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REVIEW ARTICLE

Dissection of non-pharmaceutical interventions implemented by Iran, South Korea, and Turkey in the fight against COVID-19 pandemic

Mohammad Keykhaei[1] · Sogol Koolaji[1] · Esmaeil Mohammadi[1] · Reyhaneh Kalantar[1] · Sahar Saeedi Moghaddam[1] · Arya Aminorroaya[1,2] · Shaghayegh Zokaei[3] · Sina Azadnajafabad[1] · Negar Rezaei[1,4] · Erfan Ghasemi[1] · Nazila Rezaei[1] · Rosa Haghshenas[1] · Yosef Farzi[4,1] · Sina Rashedi[1] · Bagher Larijani[4] · Farshad Farzadfar[1,4]

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Abstract

Purpose The novel coronavirus disease 2019 (COVID-19) has imposed a great global burden on public health. As one of the most affected countries, Iran has tackled emerging challenges in the path to overcoming the epidemic, with three peaks of the disease propagation as of February 19, 2020. To flatten the curve of the COVID-19 pandemic, most countries have implemented bundles of intrusive, sometimes extremely stringent non-pharmaceutical interventions (NPIs). In this communication, we have dissected the effectiveness of NPIs and compared the strategies implemented by Iran, Turkey, and South Korea to mitigate the disease's spread.

Methods We searched online databases via PubMed, Web of Knowledge, and Scopus. Titles/abstracts and full-texts were screened by two reviewers and discrepancies were resolved upon discussion.

Results Our results provide insights into five domains: prevention, screening, in-patient and out-patient facilities, governance, and management of diabetes mellitus. Analysis of previous efforts put in place illustrates that by fostering efficient social distancing measures, increasing the capability to perform prompt polymerase chain reaction tests, applying smart contact tracing, and supplying adequate personal protective equipment, Turkey and South Korea have brought the epidemic sub-optimally under control.

Conclusion From the perspective of policymakers, these achievements are of utmost importance given that attaining the aspirational goals in the management of the COVID-19 necessities a suitable adjustment of previous successful strategies. Hence, policymakers should be noticed that a suitable combination of NPIs is necessary to stem the disease's propagation.

Keywords COVID-19 · Iran · Non-pharmaceutical interventions · South Korea · Turkey

Mohammad Keykhaei and Sogol Koolaji these two authors contributed equally as the first author

✉ Farshad Farzadfar
f-farzadfar@tums.ac.ir

1 Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, No. 10, Al-e-Ahmad and Chamran Highway intersection, 1411713137 Tehran, Iran

2 Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran

3 School of Advanced Medical Sciences, Islamic Azad University, Tehran Medical Branch, Tehran, Iran

4 Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

Introduction

Since December 2019, the novel coronavirus disease 2019 (COVID-19) has imposed severe challenges on public health, which is thought to be as a result of its short-term and long-term complications [1]. Following the rapid spread of the disease, it was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 [2]. By January 6, 2021, COVID-19 had affected 86,837,053 people worldwide, resulting in 1,876,190 deaths [3]. In the absence of efficient antiviral medication, non-pharmaceutical interventions (NPIs) have played a pivotal role in mitigating the propagation of COVID-19 [4]. Indeed, most countries have implemented bundles of intrusive, sometimes extremely stringent NPIs such as social distancing, self-isolation, travel restrictions, school closure, and lockdown legislations to minimize person-to-person exposures [5–7]. However, the lack of efficient infrastructures, particularly in low and middle-income regions has raised concerns about the inability to cope with the burden of accommodating patients with COVID-19 [8].

