0-444-51862-0.50018-6.
41. CSSEGISandData/COVID-19.(<https://github.com/CSSEGISandData/COVID-19>)
42. Barrie C and Chun-ting Ho J.(2021). academic twitter: an R package to access the Twitter Academic Research Product Track v2 API endpoint. *Journal of Open-Source Software*, 6(62): 3272. doi10.21105/joss.03272
43. Pohle J, Langrock R, Beest FM.et.al.(2017), Selecting the number of states in hidden Markov models: pragmatic solutions illustrated using animal movement. *Journal of Agricultural, Biological and Environmental Statistics*, 22:270-93. doi.10.1007/s13253-017-0283-8.
44. T. Pauchant and I. Mitroff.(1992).Transforming the Crisis-Prone Organization: Preventing Individual, Organizational, and Environmental Tragedies Jossey-Bass, San Francisco, CA, 227 pages.