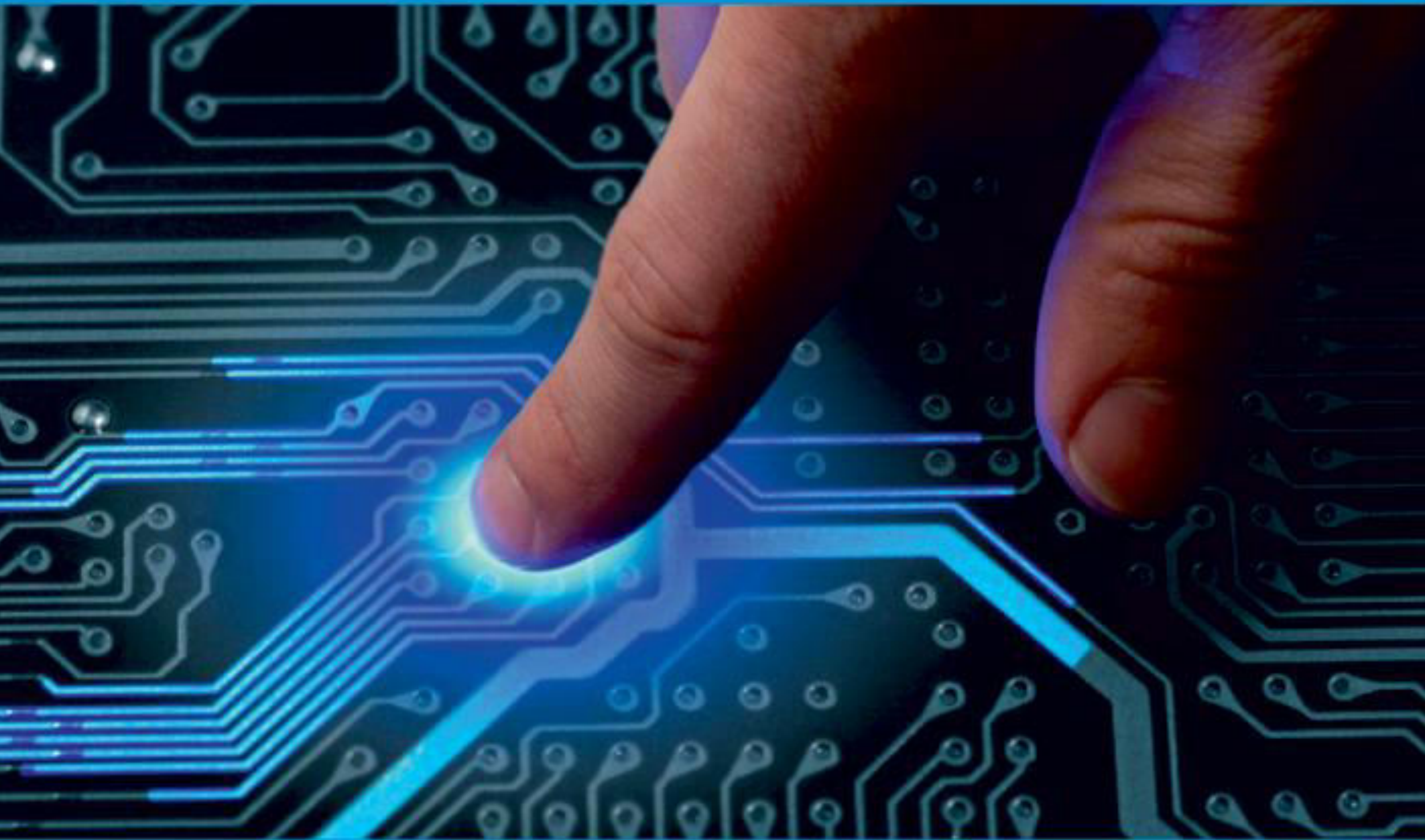
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 10, Issue 7, July 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.165

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.165 |

|| Volume 10, Issue 7, July 2022 ||

| DOI: 10.15680/IJIRCCE.2022.1007013 |

COVID-19 Transmission Mitigation in Schools Using Digital Contact Tracing

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ABSTRACT: An urgent need for COVID-19 eradication has arisen in the lack of pharmaceutical options. This study examines the effectiveness and cost of a digital contact tracing (DCT)-based on-campus mitigation strategy using epidemic simulations utilising high-resolution empirical contact networks of professors and students. The DCT-based methodology is a practical and considerably more successful way for stopping the spread of COVID-19 on a crowded campus than standard class, grade, and school shutdown measures. The DCT-based strategy, in instance, may achieve the same level of disease control as stringent school suspensions, but with a far lower proportion of students segregated. DCT-based strategies and auxiliary strategies to enhance the effectiveness of mitigation should be implemented in conjunction with social distancing, the DCT device adoption rate should be ensured, and rapid virus tests should be conducted to detect asymptomatic infections in order to stop their spread. Moreover, we argue that elementary schools have a greater risk of disease transmission than secondary schools and should be alerted when reopenings are being considered.