As one of the first countries faced with COVID-19, Iran has confronted emerging challenges in the path to overcoming the epidemic, with three peaks of disease transmissions as of February 19, 2020 [9, 10]. Confronting with the COVID-19 pandemic, health officials in Iran have designed several interventions to reduce the epidemic's growth rate, as well as the reproduction number [11, 12]. Despite such efforts, Iran is considered as one of the most affected countries by COVID-19, with a 4.4% case fatality rate, indicating the insufficiency of the measures put in place [9, 11]. On the other hand, with efficient strategies, Turkey and South Korea have brought the transmission of COVID-19 sub-optimally under control [13, 14]. In a recent study conducted by Gul and colleagues [15], the lower fatality rate of COVID-19 in Turkey compared with Germany and Italy was suggested to be as a result of the lower elderly population in Turkey compared with the other ones. However, with partially similar age distribution and socioeconomic pattern with Iran, Turkey has acquired a 0.96% case fatality rate [16, 17]. In addition, South Korea has focused on widespread and rapid testing and close tracking of individuals with COVID-19 rather than locking down the entire cities, which allowed the country to blunt the exponential transmission of COVID-19 [13, 18].

During recent decades, non-communicable diseases (NCDs) have served as the essential contributors to mortality and morbidity globally [19]. Among NCDs, diabetes mellitus (DM) poses as the largest global health concern, affecting 451 million adults in 2017 [19]. Of note, according to the reports of the International Diabetes Federation (IDF), the Middle East and North Africa (MENA) region has the highest world age-standardized DM prevalence [20]. Among countries in the MENA, Iran has faced essential challenges for controlling the imposed burden of DM during the COVID-19 pandemic [21]. In fact, it has been demonstrated that COVID-19 and DM could have reciprocal interactions [21, 22]. The COVID-19 pandemic could restrict the resources for those with DM [22]. On the other hand, DM has been indicated as an essential risk factor for COVID-19 progression [21]. Hence, it is imperative to develop effective action plans for those with DM in the COVID-19 era.

To assess the best strategy to combat COVID-19, policy analysis enables us to address the weaknesses and strengths of diverse strategies [11]. Hence, formulating the operational differences between the mentioned countries' policies is of utmost importance in order to empower evidence-informed policymaking. In this narrative review, considering the importance of the issue, we aimed to investigate the policies against COVID-19 in Iran compared with Turkey and South Korea.

Search strategy and selection criteria

We searched online databases via PubMed, Web of Knowledge, and Scopus. The following keywords and other related terms were applied: Iran, Turkey, South Korea, COVID-19, severe acute respiratory syndrome coronavirus 2 (SARS-COV-2), novel coronavirus, 2019 novel coronavirus (2019-nCOV), social distance, social distancing, mask, face mask, facial mask, infodemic, digital, air quality, air pollution, traffic, reproduction number, reproductive number, contact tracing, contact tracking, screening, polymerase chain reaction (PCR) test, personal protective equipment, hospital beds, subsidies, insurance, and diabetes mellitus. We restricted our search to studies in English and excluded correspondences and conference abstracts. Titles/abstracts and full-texts were screened by two reviewers and discrepancies were resolved upon discussion. We hope our study provides useful insights to understand the untapped potential for the management of COVID-19.

Overview of the COVID-19 outbreak in Iran

Following the transmission of COVID-19 in China, the first confirmed cases of the disease in Iran came on February 19, 2020 [23]. In response, the government launched national and provincial committees to designate different strategies against COVID-19 [11]. On March 3, 2020, the Iranian Ministry of Health and Medical Education (MOHME) compiled the first national guidelines for the prevention and control of the COVID-19 epidemic [11, 12]. Despite the implementation of different strategies, daily new cases of the COVID-19 increased, earning the first peak on March 30, 2020, which indicates the insufficient measures to contain the pandemic (Fig. 1) [9]. Afterward, there was a downward trend in the disease incidence rates, possibly originating from smart social distancing and intercity travel restrictions [11]. However, as the established restrictions were suspended, the incidence rates showed an increase, with the second peak on June 4, 2020 [9, 24]. Thereafter, the number of daily patients with COVID-19 fluctuated, mostly representing a steady-state by mid-September. Since then, Iran has been well into the third wave of COVID-19, with 55,830 lives lost to COVID-19 by January 6, 2021,

