The effectiveness of Non-pharmaceutical interventions in COVID-19 pandemic in Uzbekistan

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The effectiveness of Non-pharmaceutical interventions in COVID-19 pandemic in Uzbekistan

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December, 2022

DECLARATION

I, Davlatov Kamoliddin Jumaevich, do hereby declare that the thesis entitled "The effectiveness of Non-pharmaceutical interventions in COVID-19 pandemic in Uzbekistan " is the result of my work except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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K. Davlatov

Korea, December, 2022

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LIST OF ACRONYMS

Severe acute respiratory symptoms- coronavirus 2	SARS-Co-2
Severe acute respiratory symptoms	SARS
2019 novel coronavirus	COVID-19
Non-pharmaceutical interventions	NPIs
World Health Organization	WHO
Center of Diseases control	CDC
Ministry of Health Republic	MoH
Polymerase chain reaction	PCR

ABSTRACT

The effectiveness of Non-pharmaceutical interventions

in COVID-19 pandemic in Uzbekistan

Background

The 2019 novel coronavirus (COVID-19) outbreak in Wuhan, China has attracted world-wide attention. As of November 12, 2022, the resulting COVID-19 pandemic had caused more than 635 million confirmed cases and more than 6.6 million (approximately 0.08% of world population) deaths. After detection first case of COVID-19 in Uzbekistan top government officials decided to implement large-scale non-pharmaceutical intervention (NPIs), namely travel restriction, school closure, quarantine and isolation, social distancing, mask wearing and lockdown to control and contain infection outbreak. NPIs were essential components of the public health response to COVID-19 outbreaks before vaccine invention. The implementation durations of each type of NPI ranged from 18 to 219 days. The longest duration of implementation was observed for mask wearing 708 days (96.9% of study period). In general, the goal of the implementation of any type of NPI was to reduce the reproduction number (R) below the threshold value of 1 and as close to 0 as possible. Several NPIs, including border, closure, school

closure, social distancing, and lockdown, could reduce R substantially to near or below 1.

Purpose

The purpose of this study is to evaluate effectiveness of NPIs to reduce SARS-CoV-2 transmission in Uzbekistan and their association with basic reproduction number (R_0).

Method

A retrospective study was conducted to estimate the effectiveness of each and subgroups of the NPIs. This study included 237,341 confirmed COVID-19 cases between 15 March, 2020-2022 in Uzbekistan. Findings on dependent variables or NPIs namely, border closure, school closure, mass gathering bans, venue closure, traffic bans, mask wearing and lockdown were obtained from official webpages of high-circulation newspapers published in Uzbekistan. And, on independent variable such as basic reproduction number was calculated based on simple mathematical formula using a software. Ordinal logistic regression analysis was used to estimate the effectiveness of NPIs associated with basic reproduction number of COVID-19.

Result

Governmental interventions were implemented overall 731 days in the country. The response implementation of NPIs continued for different periods of time, the least lasted was lockdown measure 131 days (17.9%), the longest one was mask wearing and it lasted 708 days (96.9%), respectively.

The result of the study showed that an increase in basic reproduction number by 1.38 times was more likely led to implement traffic bans measure (OR: 1.38, 95% CI: 0.99 – 1.91, p=0.05), venue closure (OR: 1.41, 95% CI: 1.04 – 1.94, p=0.028), lockdown (OR: 1.43, 95% CI: 0.92 – 2.08, p=0.066), mass gathering bans (OR: 1.5, 95% CI: 1.08 – 2.09, p=0.015), border closure (OR: 2.21, 95% CI: 1.59 – 3.12, p=< .001), mask wearing (OR: 2.75, 95% CI: 1.87 – 4.25, p=< .001) and school closure (OR: 4.45, 95% CI: 2.93 – 6.97, p=< .001). The findings also revealed that Governmental response policy against coronavirus was changed several times according to level of R_0 of COVID-19. Border closure measure policy was changed 6 times in the study period. In “no measure” period average R0 was 1.35 conditionally, overall days between policy change 64 days, “2nd decision” R0 was 1.18 (54 days), “3rd decision” R0 was 1.07 (143 days), “4th decision” R0 was 1.05 (155 days), “5th decision” R0 was 1.06 (120 days), and in the final cancellation period R0 was 0.9 (195 days). Median days for impose NPIs was 131.5 /IQR: 78.0 - 152.0/.

Conclusion

In conclusion, we found that any type Governmental interventions, namely mandatory face mask in public, border and school closure, social distancing and traffic restriction, may reduce the spread of COVID-19. Border and school closure and mask wearing seem more effective than the other types of NPIs. The re-decision by policymakers based on an increase in reproduction number lead to a decrease in the reproduction rate of the COVID-19 and it may be more essential for controlling the spread of coronavirus infection.

Keywords: 2019 novel coronavirus (COVID-19) pandemic, non-pharmaceutical interventions, outbreak, basic reproduction number, Uzbekistan.

1. INTRODUCTION

1.1. Background

Global impact of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has been massive, affecting almost every aspect of human life in the world. The novel SARS-CoV-2 that emerged in Wuhan, China in December 2019 quickly spread all provinces of China and was exported all over the world, and as of November 12, 2022, the resulting coronavirus pandemic had caused more than 635 million confirmed cases and more than 6.6 million deaths (WHO, 2022). After announcing the outbreak of the new coronavirus disease 2019 (COVID-19) as a pandemic by the World Health Organization (WHO) on March 11, 2020 (WHO, 2020a), population-level non-pharmaceutical interventions (NPIs) to reduce SARS-CoV-2 transmission were introduced in many countries affected by COVID-19, and these have included border closure, school closures, bans on public events, restrictions on gathering sizes, and requirements to stay at home. On March 15th, 2020, in the Reference laboratory of the Institute of Virology in Tashkent, the first case of SARS-CoV-2 was identified by PCR testing in a citizen of Uzbekistan who recently returned travel from Paris, France (Gazeta.uz, 2020c). Due to rapid implementation of testing, isolation and contact tracing, coronavirus was detected in three close contacts of the patient, and another citizen who returned from Turkey on 16 March 2020 (Gazeta.uz, 2020e). A month before, February, 2020, in order to prevent the import and spread of SARS-CoV-2 and control epidemic situation in the territory of Uzbekistan, a “Special State Commission” (hereinafter — Commission) has been established (Ministry

of Justice, 2020). Since March 16th, 2020, according to Commission decision aimed to control pandemic situation and contain the spread SARS-CoV-2 outbreak a few groups of NPIs, such as travel restriction, quarantine, isolation and social distancing, mainly school closure was implemented, and even requirements through mass media for residents to stay within their homes until situation stabilized (Gazeta.uz, 2020h). In addition to the initial NPIs the multiple and strict social distancing measures, namely traffic closure, venue closure, gathering bans, lockdown and mandatory mask wearing were implemented from March 23th, 2020 across country. The implementation durations of each type of NPI ranged from 18 to 219 days. The longest duration of implementation was observed for mask wearing 708 days (96.9% of study period). In general, the goal of the implementation of any type of NPI was to reduce the reproduction number (R) below the threshold value of 1 and as close to 0 as possible. Several NPIs, including border closure, school closure, social distancing, and lockdown, could reduce R substantially to near or below 1. The Commission decisions on which NPIs to introduce or reintroduce were changed according to the value of R. For instance, border closure measure policy was reintroduced 6 times during the study period. Reintroducing of the policy substantial declined average of R from 1.37 to 0.9.