KEYWORDS: DCT; COVID-19; social distancing;

I. INTRODUCTION

More than 16 million and 600,000 COVID-19-related diseases and deaths have been linked to the pandemic by a pseudonymous connection as of July 2020 [1], despite extensive social distancing instructions [2]. There are several ways to limit viral infection's overall burden, including social distance, case isolation, quarantine of vulnerable individuals, and public place closures [3–5]. These steps are critical in the planning for the next few months. As a result of the significant economic and social costs associated with maintaining viral transmission [8], precise mitigation is an absolute need for easing epidemic burdens and effectively preventing and responding to future pandemics [9, 10].

In today's world, education for everyone is essential. But schools and universities, with their long-term, intimate contacts between faculty and students, are particularly vulnerable to disease transmission [11]. Suspension of courses and grades is commonly accepted as a feasible and beneficial approach to prevent epidemics on school grounds [12–14]. However, a large number of students may be imprisoned, either in a central place or at home, resulting in severe financial and psychological costs [15]. [15] It is thus critical to implement a cost-effective mitigation strategy that does not burden society or the economy [16].

When performing large-scale human research using disease prevention measures is too expensive and dangerous, mathematical modelling gives a realistic alternative. Models based on mechanistic theory, such as the SIR and SEIR models, have been used for decades to explain the spread of disease. However, the parameter selections of models may differ amongst diseases. Presymptomatic and volatile viral shedding has been seen in cynomolgus macaques infected with the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) [19]. After discovering that SARS-CoV-2 often shifts from infected patients, we propose an SEIR model with a variable infection rate to explain this phenomenon.

There must be accurate demographic data for a specific scenario in addition to a realistic transmission model in order to get valid results in epidemic modelling [20]. High-resolution statistics on human interaction mostly corroborate the realistic demographic assumption. The most common methods for obtaining such data are RFID tracing, GPS tracing, Wi-Fi hotspot sharing, and other proximity traces, such as student card presences [24, 25]. A primary school [26] and a high school [21], [27] are used in this study to establish temporal networks of campus relationships. COVID-19 transmission is most likely aided by the proximity of two RFID devices, which mimics a close-knit setting.

Mobile applications may be used to establish transmission routes and timings using digital contact tracing (DCT). If a user has a tracking device like a mobile phone or RFID, they may be able to easily verify their exposure to viruses. A growing number of nations are utilising contact-tracing apps for smart phones to automate the tedious task of keeping

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|| Volume 10, Issue 7, July 2022 ||

| DOI: 10.15680/IJIRCCE.2022.1007013 |

track of newly discovered ill people's recent contacts. Researchers have demonstrated the effectiveness of DCT by creating a contact network of 115 students at a specific university or by generating a model of individual-level transmission based on 40 162 participants. In areas with large densities of people, such as college campuses, this approach may be a more cost-effective option for early detection, case isolation and outbreak prevention of COVID-19 due to the simplicity with which it may be implemented and the scarcity of DCT studies in cluster environments.

Several campus mitigation approaches, including those using the recently proposed DCT technology, are evaluated in this study. The effectiveness of a quarantine depends on how many students are ill and how much it costs to keep them apart. As a result of the DCT-based quarantine method, the spread of sickness is greatly reduced. Aside from that, we're looking at how effective the DCT-based approach will be and whether or not it needs any auxiliary techniques, such as social distancing, device adoption rates, community infections, and the incidence of asymptomatic infections in the general population. Post-pandemic school policy is expected to be greatly influenced by the outcomes of this study.

The following is how the rest of the article is laid out: Student-teacher contact data sets, temporal contact networks, and a COVID-19 variable infection model are discussed in Section II, which also shows the spread of an infectious sickness in a real-world network. Section III examines a variety of mitigation strategies, such as class and grade closures, as well as a DCT-based strategy and the ways in which it may be applied to our proposed model. Taking into consideration additional external factors, such as the proportion of asymptotic infections and the impacts of social distance and community infections, the efficiency and cost effectiveness of different mitigation measures are discussed in Section IV.

II. RELATED WORK

As Reopening schools should be a high priority because of the ongoing COVID-19 outbreak. SARS-CoV-2 transmission in elementary and secondary schools was modelled using stochastic, network-based stochastic models in order to investigate the dangers of returning to in-person learning and the effectiveness of mitigation interventions.

According to the current approach, risk may be reduced to levels that can be tolerated by a range of mitigation measures, either individually or in conjunction with one another By dividing students into two groups and scheduling in-person meetings on different days, the practise of student cohorting may help to reduce the frequency and severity of epidemics. The discovery of introductions before they spread across the school may be helped by proactive testing of teachers and personnel. Secondary schools provide more of a challenge in infection control because of the increased vulnerability of students and the unique social patterns they develop. In these situations, planners could also consider testing youngsters once or twice a week. Vaccinating teachers and other staff members may also safeguard students. Additionally, the usage of masks, social isolation, and increased ventilation are all essential reopening precautions to keep in mind.