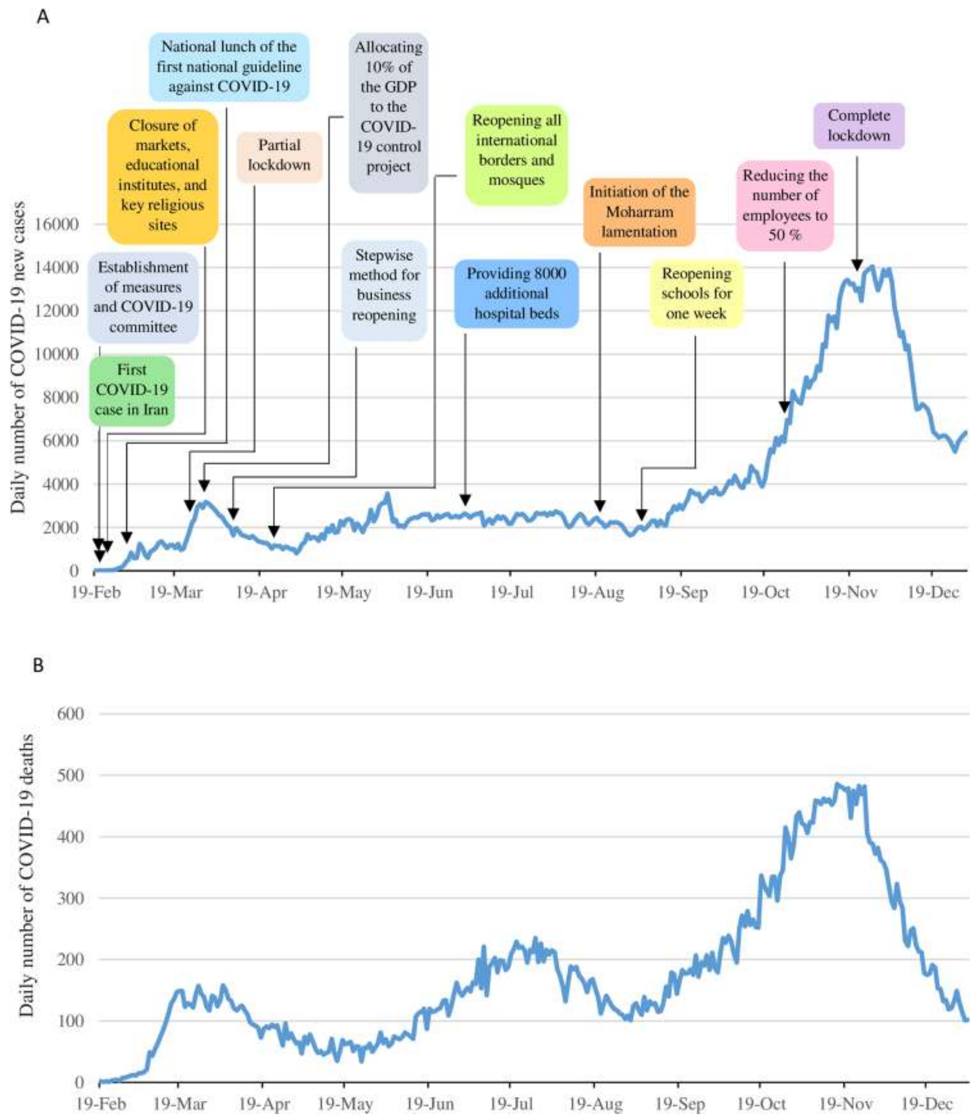

Fig. 1 Incidence and death rates of COVID-19 with key intervention timings in Iran. Data are derived from the Worldometer website. Incidence (A) and death rate (B) trends of COVID-19 are illustrated, as of February 19, 2020. The figure illustrates three peaks of the COVID-19 pandemic on March 30, June 4, and November 27. Abbreviations: COVID-19 = coronavirus disease 2019. GDP = gross domestic product

forcing policymakers to implement lockdown and curfew as of November 21, 2020 [9, 25]. Figure 1 illustrates daily number of COVID-19 new cases and deaths, with three peaks on March 30, June 4, and November 27. In addition, a brief report of the implemented strategies has been mapped in this figure. Interpretation of the causative factors of this phenomenon represents that inability to perform effective social distancing measures, as well as prompt PCR testing and contact tracing scarcity, are considered as the leading causes of increased incidence and mortality during this period [11, 26]. Given the great global burden imposed by COVID-19, applying a comprehensive approach to analyses multiple policy implementations against COVID-19 is inevitable [6]. Therefore, in this study, we categorized the strategies against COVID-19 into five groups and compared Iran, Turkey, and South Korea regarding their achievements and failures to overcome the COVID-19 epidemic.