The crucial role of NPIs, which aims at reducing social interactions, was shown to negatively impact economies and the physical, mental and social well-being of the underlying population (Nicola et al., 2020). Therefore, assessment on the impact of NPIs to reduce the transmission of SARS-CoV-2 was important to justify and validate their

implementation. A clearer understanding of the effectiveness of NPIs will also support future public health decisions regarding their use in response to potential successive waves of COVID-19 and potential future pandemics with similar modes of transmission.

1.2. Research Purpose

The purpose of this study is to evaluate effectiveness of NPIs to reduce SARS-CoV-2 transmission in Uzbekistan and their association with basic reproduction number (R_0).

1.3. Basic reproduction number

Basic reproduction number (R_0) is an epidemiological metric that can be used to assess the contagiousness of infectious agents (Liu and Rocklöv, 2021). R_0 reflects the average number of secondary infections produced by a typical infection case in a population where everyone is susceptible (Huang et al., 2020). Because of the high infectiousness of SARS-CoV-2 among the susceptible population, the calculation of the R_0 is essential for implementing prevention measures (Delamater et al., 2019).

II. LITERATURE REVIEW

2.1. Global efforts to contain of COVID-19 pandemic

The control and containment relevant NPIs aimed to reduce the serious consequences of COVID-19 pandemic were a massive conundrum for all countries across the world. Implementing NPIs was essential before vaccines became widely available. NPIs include case detection and isolation, contact tracing and quarantine, travel restrictions, restrictive closures (mass gathering restrictions, venue closures and school closures), imposing curfews and personal measures including physical distancing and wearing masks. The China was launched draconian countermeasures to prevent the escalation of SARS-CoV-2 (Chen et al., 2020b). The Chinese government began to impose a lockdown measure in the early stage of the pandemic in Hubei province, which is the place considered the first emerged of SARS-CoV-2 (Pan, Cui and Qian, 2020). Furthermore, in Italy, England, Australia and more than 90 countries lockdowns were implemented throughout 2020 and 2021. Interestingly, a few countries did not use the lockdown strategy, including Japan, Sweden, South Korea, Hong Kong, Taiwan, and the USA (except certain States). These countries implemented various types of NPIs and they could contain the SARS-CoV-2 in their territories (Sáfrán, 2022).

2.1.1. Overview implementation of non-pharmaceutical interventions

In 2020, COVID-19 spread worldwide and was officially recognized as a global pandemic. According to statistical data on the pandemic released by Johns Hopkins University, by 12 November 2022, the cumulative numbers of deaths and confirmed cases worldwide had reached 6636,123 and 635,066,217 respectively (JHU, 2022).

Nowadays, new cases of the COVID-19 have been identified in all countries of the world (WHO, 2020d). As the disease has only recently emerged, effective pharmaceutical interventions were not expected to be available for months (Heymann and Shindo, 2020), and healthcare resources have been limited for treating all cases. NPIs are therefore essential components of the public health response to COVID-19 outbreaks, and for other infectious diseases as well (Fong et al., 2020). These include border closure, quarantine and isolation, contact tracing, travel restrictions, school and workplace closures, cancellation of mass gatherings, and proper handwashing for enhanced personal hygiene, among others (Xiao et al., 2020). The positive effects of implementing NPIs in controlling the COVID-19 pandemic were widely studied both at the national (Lai et al., 2020) and international levels (Askitas, Tatsiramos and Verheyden, 2021). However, due to the high social and economic costs of many of the interventions implemented, it is

essential to understand their individual and group effectiveness to optimize implementation and lifting strategies (Nicola et al., 2020).

Such measures aim to reduce the transmission of the virus by delaying the timing and reducing the size of the peak of the pandemic, thus buying time for preparations to be made in the healthcare system and creating the potential for vaccines and drugs to be used at a later stage (Ryu et al., 2020).

The majority of findings are based on transmission models where epidemiological parameters are informed by previous studies or corroborated via simulation. One study analyzed the impact of NPIs using data from different countries and found that the travel restriction, social distancing and mask wearing considered were together effective in reducing transmission rates (Chen et al., 2020c). Moreover, workplace closures, business or venue closures and public event bans were also consistently considered among the most effective measures in reducing the number of cases. Public information campaigns and mask wearing requirements also proved to be effective in controlling the pandemic, while having less disruptive effects on the population than other NPIs (Chen et al., 2020c; Flaxman et al., 2020). In contrast, public transport closure, testing strategies, contact tracing strategies and isolation or quarantine strategies showed no evidence

of being effective in the studies assessed in most of Europe countries in early stage of COVID-19 pandemic (Flaxman et al., 2020).

Several studies conducted in the United States (US) demonstrated that school closure was the most effective in reducing COVID-19 cases during the first wave of the pandemic (Chen et al., 2020c; Flaxman et al., 2020; Ryu et al., 2020). However, some studies on effectiveness of school closure during the COVID-19 pandemic shown that restrictive measure insufficient to mitigate the outbreak of influenza in Russia (Litvinova et al., 2019). In China, it was found that school closure for 2 months was not significantly effective for disease prevention mainly because of the very low incidence of symptomatic disease among school-aged children (Esposito and Principi). Moreover, in Taiwan, it was evidenced that the risk of transmission of infection among children in a classroom was very low, with an R_0 less than 1, clearly highlighting that school closure could be only marginally effective (Pang et al., 2003). Data from the severe acute respiratory syndrome 1 (SARS-1) outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic. Recent modeling studies of COVID-19 from the United Kingdom (UK) using data from Wuhan, China, outbreak predicted that school closures alone would prevent only 2% to 4%

of deaths, much less than other social distancing interventions (Mashamba-Thompson and Crayton, 2020).

Face mask wearing has played an important role in protecting the general public by reducing the incidences of infection through airborne transmission. The face mask worn by a patient can reduce not only the release of virus-carrying droplets into the open air but also the inhalation of the virus-carrying droplets from the open air (Ferguson et al., 2020). Analyses comparing infection rates in Hong Kong, Japan and South Korea, and the US and the UK where general consensus as to whether face coverings should be mandatory in community (nonmedical) settings, have provided ample evidence on the efficacy of face coverings to slow transmission (Liao et al., 2021). Moreover, a small retrospective cohort study from Beijing found that mask use by entire families before the first family member developed COVID-19 symptoms was 79% effective in reducing transmission (OR: 0.21, 0.06-0.79) (Martin et al., 2020). A case-control study from Thailand found that wearing a medical or non-medical mask all the time during the contact with a COVID-19 patient was associated a 77% lower risk of infection (OR 0.23; 95% CI 0.09-0.60) (Mendez-Brito, El Bcheraoui and Pozo-Martin, 2021). Several small observational studies with epidemiological data have reported an association

between mask use by an infected person and prevention of onward transmission of SARS-CoV-2 infection in public settings (Chu et al., 2020).

The travel restrictions, such as, border closure and international flight cancelation were highly effective at reducing exportation of cases in Wuhan (Grépin et al., 2021). The studies investigated the impact of the Wuhan travel measures, there was a consensus that the measures led to a 70 – 77% reduction in the number of cases exported internationally through early to mid-February (Anzai et al., 2020). However, one scientific study, proven by a simple statistical analysis, has shown that international air flights are less significant for the development of the COVID-19 pandemic. According to this paper travel ban on international flight majority countries could be divided into 3 categories: the ones that prohibit entry of foreigners, besides a few exceptional cases; the countries that welcome travelers from most states, but generally send them to a mandatory 10-14 days quarantine upon arrival; and the countries in which neither of the two types of restrictions exist. Four countries have picked from each category, and an unpaired t-test was performed to compare the monthly number of COVID-19 infection cases during 24 May 2021 and 24 June 2021 to determine whether these numbers show a strong correlation with the type of preventative measures that places a country in one of the three categories. The comparison of the "closed borders" countries with the ones

that permit most travel, but impose a quarantine period on most passengers yielded a P value of 0.242, and a different test with the countries that do not require quarantine exhibited a value of 0.535. A t-test between the two categories of open border countries revealed a P value of 0.478. All of these values suggest that the difference between the monthly increases in COVID-19 patients in any of the three categories of countries was not statistically significant. This analysis was crude and did not account for any other factors that might influence the spread of the epidemic in a particular region, being therefore insufficient to make any certain and specific conclusions. Still, even this simplistic analysis illustrated the general idea that restricting flights did not provide a state with a guaranteed protection from the pandemic, and that air travel was not the most significant factor that influences its spread. Moreover, even in the rather delicate case of avoiding the introduction of the COVID-19 into one of the few currently existing COVID-19-free countries, a modelling study showed that simple methods of prophylaxis (preliminary PCR testing, mask use and contact tracing) can ensure a low risk of COVID-19 spread for the passengers who come from the countries with a good epidemiological situation (Chen et al., 2020d).

