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Mitigating COVID-19 Transmission in Schools with Digital Contact Tracing

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ABSTRACT

Precision mitigation of COVID-19 is in pressing need for postpandemic time with the absence of pharm aceutical interventions. In this study, the effectiveness and cost of digital contact tracing (DCT) technology-based on-campus mitigation strategy are studied through epidemic simulations using high-resolution empirical contact networks of teachers and students. Compared with traditional class, grade, and school closure strategies, the DCT-based strategy offers a practical yet much more efficient way of mitigating COVID-19 spreading inthe crowded campus. Specifically, the strategy based on DCT can achieve the same level of disease control as rigid schools us pensions but with significantly fewer students quarantined. We further explore the necessary conditions to ensure the effectiveness of DCT-based strategy and auxiliary strategies to enhance mitigation effectiveness and make the following recommendation: social distancing should be implemented along with DCT, the adoption rate of DCT devices should be assured, and swift virus tests should be carried out to discover asymptomaticinfections and stop their subsequent transmissions. We also argue that primary schools have higher disease transmission risks than high schools and, therefore, should be alerted when considering reopening.

1.INTRODUCTION

The COVID-19 pandemic has emerged into a global threat and was pseudonymously linked to more than 16 million and 600 thousand COVID-19 related cases and deaths as of July 2020 [1], albeit a mass of social distancing orders that have been enacted worldwide [2]. In the absence of pharmaceutical interventions, measures to

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www.ijasem.org
Vol 18, Issue 3, 2024

reduce the overall burden of viral infection—including social distancing [3], case isolation [4], quarantine of susceptible [5], closure of public places [6], and increased availability of diagnostics— are paramount in planning for the months ahead [7]. Given the epidemiological disparity of strategies with the substantial economic and societal costs to sustain the virus transmission [8], there is a clear need for precision mitigation to alleviate the persistent burden of epidemics and prevent and respond effectively to future pandemics [9], [10].

Mass education is an indispensable foundation of modern society. Nevertheless, schools and universities, where teachers and students have long-term and intimate connections, are particularly risky areas for disease transmission [11]. To prevent campus outbreak, school suspension and closure of classes and grades are generally considered feasible approaches that can effectively reduce the number of infections [12]–[14]. However, school suspension or parts thereof can also result in a large number of students quarantined, either concentrated or at home, causing substantial socioeconomic costs and psychological problems [15]. Therefore, the critical question in effective retention lies in the selection of an effective mitigation strategy while inflicting a minimum cost to the society and economy [16].

Since large-scale human experiments with disease control measures are costly and risky to conduct, mathematical modeling offers a viable way to examine the impact of these measures with varying rates of controls [17]. Traditional transmission models are built upon mechanistic ones, such as the susceptible-infectious-removed (SIR) or susceptible-exposed infectious- removed (SEIR) models [18]. However, the parameter settings of the models can vary among different diseases. Recently, animal experiments on cynomolgus macaques inoculated with the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) have shown that the virus shedding can be pre symptomatic and volatile [19]. Based on this finding, we propose an SEIR model with a variable infection rate that takes into account the frequent shift of SARS-CoV-2 from infections hence their transmissibility.

Except for the realistic transmission model, realistic assumptions, such as the accurate demographic data of a specific scenario, are also the prerequisite of epidemic modeling

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www.ijasem.org

Vol 18, Issue 3, 2024

with validating results [20]. The realistic demographic assumption mainly relies on high-resolution human interaction data. Common ways of acquiring such data include radio frequency identification devices (RFID) tracing [21], GPS tracing [22], Wi-Fi hotspot sharing [23], and other proximity traces, such as student card presences [24], [25]. In this study, we use two empirical data sets of wearable RFID devices' proximity collected from a primary school [26] and high school [21], [27], to construct

temporal networks of campus interactions. The spatial proximity of two RFID devices resembles a close contact scenario that most probably facilitates the COVID-19 transmission.