Prevention

Social distancing

Social distancing, also known as physical distancing, is considered as one of the best NPIs during the COVID-19 epidemic [7, 27]. This method consists of a spectrum, ranging from small gathering cancellation to locking down the entire cities. The prosperity of such measures highly relies on the duration of the confinement, extent of the social mixture restrictions, and the precise nature of the interventions [4, 28]. So far, several studies have addressed the casual pathway, linking social distancing with flattening the curve of COVID-19 incidence rates [4, 29, 30]. In support of this concept, a recent study quantified the impact of thousands NPIs implemented in different regions, indicating that social distancing methods such as small gathering cancellation and closure of education institutes were of the most effective methods to curb the spread of the COVID-19 [4]. In a meta-analysis on 26 studies, social distancing and screening tests were considered as the most cost-effective alternatives to refine the COVID-19 pandemic [29]. Moreover, in a study that assessed the effectiveness of social distancing in Iran, it was suggested that the implementation of this method induced a decrease in COVID-19 incidence patterns [31]. However, afterward, analyzing the pattern of the COVID-19 incidence represents an upward trend, proving the considerable flaws in performing desired methods [9]. Thus, we categorized and compared social distancing methods applied in Iran, Turkey, and South Korea as follows:

Prohibitions and restrictions

To address the efficiency of the prohibitions, we tried to use several measures in order to quantitatively compare several methods applied in the three countries. First, traffic and travel bans are often the first component of social distancing methods in response to highly transmissible infections [30]. Consistent with this issue, a decrease of 80% in terrific volume was reported in Daegu city following the detection of the epidemic [13]. During the third wave of the COVID-19 epidemic in Iran, travel and traffic restrictions led to a decrease of 23% in intercity mobilization on October 18, 2020 [32]. On the other hand, Seoul and Istanbul experienced a reduction in the city mobility by 59% and 45% respectively according to the Cittymapper Mobility index data, indicating a notable decrease in city mobilization compared with Iran [33]. It is noteworthy to note that even during the lockdown implementation in Iran as of November 21, 2020, only a 40% decrease in traffic volume has been registered, while during the same period, traffic volume decreased by 70% and 65% in Seoul and Istanbul respectively [33, 34]. The second method that could quantify the prohibition achievements is air quality. According to a recent study, the 2.5 μm particulate matter ($PM_{2.5)}$ index improved by 34.5% by the end of April 2020 in Turkey [35]. Furthermore, Ju and colleagues [36] indicated a decrease of 45.5% in $PM_{2.5}$ concentrations in March 2020 compared with the previous year's mean levels. In contrast, by April 3, 2020, Tehran, the capital of Iran, experienced an increase of 20.5% in $PM_{2.5}$ concentrations compared to those from the corresponding period last year [37].

Reproduction number

Reproduction number is considered as the critical parameter to determine the transmission spread through the population [38]. So far, studies have utilized two forms of this number including basic reproduction number (R_0) and real-time reproduction number ($R_{t)}$ [4, 38]. The corresponding estimates of R_0 at the beginning of the pandemic in Iran revealed a range from 3.5 to 4.86 regarding different analysis methods [39, 40]. Similarly, the initial reproduction number in South Korea has been reported as 3.53. Utilizing practical NPIs methods, the mean R reduced to 0.45 by April 29, 2020 in South Korea [41]. During the same period, the accurate rate of reproduction number in Iran has been disputed [40, 42]. Using Susceptible–Infected–Removed epidemic model, Sahafizadeh, et al. [40] designed the R curve and reported that the mean R had been less than 1 as of April, 7, 2020. In another study, Ahmadi and colleagues [42] found that the mean R had fallen below 2 by May 13, 2020. Despite all of the projections about the COVID-19 incidence trends in Iran, the second peak occurred in June 2020 [9]. On the other side, South Korea had a steady pattern of R, with an estimate of 1.03 during the same period [41].