Public transportation is easy to accelerate the spread of the pandemic. In order to cope with COVID-19, Chinese governments at all levels have strictly

controlled urban transportation. Many transportation policies are aimed at preventing the spread of the virus and protecting people's health more effectively (Wilson, Baker and Eichner, 2020). From the end of January to the beginning of February of 2020, the Center diseases control (CDC) of Hunan province received 6 suspected cases of COVID-19. Investigations revealed that these cases were all on a same bus with a confirmed patient on January 22nd, 2020 (Chen et al., 2020d). In addition, there were 13 infected people taking a same bus as reported, illustrating the possibility of aerosol transmission on buses (Chen et al., 2020d). The study found that coronavirus is highly infectious within a maximum distance of 4.5 m of a closed air-conditioned compartment. The virus can float in the air for at least 30 min and cause infection. There are still many cases of this kind of infection, which deeply remind people of conventional safety problem of urban public transport. The existing buses can't ensure the public health and safety of passengers at current situation. Based on this, Italian Lombardia President Attilio Fontana said he and 12 other regional mayors believed that public transportation should be suspended to prevent the spread of COVID-19 (Chen et al., 2020d).

Lockdown was increasingly implemented in Europe during the COVID-19 pandemic waves, especially in first wave. It is a colossal measure that was previously implemented only in Italy, Spain, France and Austria, following the

example of China (Figueiredo et al., 2020), to curb the dramatic increase of hospitalizations and admissions to ICU that resulted in saturation of the healthcare system. However, as opposed to the rigorous measures implemented in Hubei, Italian authorities allowed residents to continue working, as well as eating out until 6 o'clock in the evening if they maintain a one-meter distance to other guests (Iezadi et al., 2021). A few studies showed that, early enforcement of lockdown, when the incidence rate is not high, contributed to a shorter duration of lockdown and a lower increase of the case growth rate in the post-lockdown era (WHO, 2020c).

2.2. Governmental response on COVID-19 in Uzbekistan

Several of NPIs have been implemented step-by step to contain the spread and reduce the size of the outbreak of COVID-19 in Uzbekistan since the day after first case was detected in the patient who came from France on 15 March 2020 (Kun.uz, 2020). The aim of these measures was to significantly increase the social distance between individuals to break the chains of transmission and reduce COVID-19 spread. At that time, detailed knowledge on the biology and transmission modes of the SARS-CoV-2 virus was limited (Chen et al., 2020a). Tedros Adhanom, a WHO General-director, said "we didn't know then what we know now" about preventive measures and treatment methods on SARS-CoV-2 (WHO, 2020b). Uzbekistan focused on implementing traditional health care

measures which have been experienced in preventing and controlling other epidemics to contain the spread of the virus among the population. The COVID-19 disease trend was not become the same in all regions of the country. In large areas, mainly densely populated, there was a high incidence of disease (Figure 1). However, despite this, the NPIs were implemented in all regions in the same way. In Uzbekistan the large-scale non-pharmaceutical interventions were implemented in three stages, depending on the increased number of the COVID-19 cases, including preventing the imported cases, reducing internal and interregional transmission, and containment. In first stage, travel restriction on international flights, land border closure, isolation and quarantine measures were implemented to contain or combat imported cases in Uzbekistan. Second, implemented a sort of social distance measures, including a domestic travel ban, closure of educational institutions and work activities, public event ban in order to reduce the number of cases and contacts over the country. Third, the implementation of extreme measures of social distancing, including mobility restrictions, mandatory face mask wearing, stay-at-home requirements and lockdown helped control the first month of the SARS-CoV-2 pandemic in Uzbekistan.

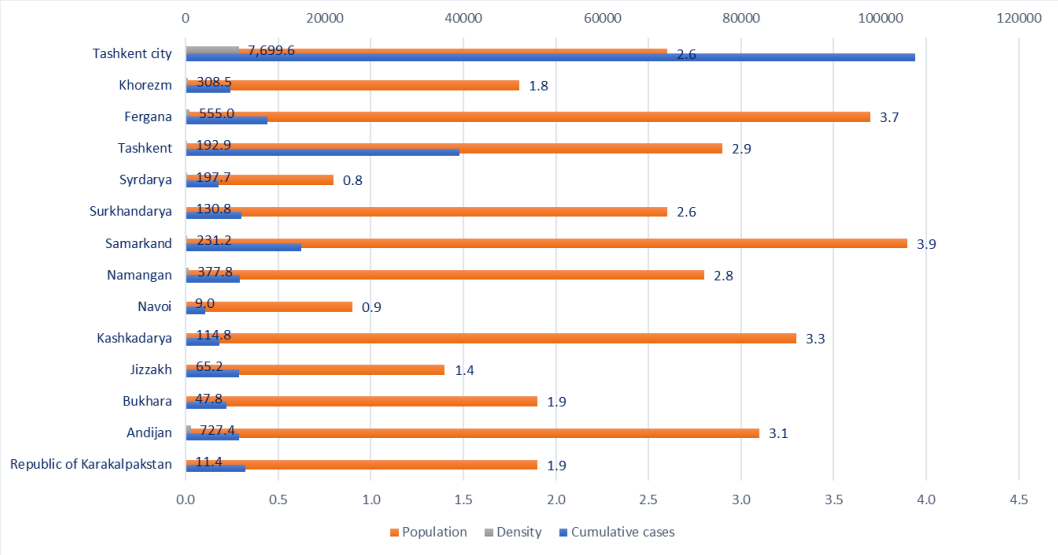


Figure 1 Cumulative cases of COVID-19 by regions of Uzbekistan as of 15 March 2022

The chart shows the association COVID-19 cases with density and number of populations. Blue Clustered bar is cumulative cases of COVID-19, orange is number of populations, and brown bar is density of population.

2.2.1. Border closure

Since March 16th 2020, in order to reduce of the imported cases to the country, international flights were cancelled and land cross borders closed for foreigners by the decision of Commission (Gazeta.uz, 2020h). It was organized that Uzbek citizens abroad were brought only by special charter flights. Citizens arriving from another country through land border posts and charter flights were quarantined for 14 days and tested to COVID-19. For 10 days from the date of

detection of the COVID-19, a total of 3,800 passengers who arrived by charter flight and about 7,450 who entered the country through the land border were quarantined (Gazeta.uz, 2020g). The implementation of the quarantine and isolation measures for passengers who have arrived from abroad was effective in detection of new cases. The Ministry of Health Republic of Uzbekistan report 102 imported cases out of 263 total cases confirmed in 7 regions of the country within the 25 days of implementation of this policy. In three regions, including Tashkent city incidence was distributed among the close contacts of the patients, who had come from France and Turkey before March 15th 2020. The patients in the other 4 regions were tested positive during their quarantine period and isolated in the local special COVID-19 hospitals (Figure 2). A strict travel restriction proceeded until May 16th 2020. In other words, travel restrictions on international flights were impacted to contain the spread of SARS-CoV-2 in the early stage of the pandemic in the country (Figure 3).