Digital contact tracing (DCT) is a new and valuable technology based on mobile applications to understand the routes and timings of transmission [28]. Tracing devices, e.g., mobile phones or RFID, can log their mobility or close contacts with other devices so that wearers can monitor their virus exposure in a timely fashion [29]. Many governments have used smart phone contact tracing apps to automate the difficult task of tracing all recent contacts of newly identified infected individuals [30]. Researchers have verified the effectiveness of DCT by constructing a contact network of 115 students at a certain university [31] or setting a model of individual-level transmission based on 40 162 participants [32]. At present, there are few DCT studies on the cluster environment, and considering the easiness of technology adoption, this method can potentially provide a cost-effective solution to early detection, case isolation, and outbreak prevention of COVID-19 in certain environments where the population density is high, such as on campus.

In this study, we examine the effectiveness and cost of several mitigation strategies on campus, including the ones that utilize the newly proposed DCT technology. The effectiveness is measured by the number of infected students and the cost of the quarantined students. Compared with traditional suspension and closure methods, the DCT-based quarantine strategy can control disease-spreading much more efficiently. Necessary conditions for ensuring the DCT-based strategy's effectiveness and possible auxiliary strategies that provide further enhancement are also explored, including the social

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www.ijasem.org
Vol 18, Issue 3, 2024

distancing strategy, the DCT device adoption rate, the influence of community infections, and the asymptomatic infections in the population. The results obtained from this study are expected to significantly impact the making of school policies in the post pandemic era.

The rest of this article is organized as follows. Section II describes the student and teacher contact data sets, constructs temporal contact networks, proposes the COVID-19 variable infection model, and demonstrates disease spreading in the real-life network without mitigation measures. Section III discusses several mitigation strategies, including the closure of classes and grades, as well as one that is based on DCT, and their potential interventions to our proposed model. Section IV demonstrates the effectiveness and cost of different mitigation strategies, considering influences from further external factors, such as the proportion of asymptotic infections, the influences of social distancing and community infections, and the DCT device adoption rate in schools. Section V concludes this study.

2. EXISTING SYSTEM

- Reopening schools is an urgent priority as the COVID-19 pandemic drags on. To explore the risks associated with returning to in-person learning and the value of mitigation measures, we developed stochastic, network-based models of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission in primary and secondary schools.
- The existing systemfind that a number of mitigation measures, alone or in concert, may reduce risk to acceptable levels. Student cohorting, in which students are divided into two separate populations that attend in-person classes on alternating schedules, can reduce both the likelihood and the size of outbreaks. Proactive testing of teachers and staff can help catch introductions early, before they spread widely through the school. In secondary schools, where the students are more susceptible to infection and have different patterns of social interaction, control is more difficult.
- Especially in these settings, planners should also consider testing students once or twice weekly. Vaccinating

teachers and staff protects these individuals and may have a protective effect on students as well. Other mitigations, including mask wearing, social distancing, and increased ventilation, remain a crucial component of any reopening plan.

Disadvantages

1) .There is no Digital contact tracing (DCT) which is a new and valuable technologybased on mobile applications to understand the routesand timings of transmission.

2). There is no Transmissibility of Different Infection Models.

3. PROPOSED SYSTEM

- Digital contact tracing (DCT) is a new and valuable technologybased on mobile applications to understand the routesand timings of transmission [28]. Tracing devices, e.g., mobilephones or RFID, can log their mobility or close contactswith other devices so that wearers can monitor their virusexposure in a timely fashion [29]. Many governments haveused smartphone contact tracing apps to automate the difficulttask of tracing all recent contacts of newly identified infectedindividuals [30]. Researchers have verified the effectiveness ofDCT by constructing a contact network of 115 students at acertain university [31] or setting a model of individual-leveltransmission based on 40 162 participants [32].
- At present,there are few DCT studies on the cluster environment, andconsidering the easiness of technology adoption, this methodcan potentially provide a cost-effective solution to early detection,case isolation, and outbreak prevention of COVID-19 incertain environments where the population density is high,such as on campus.
- In this study, the system examines the effectiveness and cost ofseveral mitigation strategies on campus, including the ones thatutilize the newly proposed DCT technology. The effectivenessis measured by the number of infected students and thecost of the quarantined students. Compared with traditionalsuspension and closure methods, the DCT-based quarantinestrategy can control disease-spreading much more efficiently.Necessary conditions for ensuring the DCT-based