Innovative methods

Interpretation of the methods applied in South Korea to curb the spread of the virus shows several innovative interventions. First, to expand disease screening in settings with limited health care resources, South Korea launched drive-through testing centers, which enables the country to reduce the infection risk associated with being in a crowded area and expanding the disease surveillance sufficiency [18]. Second, providing safe and quick walk-through testing centers led to minimizing the risk of cross infections at the testing centers [18]. Last but not least, the installation of artificial intelligence with the ability to interpret the X-ray photographic data resulted in relieving the burden of healthcare workers [43].

Mask utilization

Confronting the highly respiratory transmissible diseases necessitates mask utilization to prevent the spread of the disease [44]. In response to the COVID-19 epidemic, the WHO recommended the use of face masks in public, as well as regions with known or suspected community transmission [45]. In line with this concept, in a systematic analysis, Barasheed, et al. [46] reported that mask-utilizing in crowded areas could diminish the risk of respiratory infection by 20%. As of October 26, 2020, the Iranian government announced the capacity of 22 million mask production per day [47]. However, we believe the implemented strategies regarding mask utilization were partially insufficient due to the following reasons: first, during the second wave of the epidemic, Iranian's face mask production was estimated at 195 million per month [48]. Considering the country's population, the mentioned mask production provided only 2.3 masks per person. On the other hand, Korean's daily mask production stood at some 18 million per day, providing 10.4 masks per person in a month [49]. In addition, considering the lack of surveillance technologies, efficient supervision of the population regarding the mask utilization might be lower in Iran compared to the other countries [50].

Digital health platform

Digital health platforms play a critical role in providing numerous opportunities, as well as anticipating the next hotspot in the fight against the COVID-19 pandemic [51]. Following the COVID-19 transmission, Iran launched several digital platforms such as 190 and 4030 hotlines to provide specialized advice [12, 52]. Alongside the implementation of such methods, several websites and startup soft wares have been designed to screen individuals with symptoms, favoring COVID-19 [53, 54]. Although, despite such efforts, there are multiple fundamental differences exist between the strategies implemented in Iran and South Korea. First, alongside transmitting emergency alerting text messages, cellular broadcasting services in South Korea have enabled the government to send warning messages when people enter disaster areas. Second, developing a self-quarantine safety mobile application has empowered health officials to smart tracking the COVID-19 patients [43]. Also, the privacy section and government coordination have enabled further screening through PCR test performance. By contrast, most of the startups developed in Iran are not allowed to perform PCR tests for COVID-19 suspected individuals [43, 55]. Last but not least, the progression of telemedicine and remote public health strategies have contributed to a decrease in group contagion in virus vulnerable facilities [43].

During the COVID-19 epidemic, several countries have launched and utilized mobile apps for online purchasing and communicating in order to prevent the virus spread [11]. Besides, digital acquisition of administrative information can play a critical role in the improvement of timely contact tracking [56]. In this regard, global internet performance has been applied to quantify COVID-19 tracking [57]. Analysis of the COVID-19 affections on internet performance reveals that countries with advanced tracking technologies such as South Korea have improved their facilities to supply better speeds compared with similar slopes of previous years (mobile speed: 166.7 Mbps in November 2020 compared with 117.79 Mbps in November 2019). In comparison, countries without efficient tracking strategy such as Iran experienced remarkably lower speeds (25.64 Mbps in November 2020 compared with 28.49 Mbps in November 2019) [57].

Infodemic

During the COVID-19 pandemic, infodemic defines as conspiracy theories and fake news emerged and transmitted via social media, resulting in speed up the epidemic process by impacting on the social response [58, 59]. Cinelli, et al. conducted a study on five social media platforms during the COVID-19 pandemic and indicated the critical role of such pathways in spreading misinformation [58]. Following the COVID-19 outbreak in Iran, consistent disregard of the seriousness of the crises within the society is thought to be as a result of the primitive approaches of the government and social media. Addressing the COVID-19 pandemic to be less fatal than influenza and underestimating the important impact of quarantine on curbing the virus spread contributed to an upward trend in COVID-19 incidence cases [26]. On the other hand, to assess and compare different countries regarding the infodemic term, a recent study utilized Instagram hashtags and Google trends. Country-wise dispersion of the infodemic terms revealed that Turkey remained among the countries with the least infodemic searches [60].