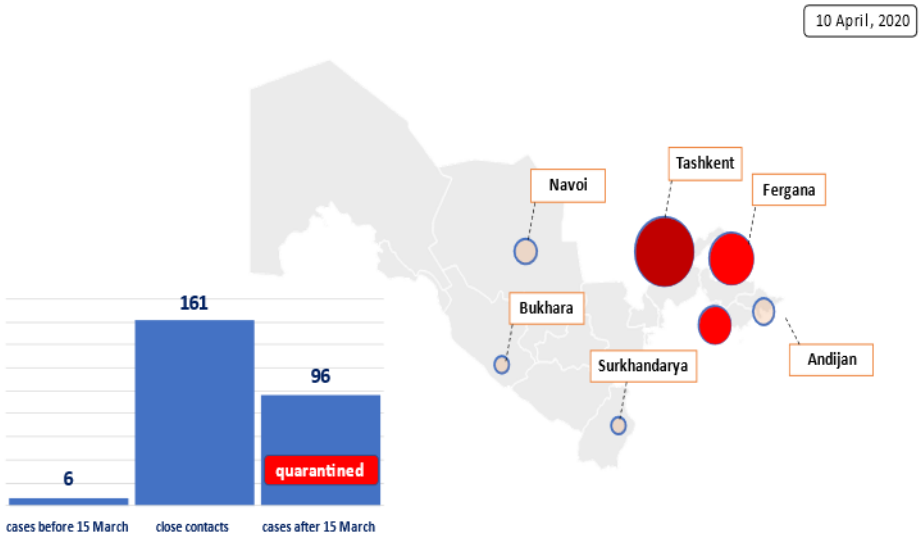


Figure 2 Spread of virus across the territory, before-and-after March 15th 2020
Comparable analyses on the efficacy of extreme NPI

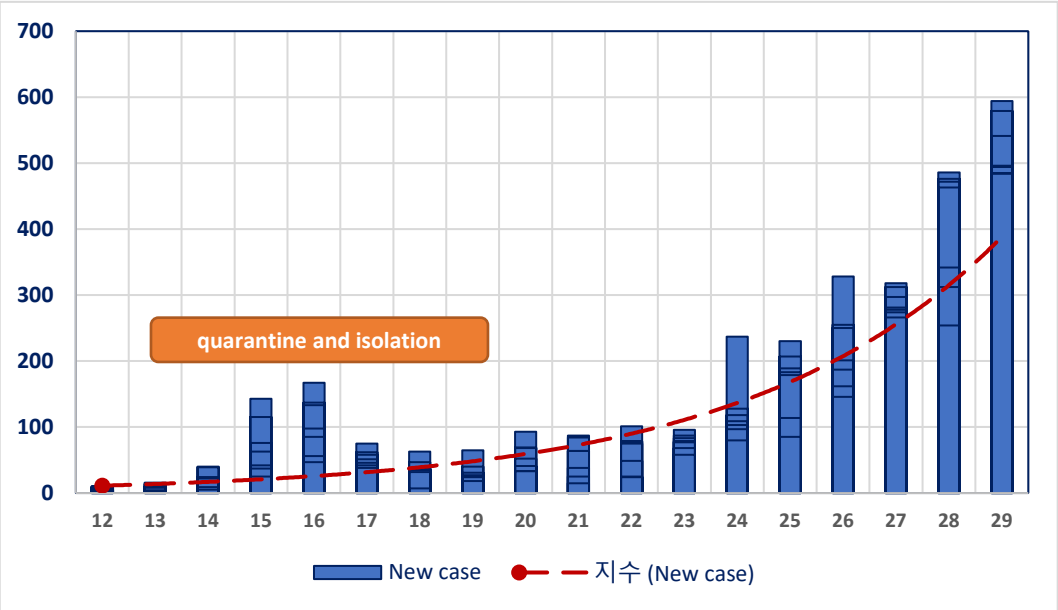


Figure 3 Comparing weekly new cases before and after implementation of border closure measure on COVID-19 in Uzbekistan 2020
X-axis is weekly number of new cases. Y-axis is number of weeks of the year. Exponential red line is showing a significantly increasing number of daily cases after relaxed governmental intervention.

2.2.2. Educational institutions closure

Several studies demonstrated that children younger than 10 years can experience an asymptomatic disease, but they are considered as carrier of infection among their family or relevance. Since, 16 March 2020, in order to control and contain transmission of coronavirus in every layer of the population spring semester was postponed by decision of the Commission (Gazeta.uz, 2020h). Furthermore, disinfection measures were carried out in educational institutions during the holiday, and community centers provided with essential medicines and

disinfectants (Gazeta.uz, 2020a). Although, such activities were canceled by the WHO, more precisely, were considered ineffective (WHO, 2021).

The school closure measure was implemented step-by-step across the country, first of all in Tashkent, Namangan and Fergana regions where initial cases were already detected. Later, all schools in the country were closed, and classes were transferred to the online. Despite the closure of schools, the first wave of COVID-19 was observed in territory of Uzbekistan. For this reason, on September 14, the 2020/2021 academic year began in secondary schools of Uzbekistan. Only 25.5% of schools in Uzbekistan (2,550 out of 9986) resumed the academic year in the traditional form (Gazeta.uz, 2020f). In the first month of the 2021 average level of reproduction number was 0.7-1.0 due to implementation of proper NPIs. Although the epidemiological situation on COVID-19 was somewhat improved, this is perhaps due to limit testing capacities or changes in testing policy. Because of the lifting of some NPIs and relaxation, the work activity of educational institutions was fully restored. However, in mid-March 2021 there was a sharply increase in COVID-19 new cases in Uzbekistan (Figure 4). Result of this resurgence in Uzbekistan was the second wave of the COVID-19 pandemic.

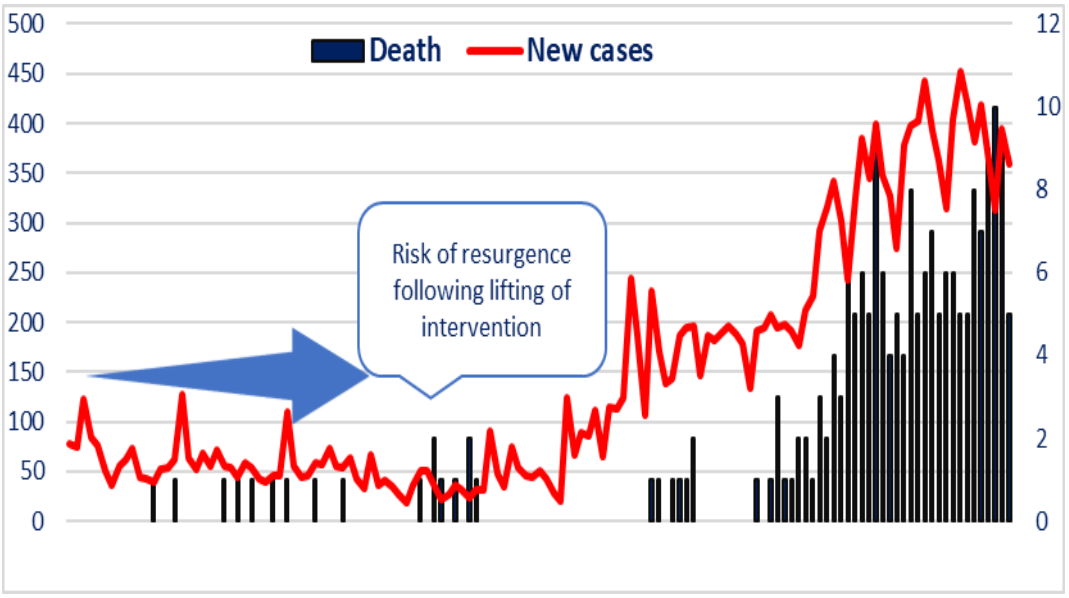


Figure 4 Efficiency of school closure measure at the mitigation (easing) stage of the SARS-CoV-2 pandemic in the beginning of 2021 in Uzbekistan.
Red line is number of new cases. Stacked column (dark blue) is number of the death.