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Vol 18, Issue 3, 2024

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Advantages

- The system more effective due to Quarantine Strategy Based on Digital Contact Tracing techniques.
- The gives accurate results due to presence of Epidemic Model With Variable Infection Rate.
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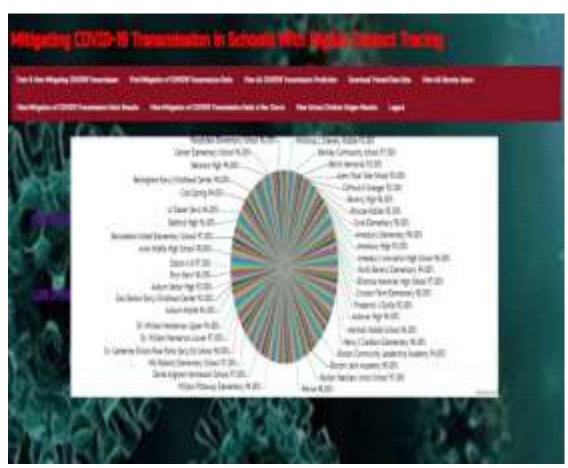
4.OUTPUTSCREENS

Screen Shorts



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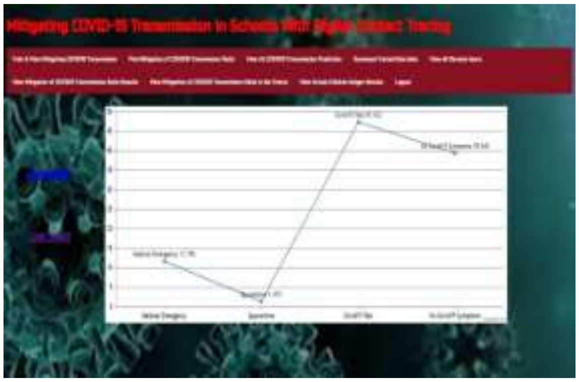
www.ijasem.org
Vol 18, Issue 3, 2024



5.CONCLUSION

DCT with wearable hardware is a new and effective epidemic mitigation strategy that could be used to fight against highly infectious diseases, such as COVID-19. In this study, we proposed to examine its effectiveness and cost, quantified by the numbers of infections and quarantined individuals, respectively, in controlling disease spreading on campus. Two empirical high-resolution on-campus interpersonal close contact data sets and a modified SEIR model with a variable infection rate setting are employed to simulate epidemics. Compared to traditional mitigation strategies, such as the closure of classes, grades, and the whole school, the DCT quarantine strategy can achieve a similar effect as more rigid strategies but with a much smaller cost. Several factors can strongly affect the mitigation effectiveness of the DCT-based strategy. First when the probability of asymptomatic is high, the prevention and control effects of various strategies will be weakened as they can transmit the disease for an extended period than symptomatic infections, who are isolated as soon as they show any symptom. Second, community-introduced infections can jeopardize the efforts made by any mitigation strategy. Third, the adoption rate of teachers and students profoundly affects the effectiveness of the DCT-based strategy. Fourth, social distancing can help with the mitigation strategy and further increase its effectiveness.

Considering the above results, we make the following recommendations for the on-campus mitigation of COVID-19. First, a DCT-based strategy is encouraged in schools. Second, the strategy's adoption rate must be monitored and assured continuously. Third, whenever an infection

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Vol 18, Issue 3, 2024

is detected on campus, rigid virus testing must be carried out to a larger extent of the population for asymptomatic or community introduced case discovery. Fourth, social distancing measures must be placed in schools to minimize the probability of disease spreading.

Note that the density of the primary school empirical contact network is much higher than that in the high school. Although the contact data are collected from two individual schools in a particular period, we argue that this phenomenon can be universal, as pupils in primary schools are more physical activity-intensive (i.e., having more physical contacts) than students in the high schools, who are in contrast more academic activity-intensive. Therefore, we warn that primary schools have a higher risk than high schools in disease transmission, thereby less suitable for pushing school reopens.

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