Screening

To confine the propagation of COVID-19, one of the essential approaches is organizing an appropriate screening strategy [61]. To achieve this goal, countries and governments should provide a high capacity screening system to test and identify suspected cases, followed by isolating and monitoring the confirmed ones [61, 62]. With the implementation of rapid diagnostic tests and isolating the suspected individuals, South Korea has brought the epidemic under control [63]. With regard to the WHO announcement, it is also essential to identify and trace the close contacts of every confirmed or probable cases and quarantine and monitor them for 14 days [64]. Moving toward this achievement, necessitates interventions that prevent the interactions between pre-symptomatic (and potentially asymptomatic) individuals with the general population. Besides, considering the huge mental and economic pressures imposed by quarantine on society, population education and quarantine enforcement, as well as financial, medical, and psychological supports are considered as the other aspects of this target [61, 64].

Test performance

The first aspect of the best screening strategy to combat an epidemic is to identify suspected individuals [61]. South Korea's prosperities enlighten the importance of rapid diagnosis, which is thought to be as a result of the prompt detection of suspected cases after the initiation of the symptoms (7 days) [63]. To achieve this goal, the capacity of the testing system should be increased. Along with the capacity to perform daily PCR tests, the price, timeliness, and positivity rate of the performed tests rate are among the essential measures to appraise the function of COVID-19 screening strategies [63].

Drawing from the Worldometer data, by January 6, 2021, 4.5, 7.9, and 25.3 million PCR tests have been performed in South Korea, Iran, and Turkey, respectively, representing the diversities in screening strategies between these countries [3]. Even though Turkey and Iran had the same strategy to assess suspected individuals through the whole population, Iran did not invest enough in mass screening, leading to pointless and unfruitful results. On the other side, South Korea has developed different screening strategies by conducting PCR tests for suspected clusters and high-risk individuals recognized by smart tracing and tracking [13, 65]. Noticeably, enhancing test capacity has contributed to an increase in COVID-19 incidence rates [4]. Consistent with this concept, in March 2020, throughout a mass screening by the Iranian government, the number of cases detected increased significantly ($P = 0.003$), in addition to the number of recovered cases ($P = 0.001$); although, the number of deaths due to COVID-19 did not change during the same period [65]. In South Korea and Turkey, specific clusters of suspected people were recognized with contact tracing and screening. For example, in South Korea, screening of 394 high-risk groups including a total of 33,610 workers, living persons, and hospitalized patients resulted in 322 case confirmations (from March 18 to April 25) [13, 66].

To ascertain and compare the efficacy of the mentioned strategies, the proportion of positive tests among the total performed tests should be addressed. This indicator could specify the efficacy of the implemented strategies by different countries [13]. Drawing from the WHO recommendations, the approximate positivity rate of 3–12% is considered as a benchmark, representing the adequacy in test performance [67]. Looking at the values of this index represents that of all tests performed, positive cases in Iran, Turkey, and South Korea have been 15.9%, 8.9%, and 1.4%, respectively by January 6, 2021 [3]. A possible explanation for this finding could be as COVID-19 case numbers have been remarkably lower in South Korea compared with the other two countries, the average number of confirmed cases per test is remarkably lower in South Korea than the other countries [13]. Indeed, with conducting less than half of the tests performed in Iran, the cumulative incidence rates of COVID-19 in South Korea have been about 5% of the corresponding incidence in Iran [3]. These results illustrate the effectiveness of early contact tracing and tracking applied by South Korea to flatten the curve of the COVID-19 pandemic. On the other side, looking at the mentioned proportion in Iran illustrates higher values than the WHO' desired values, which indicates the incapacities of the performed tests to accurately diagnose suspected cases. Time trend of the average number of cases per total tests for the mentioned countries is illustrated in Fig. 2, indicating 15.9%, 8.9%, and 1.4% for Iran, Turkey, and South Korea, respectively, by January 6, 2021 [18]. Besides, the response preparation time of the PCR test in Iran is estimated at about 24 to 48 h. Although, South Korea has elevated its efficiency in PCR performance, with a turnaround time of 6 h [68, 69]. Furthermore, reports of the previous studies have narrowed the path between cluster screening, in addition to contact tracing and slowing the slope of COVID-19 propagation, resulting