2.2.3. Social Distancing

As noted above, the penetration of coronavirus into our republic, as well as the preservation of the epidemiological stability of the population and the reduction of the negative consequences of the pandemic, forced the acceleration of measures to combat the disease. Messages and videos provided through social sites and TV increased public awareness of the virus. The situation in the global, especially in Europe, including Italy and France, caused a feeling of fear in all people. Of course, this situation has been a good option for those who mark Anti-disease measures, policymaker. For instance, in Uzbekistan at the beginning of the pandemic, 75.4%

of participants in a survey among the population supported the non-pharmaceutical interventions carried out (Gazeta.uz, 2020e). After that, all governmental interventions were implemented according to the following schedule (Table 1). Imposing NPIs, such as private gathering bans and closing schools and workplaces had significant effects on reducing COVID-19 cases.

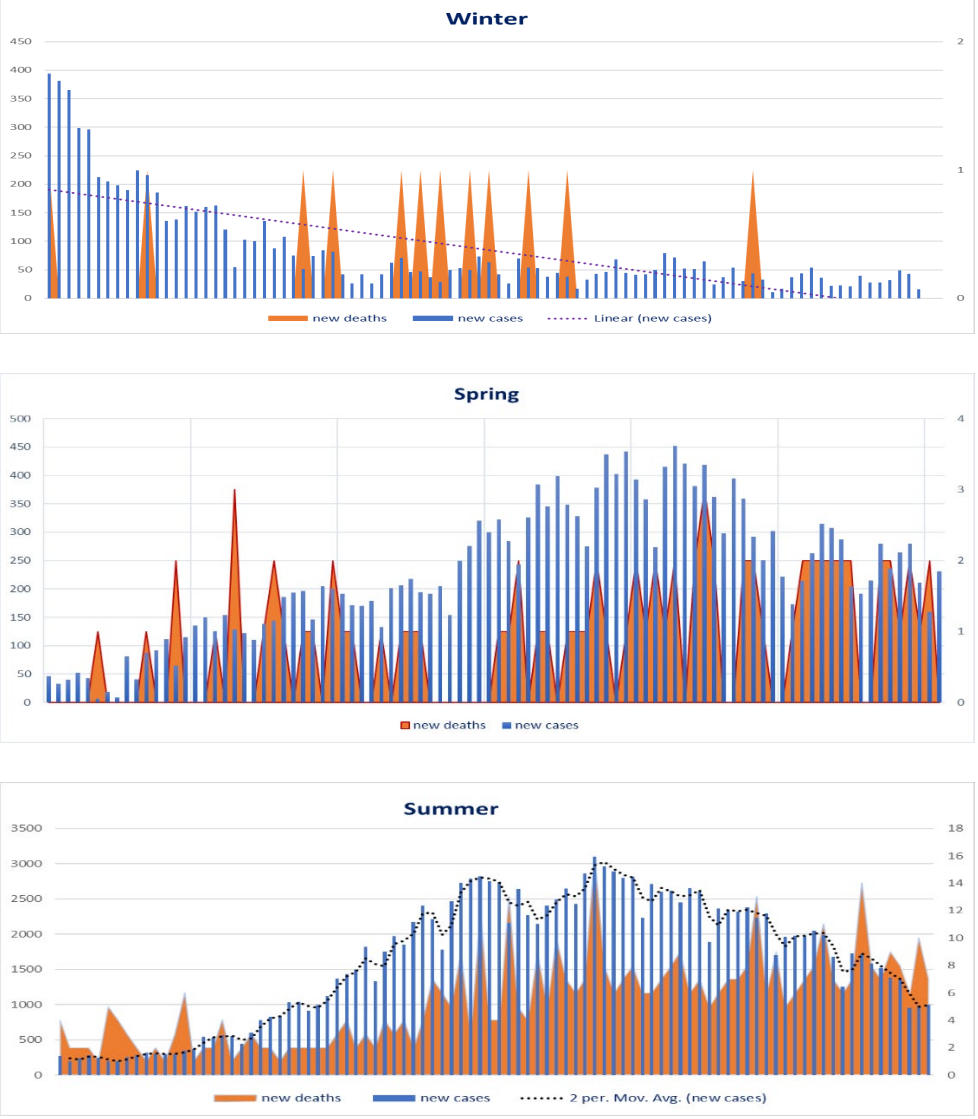
Besides, we focused on the dynamics of the spread of the COVID-19, we defined that the growth of the new cases was observed mainly in the summer season of the year (Figure 5). In Uzbekistan during the summer months lots of people provide wedding ceremonies or events where many other people gather. It leads contact individuals. Tragically, all of the COVID-19 pandemic waves were observed precisely in the summer months in Uzbekistan.

Nevertheless, the first wave of the pandemic occurred in the beginning of summer, and proceeded until November 2020. COVID-19 pandemic reached its peak in Uzbekistan due to relaxation of a few NPIs, such as border closure, lockdown and bans on public gatherings of more than ten people, requirements to stay at home. Number of new cases and deaths increased dramatically. Health care system was overloaded, hospital and ICU beds insufficient, medical supply and manpower as well. Due to the extremely increasing number of infected patients with COVID-19 Commission decided to convert big shopping malls and sport

complexes to field hospital or distribution centers in the big cities. There, depending on the severity of the disease and age (especially children and elderly) patients were transported to special COVID-19 hospitals. The real COVID-19 outbreak rate was perhaps much higher than reported because of lack of PCR and testing kits. The Commission permitted Private laboratories to conduct polymerase chain reaction (PCR) tests for COVID-19.

Moreover, the second wave of the COVID-19 pandemic was observed in summer 2021 in Uzbekistan. Almost most of NPIs, border closure, school closure, venue ban and intercity public transportation bans were lifted, and some of them, mass gathering ban (more than 50 people) and mask wearing (indoor) were mitigated before another wave of the COVID-19 in the country. A range of changes in terms of preventive measure policies resulted in an increased number of patients and deaths, even reinfected people. The health system was ready for this situation. Patients with mild symptoms of the disease were advised to implement treatment measures at home, and free medication was delivered for them. All social distancing governmental measures were reintroduced to contain the current epidemic situation and reduce transmission of SARS-Co-2 among the population and consequences of COVID-19, mostly deaths rate. Reintroducing preventive social distancing measures was not strict, for instance, imposed curfew after 9 o'clock in the evening,

supermarkets and restaurants worked until 7 pm, praying events performed in the open-air, requirement on keeping social distance, sport events conducted without fans, more than 50 people not allowed to attend wedding ceremonies.