III.PROPOSED ALGORITHM

A. *Modules:*

1. Service Provider

This module requires a user name and password from the Service Provider. As soon as the user logs in, they may do a variety of tasks, including training and seeing mitigation of COVID19 transmission, finding mitigation of COVID19 transmission ratio and viewing all COVID19 transmission predictions. COVID19 transmission ratio results, COVID19 transmission ratio bar graphs, school children oxygen results, and remote user results are all available for viewing and downloading here.

2. View and Authorize Users

An administrator may see a list of all the people who have signed up for the system in this module. User information, such as email and physical address, may be accessed and approved by the administrator in this situation.

3. Remote User

This module has n users currently logged in. Registration is required prior to engaging in any activity. Users' personal data is stored in a database when they sign up. An authorised user name and password must be entered by the user when registration has been completed successfully. It's possible to see your profile, view your post-school data sets, predict mitigation of your COVID19 status, and more when you've logged in successfully using your email address and password.

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IV. PROPOSED SYSTEM

Mobile applications may be used to establish transmission routes and timings using digital contact tracing (DCT). If a user has a tracking device like a mobile phone or RFID, they may be able to easily verify their exposure to viruses. The time-consuming task of tracking down all of a person's recent contacts after being diagnosed with a disease has been automated in a number of nations. Researchers have demonstrated the effectiveness of DCT by creating a contact network of 115 students at a specific university or by generating a model of individual-level transmission based on 40 162 participants.

Since this technology is easy to use and there is little DCT research on cluster settings, this approach may provide a cost-effective alternative for COVID-19 early detection, case isolation, and outbreak prevention on college campuses and other high-density places.

Among the possibilities evaluated in this study are those using the recently proposed DCT technology, which has been shown to be effective and cost effective. The effectiveness of a quarantine depends on how many students are ill and how much it costs to keep them apart. As a result of the DCT-based quarantine method, the spread of sickness is greatly reduced. Aside from that, we're looking at how effective the DCT-based approach will be and whether or not it needs any auxiliary techniques, such as social distancing, device adoption rates, community infections, and the incidence of asymptomatic infections in the general population. Post-pandemic school policy is expected to be significantly influenced by this study's conclusions.

V. RESULTS

The experimental results are shown below:

Table I: Epidemic Probabilities Pe and Medians of Numbers of Quarantined Individuals Nq under Different Mitigation Strategies

Place	Primary school		High school	
Mitigation measures	P_e	N_q	P_e	N_q
Case isolation	94.1%	224	71.2%	86
Class closure	36.6%	46	2.4%	67
Grade closure	21.8%	90	0.9%	111
School closure	2.8%	242	0.0%	329
DCT-based quarantine	**4.4%**	**96**	**0.0%**	**49**

Table II: Precision and Recall of Different Mitigation Strategies

Place	Primary school		High school	
Mitigation measures	Precision	Recall	Precision	Recall
Case isolation	100%	18%	100%	30%
Class closure	30%	64%	14%	88%
Grade closure	20%	75%	6.0%	91%
School closure	4.0%	100%	1.7%	100%
DCT-based quarantine	**13%**	**91%**	**17%**	**92%**

VI. CONCLUSION AND FUTURE WORK

In the fight against highly infectious diseases like COVID-19, DCT with wearable electronics is an innovative and effective method of epidemic mitigation. To determine the effectiveness and cost of campus quarantine in avoiding the spread of disease, we will use the number of diseases and the number of people confined as indicators. The SEIR model with a variable infection rate setting and two empirical high-resolution on-campus interpersonal close contact data sets are used to simulate epidemics. Comparable outcomes may be achieved at a cheaper cost with the DCT quarantine strategy than with traditional methods such as the closure of classrooms and the whole school. The effectiveness of the DCT-based method in minimising risks may be considerably impacted by a number of elements. There are several

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reasons why prevention and control efforts will be less effective when the likelihood of an asymptomatic infection is high. Asymptomatic infections can spread the disease for longer periods of time than the symptomatic infections that are isolated as soon as they become symptomatic. In addition, community-acquired diseases may reduce the effectiveness of any preventative measures. Thirdly, the success of the DCT-based approach depends heavily on the success rate of instructors and pupils. Lastly, social isolation may aid in the mitigation method's effectiveness.

The following COVID-19 mitigation strategies are recommended for campus implementation in light of the aforementioned results. Schools are encouraged to begin with a DCT-based strategy. Second, the rate of adoption must be monitored and assured on a regular basis. For the third time, if an infection is discovered on campus, stringent virus samplings must be undertaken on a larger percentage of the population in order to uncover asymptomatic or community-infected patients. To prevent the spread of illness in schools, social isolation tactics must be used.

The elementary school empirical contact network is much more dense than the secondary school empirical contact network. Since elementary school children are more physically active (i.e., have more physical encounters) than high school students, even if the contact data came from two unique schools across a particular time period, we propose that this phenomenon may be widespread. Consequently, we advise against reopening primary schools since they represent a larger risk of illness transmission than secondary schools.

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