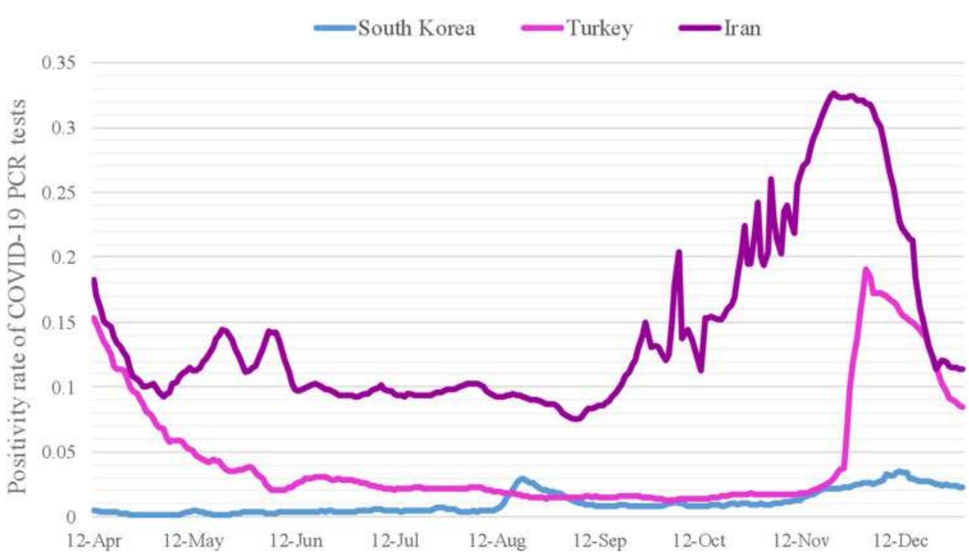

Fig. 2 Rolling 7-day average of COVID-19 confirmed cases per number of individuals tested. Data are taken from the Worldometer website. This figure demonstrates the proportion of confirmed cases among total tests performed for COVID-19 diagnosis in South Korea, Turkey, and Iran, indicating 15.9%, 8.9%, and 1.4% for Iran, Turkey, and South Korea, respectively, by January 6, 2021. Different countries are pictured on a color-based scale where purple, pink, and blue represent Iran, Turkey, and South Korea respectively. Abbreviations: COVID-19 = coronavirus disease 2019. PCR = polymerase chain reaction

in the timely detection of asymptomatic individuals and patients with mild diseases [13, 18].

Tracing contacts and tracking confirmed cases

As emphasized by the WHO, tracing and detecting interpersonal contacts are crucial to cease the COVID-19 transmission [64]. Consequently, different strategies were applied, such as detecting contacts of confirmed cases, developing digital tools for COVID-19 contact tracing, and designing applications for self-assessment [68]. For instance, the percentage of positive test results with a known route of infection was estimated at about 41% in Tokyo and 86% in South Korea by November 2020 [70, 71]. In this regard, several applications have been designed to inform the population about high-risk regions encompassing Contact-Confirming Application (COCOA) in Japan and KI-Pass System as a proximity tracing tool in South Korea [71, 72]. Also, an application named "Hayat Eve Sığar" (Life Fits into Home) contains a self-assessment tool for the COVID-19 and shows risk maps of cities with more than 10 million users in Turkey [73]. In Iran, an online platform of COVID-19 self-assessment has been designed; although, this platform does not provide the risk map of the COVID-19 [74].

Confirmed cases should be isolated and monitored. In Iran, the duration of the isolation is 14 days, which is consistent with international guidelines. However, Turkey has conducted different strategies among special subgroups of the population [75]. For instance, health workers should get back to work 7 days from the symptoms initiation or three days after two negative PCR tests were taken 24 h apart [76]. In terms of asymptomatic cases in Iran, this duration is about 10 days after the positive PCR test [75]. In addition, to ensure proper implementation of quarantine legislation, a fine of about $8000 has been imposed by the Korean government on confirmed cases that do not follow the instructions [68].