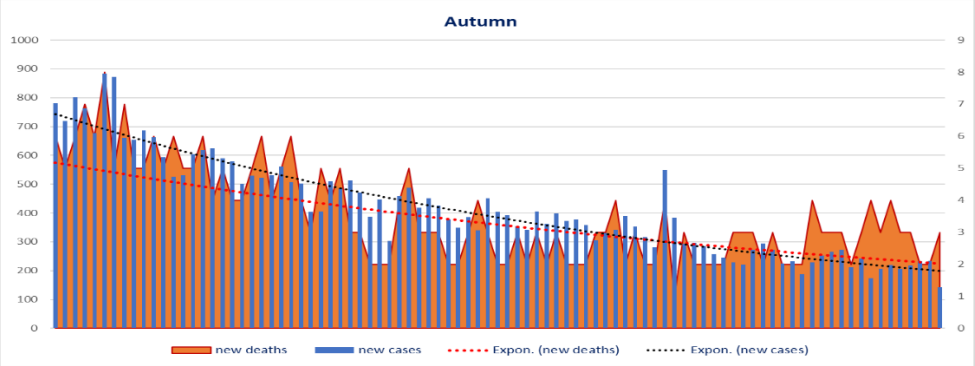


Figure 5 COVID-19 daily new cases and death ratio during the season of the year
Clustered column is new cases (blue), Stacked area is death case (orange)

Table 1 Measures aimed at maintaining social distance in Uzbekistan

Date (2020)	№	Measures addressed to social distance
16 March	1	Announced the closure of cinemas, cancellation of mass events and football matches
	2	All governmental and non-governmental organizations have been instructed to stop meetings
17 March	3	Domestic tourist tours suspended
	4	All religious denominations have canceled services
19 March	5	Children's playrooms, discos, disco bars, massage parlors were closed
	6	Zoo, park and resorts were closed
21 March	7	Catering establishments and entertainment facilities were closed
22 March	8	Public transport was suspended in Tashkent*
23 March	9	All workplaces in Tashkent were closed
	10	Weddings and other events involving more than 15 people are prohibited

24 March	11	All non-food markets and shopping centers were suspended in Tashkent
27 March	12	It was forbidden to gather more than three people. In public places, the observance of a social distance between people of 2 meters was introduced.
	13	Movement of all types of transport between the regions was suspended

*- Due to the fact that the first case of the disease was detected in Tashkent, as well as the large number of patients, that is why interventions were implemented primarily in Tashkent.

2.2.4. Mask wearing

One of the major strategies in preparedness and response to COVID 19 is effective utilization of personal protective equipment (PPE) among which the masks of different kinds are on the top of the list especially for activities in the public places. According to Degree of Commission since March 23, 2020 it was prohibited to be in public places without personal protective equipment (masks) throughout Uzbekistan. In a nutshell, face mask wearing was mandatory since that day (Gazeta.uz, 2020d). In some countries, mask wearing has been set to be mandatory, however in some states this regime has been voluntary whether recommended to wear a mask in public places. For instance, in Korea the administrative order for mandatory mask wearing has been implemented as of August 24, 2020 (Seoul, 2020). Later on, starting November 13, 2020 imposed fines (penalties) on those who violate the regulations for disease control and prevention,

such as wearing a mask, at multi-use facilities with a high level of transmission. Fines has been set at 100,000 KRW (75$ in US dollar) for violators (Seoul, 2020). In Japan, mask wearing hasn't been compulsory even during the major detection of COVID-19. It has been recommended to wear a mask when talking to others at a distance of at least 2 meters (Japan, 2020). From March 25, the fines in the amount of 1 basic calculated amount (223,000 Uzbek som, approximately 25$ in US dollar) was issued for violation of mandatory mask-wearing regulation, in case of repeated violation, the fines were 3 basic calculated amounts (669,000 Uzbek som, 75$ in US dollar) (Gazeta.uz, 2020b).

The consequences of the pandemic caused a sense of fear in all people, which was why wearing a mask was warmly accepted by the population of Uzbekistan and this regulation was strictly observed.

At the end of February 2022, the spread rate of COVID-19 was 0.4%, while according to WHO standards, with an indicator of less than 1%, the epidemiological situation is considered stable for two weeks. Based on these, the Commission made a decision to cancel one of NPI measures, such as mask wearing in public places from March 1, 2022 in Uzbekistan. At the same time, masks are recommended to be worn in public transport, shopping malls, markets, mosques, cinemas and other entities (Gazeta.uz, 2022).

2.2.5. Lockdown

In order to reduce the negative consequences of the SARS-CoV-2 pandemic and control epidemic situation, and prompt the number of deaths, strict form of social distancing, lockdown was taken in more than 90 countries (WHO, 2020d). As we mentioned in the beginning of the research two waves of COVID-19 were obsessed in Uzbekistan. The first was from April 6 to May 10, 2020, other one was lasted approximately 30 days (WHO, 2021). In all waves R_0 was increased, this led to implementation of strict preventive measures. The aim of this measure was minimization physical contact between potentially infected individuals and healthy people, and to reduce health-care demand.

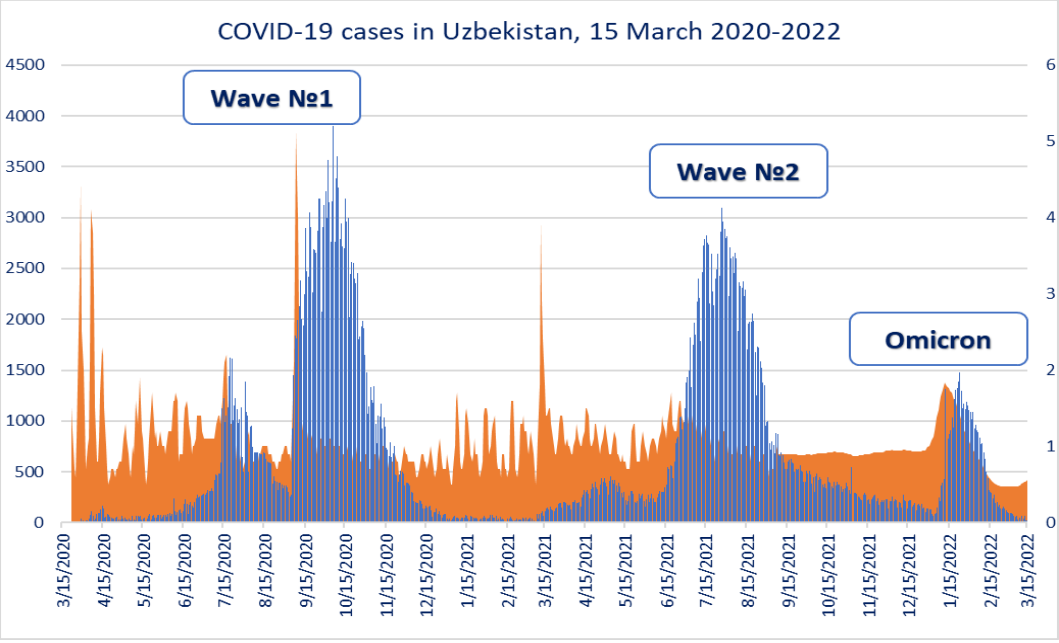


Figure 6 COVID-19 cases in Uzbekistan between 15 March 2020-2022

This type of chart demonstrates that of daily new cases and reproduction rate of the SARS-CoV-2 was dramatically increased during the first and second waves pandemic in Uzbekistan. Clustered axis (blue color) is daily new cases, and "Area" axis (orange color) is reproduction rate of COVID-19.

III. METHODOLOGY

3.1. Research design

A retrospective study is used to estimate the effectiveness of each and subgroups of the NPIs in the study period. Typically, non-pharmaceutical interventions should reduce the rate of R while it is implemented. We will estimate the effectiveness of NPIs through increasing or decreasing R.

3.2. Data collection

Information on the number of COVID-19 daily cases confirmed by PCR test, and death rate were extracted from a data repository sourced from Johns Hopkins University Center for Systems Science and Engineering, which archive data from the official website of Ministry of Health of the Republic of Uzbekistan between 15 March, 2020-2022.

Data pertaining to the implementation of NPIs were obtained from official (governmental) webpages of high-circulation newspapers published in Uzbekistan (gazeta.uz, kun.uz, ssv.uz (in a governmental language)). In brief, first recorded any legal NPIs announced by the government of implementation date [i.e., start date

and end date (if applicable before the study end date)]. Moreover, we had received findings on policy changes, the lifting or reintroduction of implementation of the NPIs from the websites mentioned above during the study period.

3.3. Variables

3.3.1 Dependent variables

In our study the dependent variables are all types and subgroups of the NPIs (border closure, school closure, public gathering bans, venue closure, traffic restriction, mandatory mask wearing and lockdown) introduced by Commission during the study period.

3.3.2. Independent variable

In this study chosen basic reproduction number (R0) as independent variable, which presents the average number of new cases generated by an infected person, to estimate the changes in COVID-19 transmissibility.

3.4. Case definition

In order to assess their effectiveness, we categorized governmental measures, the NPIs into following groups: border closure, school closure, public gathering bans, venue closure, traffic restriction, mandatory mask wearing (referred to as mandatory mask hereinafter) and lockdown. Every imposing social intervention is grouped into three periods, as “no measure” (no interventions were

held (assigned 1)), “moderate” (restrictions were eased (assigned 2)) and “strict” (extremely social distancing (assigned 3)).

3.5. Data analysis

First, we decided to calculate of R_0 based on epidemiological or mathematical formula as R=BT (Alimohamadi, Taghdir and Sepandi, 2020), using Microsoft Excel software. The formula represents as below:

- R_0 is the reproduction number, the total number of infections caused by an infectious person.
- B is the contact rate, number of new cases per day.
- T is duration infectability of the infected individuals.

Epidemiological facts for NPIs argue that preventive measures should decrease R_0 by decreasing B, while T is isolated.

Second, Ordinal Logistic Regression analysis was used to determine the influence of reproduction number in implemented NPIs, such as border closure, school closure, mass gathering bans, venue closure, traffic bans, mandatory mask and lockdown. The data is presented in a Table 4 using p-value (<0.05), odds ratio and 95% confidence interval.

Third, we estimated the impact of the NPIs policy change periods to the average number of R_0, and duration of each period for each governmental measure. Then, we grouped them into 1st decision, 2nd decision, 3rd decision..... and so on.

Finally, we estimated governmental interventions introducing time, which was defined as the number of days between the date of activation of the first NPI and the date on which the first case was reported. Duration for which a type of NPI was implemented to control for the potential effects of implementation duration.

All statistical analysis were performed using Ordinal Logistic Regression (Jamovi 2.2.5.0. version) and Microsoft Excel. P value was considered statistically significant (<0.05).

IV. RESULT

In this study we estimate implementation of the NPIs to contain and control COVID-19 pandemic in Uzbekistan during the study period. The duration of the governmental measures and restriction level were changed according to the pandemic situation. Table 1 illustrates that although the border closure measure began on the first day of the pandemic, strict restrictions were continued for 82 days (11.5%). A slight normalization of the epidemiological situation of disease mitigated strict restrictions, and lasted 328 days (44.9%). No measure period was 319 (43.6%), respectively. School closure measure was one of the NPIs which implemented in early stage of the pandemic in the country. And it lasted “strict restriction” 182 days (24.9%), “moderate” level 352 days (48.2%), “no measure” level 197 days (26.9%), respectively. Mass gathering bans and venue closure include social distancing measures, therefore “strict restrictions” were implemented at the same duration, such as 165 days (22.6%) and 164 days (22.4%). “No measure” and “moderate” levels were proceeded 178 days (24.1%) and 388 days (53.1%), 268 days (36.7%) and 299 days (40.9%), respectively. This study also revealed that one of the interventions implemented for another long period was mandatory mask wearing (“no measure” 53 days (7.3%), “moderate” 425 days (58.1%), “strict restriction” 253 days (34.6%), respectively). The frequencies of the

traffic bans were “no measure” 251 days (34.3%), “moderate” 374 days (51.2%), “strict restriction” 106 days (14.5%), respectively. It was found that duration of the implementation of “strict restriction” in lockdown period was 69 days (9.4%).

Table 2 Frequencies of non-pharmaceutical interventions between 15 March 2020-2022 in Uzbekistan

Border closure		
Levels	**Counts**	**% of Total**
no measure	319	43.6 %
moderate	328	44.9 %
strict	84	11.5 %
School closure		
no measure	197	26.9 %
moderate	352	48.2 %
strict	182	24.9 %
Mass gathering bans		
no measure	178	24.4 %
moderate	388	53.1 %
strict	165	22.6 %
Venue closures		
no measure	268	36.7 %
moderate	299	40.9 %
strict	164	22.4 %
Mandatory mask wearing		
no measure	53	7.3 %
moderate	425	58.1 %
strict	253	34.6 %
Traffic bans		
no measure	251	34.3 %
moderate	374	51.2 %
strict	106	14.5 %
Lockdown		
no measure	127	17.4 %

moderate	535	73.2 %
strict	69	9.4 %

In the governmental newspaper webpage where we extracted duration of the implementation of NPIs we found that policy in terms of governmental interventions against COVID-19 was changed several times according to epidemiological situation of disease. This study illustrated that how many times each NPIs imposing policy changed, average reproduction number at that period, overall days between policy change and median days for governmental response during the study period. A significant aspect is that the governmental response imposed were implemented as a result of an increase in R_0. Table 3 showed that border closure measure policy was changed 6 times in the study period. In "no measure" period average R_0 was 1.35 conditionally, overall days between policy change 64 days, "2nd decision" R_0 was 1.18 (54 days), "3rd decision" R_0 was 1.07 (143 days), "4th decision" R_0 was 1.05 (155 days), "5th decision" R_0 was 1.06 (120 days), and in the final cancellation period R_0 was 0.9 (195 days). Median days for impose NPIs was 131.5 /IQR: 78.0 - 152.0/. The least changed governmental response policy was school closure, and it was 3 times. At the first "no measure" period, the R_0 was high, 1.25 (183 days), "2nd decision" R_0 – 1.03 (352 days), lifting period R_0 – 0.9 (196 days), median days for NPIs 91.5 /IQR: 0.0 - 192.7/.

Table 3. NPIs policy change periods during the COVID-19 pandemic in Uzbekistan

*NPIs	NPIs policy change periods	Average Reproduction number (*Ro*)	Overall days between policy change	Median days for NPI	Interquartile range	
					Low	High
Border closure						
	1(no measure)	1.35	64	131.5	78	152
	2nd decision	1.18	54			
	3rd decision	1.07	143			
	4th decision	1.05	155			
	5th decision	1.06	120			
	6 (canceled)	0.9	195			
School closure						
	1 (no measure)	1.25	183	91.5	0	192.8
	2nd decision	1.03	352			
	3 (canceled)	0.9	196			
Mass gathering bans						
	1 (no measure)	1.35	9	119.5	79.5	159.5
	2nd decision	1.2	165			
	3rd decision	1.01	143			
	4th decision	1.16	96			
	5th decision	0.98	244			
	6 (canceled)	0.94	74			
Venue closure						
	1 (no measure)	1.31	10	148	114.5	155.3
	2nd decision	1.19	164			
	3rd decision	1.01	143			
	4th decision	1.13	153			
	5th decision	0.95	156			
	6 (canceled)	0.94	105			
Mandatory mask						
	1 (no measure)	1.5	8	75	18.75	219.8
	2nd decision	1.16	253			
	3rd decision	1.03	305			
	4th decision	0.91	30			
	5th decision	0.99	120			
	6 (canceled)	0.4	15			
Traffic closure						
	1 (no measure)	1.5	8	54.5	36.75	132.3
	2nd decision	1.31	70			
	3rd decision	1.2	39			

	4th decision	1.13	36			
	5th decision	0.99	164			
	6th decision	1.13	153			
	7th decision	0.95	171			
	8 (canceled)	0.94	90			
Lockdown						
	1 (no measure)	1.6	22	36	33	62
	2nd decision	1.3	33			
	3rd decision	1.19	62			
	4th decision	1.13	36			
	5 (canceled)	1.01	578			

* NPIs – non-pharmaceutical interventions

Table 4 illustrated that implementation durations of each type of governmental interventions during the COVID-19 pandemic in Uzbekistan. Relatively overall durations of implementation were observed for “lockdown” – 131 days (17.9%), “school closure” – 352 days (48.2%), “border closure” – 472 days (64.6%), “venue closure” – 616 days (84.3%), “traffic closure” – 633 days (86.6%), “mass gathering bans” – 648 days (88.6%), and “mandatory mask wearing” – 708 days (96.9%). The median days of the governmental intervention implementation showed in table 2. It is noteworthy that the lockdown measure was imposed short time in the study period. This definitely might be economic impacts of the non-pharmaceutical interventions. And plus, duration of the social distancing measures such as venue closure, traffic closure and mass gathering bans were almost similar.

Table 4 Overall duration of governmental response implementation by days

Types of NPIs	Overall days of response implementation by days	% of response implementation during study period	Median days of implementation until change of policy /IQR/
Lockdown	131	17.9%	36 /33.0 - 62/
School closure	352	48.2%	91.5 /0.0 - 192.7/
Border closure	472	64.6%	131.5 /78.0 - 152.0/
Venue closure	616	84.3%	148 /114.5 - 155.2/
Traffic closure	633	86.6%	54.5 /36.7 - 132.2/
Gathering bans	648	88.6%	119.5 /79.5 -159.5/
Mask wearing	708	96.9%	75 /18.7 - 219.7/

Table 5 presents the associations between introducing any type of NPIs with increased level of R_0 of COVID-19. The increasing level of R_0 was significantly associated with introducing governmental response to reduce transmission of SARS-CoV-2 among the population. The imposing “School closure” was greater than other type of NPIs to control and contain infection outbreak in the early stages of pandemic in Uzbekistan (OR: 4.45, 95% CI 2.93 – 6.97). Besides, the implementations “border closure” and “mask wearing” also were significantly associated with shifting R_0 of COVID-19 ((OR: 2.21, 95% CI 1.59 – 3.12), (OR: 2.75, 95% CI 1.87 – 4.25)). The social distancing measures, namely venue closure, mass gathering bans and traffic bans were generally associated with increase in the R_0 (OR: 1.41, 95% CI 1.04 – 1.94), (OR: 1.5, 95% CI 1.08 – 2.09), (OR: 1.38, 95%

CI 0.99 – 1.91), respectively. No significant association was observed for "lockdown" (OR: 1.43, 95% CI 0.92 – 2.08).

Table 5 Associations of individual type of NPIs with the R_0 of COVID-19.

	p	Odds ratio	95% Confidence Interval	
			Lower	Upper
Traffic bans				
*R_0	0.05	1.38	0.998	1.91
Venue closure				
R_0	0 .028	1.41	1.04	1.94
Lockdown				
R_0	0.066	1.43	0.972	2.08
Mass gathering bans				
R_0	0.015	1.5	1.08	2.09
Border closure				
R_0	< .001	2.21	1.59	3.12
Mask wearing				
R_0	< .001	2.75	1.87	4.25
School closure				
R_0	< .001	4.45	2.93	6.97

*R_0-basic reproduction number

V. DISCUSSION

This comprehensive retrospective study was carried out in order to assess the effectiveness of the implementation of the NPIs, namely border closure, school closure, mass gathering bans, venue closure, traffic closure, mandatory mask wearing and lockdown by the Government of Uzbekistan to prevent coronavirus infection during the COVID-19 pandemic last two years. All NPIs implementations involving distancing were associated with a change in the level R_0 of COVID-19. Moreover, estimated impact of the policy changes of governmental response to contain and control transmission of SARS-CoV-2 in the country.

The results of our study were concluded that the implementation of NPIs was associated with an increase in transmissibility. The difference of our study from other studies is that we have shown that the increase in reproduction number is mainly due to the introducing by the Commission of NPIs aimed at preventing the disease.

Most previous studies have investigated the effectiveness any type of NPIs (Bo et al., 2021). The overall reduction of infections in mainland China was close to 10% by 31 January 2020, with a relative reduction of infections across specific locations ranging from 1 to 58%(Chinazzi et al., 2020), and mandatory mask wearing was most effective in the early stage of coronavirus outbreak in European

countries (Bo et al., 2021). Social distancing measures implemented during the COVID-19 outbreak reduced community transmission by 44%, which was much greater than the estimated 10–15% reduction in influenza transmission conferred by school closures implemented alone during the 2009 pandemic in Hong Kong (Kwok et al., 2020). A preprint study estimated that the school closure resulted in a 5.6% (95% CI 4.1–6.9) reduction in coronavirus infections in Wuhan, China (Viner et al., 2020). Overall, school closing was found to be the most effective measure: 14 out of 24 studies (58%) that analyzed this NPI found an association with reduced number of cases and its implementation (Mendez-Brito, El Bcheraoui and Pozo-Martin, 2021). The partial lockdown with curfew was more effective than full restriction (Nanovsky, Arynov and Alzhanova, 2021). In general, the NPIs were implemented all over the world to reduce cases of coronavirus infection and eliminate its consequences. In neighbor countries, namely Kazakhstan, Kyrgyzstan and Russia were also implemented strict intervention to contain transmission of COVID-19. Uzbekistan and Kazakhstan's government response policy against coronavirus was quite similar to reduce social and economic consequences of COVID-19 pandemic. Kyrgyzstan and Russia were not implemented strict restriction measures, such as fully lockdown and venue closure and so on, except curfew.

One of the ecological studies conducted in 190 European countries during the COVID-19 pandemic to estimate effectiveness of different NPIs and their combinations. In this study included a total of 415 sites between 23 January and 13 April 2020. According to research, implementation two or three any type of NPIs, namely ‘distancing + mandatory mask’, ‘distancing + quarantine’ and ‘distancing + quarantine + mandatory mask’, ‘traffic + quarantine + mandatory mask’ were combinate at same time. In a result, the simultaneous implementation of two or more types of NPIs may be more effective for containing the spread of COVID-19(Bo et al., 2021).

Our study has several important strengths. First, we captured the available data on confirmed cases of COVID-19 infection and legal NPIs implemented from Uzbekistan, which suggests that our findings are applicable in several sites of country. The information obtained from the website was enough to partially assess the effectiveness of the work carried out in the country against the coronavirus.

Second, this study was the first scientific work to evaluate what was done during the pandemic, as a result of which it also showed what measures should be taken by policymakers in the future to prevent any kind of infectious outbreak above all during the pandemic period.

The only limitation our study that we have encountered was that, there was no literature or scientific research on Governmental response by the Government of Uzbekistan, mainly the Ministry of Health, that assesses the effectiveness of the work to combat the coronavirus infection during the COVID-19 pandemic.

In conclusion, we found that any type Governmental interventions, namely mandatory face mask in public, border and school closure, social distancing and traffic restriction, may reduce the spread of COVID-19. Border and school closure and mask wearing seem more effective than the other types of NPIs. The re-decision by policymakers based on an increase in reproduction number lead to a decrease in the reproduction rate of the COVID-19 and it may be more essential for controlling the spread of coronavirus infection.

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