In-patient and out-patient facilities

So far, the COVID-19 epidemic has contributed to a disruption in the global supply chain of essential protective supplies [77–80]. Indeed, one of the essential challenges of lower developed countries is the lack of pivotal supplies such as personal protective equipment (PPE), as well as inadequate numbers of beds per capita compared with other countries [77, 81, 82]. As of April 5, it has been reported that healthcare workers make up 2.4% of COVID-19 confirmed cases in South Korea [83]. On the other hand, by May 21, there were more than ten thousand (7.7%) COVID-19 cases in healthcare workers in Iran, among a total of 129,341 positive COVID-19 cases, indicating a possibility of deficiency in providing PPE for healthcare staffs [9, 84].

In terms of bed preparation, despite the implementation of several strategies such as allocating the empty capacity of hotels and shopping malls for COVID-19 patients, there exist several barriers to achieve the aspirational targets in Iran [11]. In support of this concept, a quantitative indicator that enables us to compare the adequacy of bed preparation among different countries could be hospital beds per 1000 people. Of note, Iran, Turkey, and South Korea earned 1.5, 2.81, and 12.27 hospital beds per 1000 people, respectively [85]. In addition, in 2017, the number of physicians and nurses per 1000 people was 1.1 and 2.6 in Iran; while, South Korea earned 2.4 and 7.1 in the mentioned indexes, respectively [86, 87]. Taken together, these results provide strong but still inconclusive evidence that more resources should be allocated to provide adequate PPE, as well as hospital beds.

Governance

The policy process can be defined as a collaborative process between stakeholders and a coalition of actors [11]. Given the remarkable impact of the COVID-19 pandemic on the population, the policies to mitigate the spread of the infection should be pushed into the agenda [11]. Therefore, appraising the essential economic responses that have been put in place by governments to confront COVID-19 spreading is of utmost importance.

Subsidies and insurance

In response to the pandemic impacts on economics, governments have implemented subsidies to bridge the drop in demand [88]. In Iran, 10 percent of the gross domestic product (GDP) was allocated into the relief of the COVID-19 affections at the end of March 2020 [24]. Turkey and South Korea's allocated budgets to refine the pandemic is estimated to be 12.8 and 14.4 of their GDP respectively [24, 89]. Besides, as the end of August 2020, $245 million have been paid to 13% of business applicants to compensate for the economic affections of COVID-19 in Iran [24]. On the other hand, Turkey's government has covered more than 50% of lost salaries regarding the COVID-19 pandemic, indicating a considerable difference to compensate affected professions [90].

Implemented strategies

To appraise the achievements toward aspirational goals, contextual policy analysis is of utmost importance [11]. Following the identification of the first case with COVID-19 in Iran, underestimating the essential impacts of this pandemic on society contributed to an increasing trend in COVID-19 incidence rates [26]. Afterward, as of May 26, reopening the international borders, as well as major religious sites and businesses resulted in the second peak that occurred on June 4, 2020 [9, 24]. In addition, the third wave of virus cases hit Iran on November 27, 2020, which led to the development of lockdown strategies all through the country [9]. On the other hand, with the help of a comprehensive strategy to combat the COVID-19 based on aggressive contact tracing and widespread testing, South Korea has brought the epidemic under control without lifting stringent strategies, indicating a necessity for other countries to utilize the strategies [13].

Management of DM

So far, several studies have narrowed the path, linking DM with poor outcomes in patients with COVID-19 [91–93]. In this respect, increased permeability of alveolar epithelium vasculature, defects in the immune system, and propagation of proinflammatory cytokines are the essential pathogenesis pathways [94]. Consistent with this concept, a recent nationwide study from Turkey indicated higher 30-day mortality after hospitalization rates in patients with type 2 DM compared with those without DM [91]. In another investigation in South Korea, DM was associated with increased risk of worse outcomes (odds ratio (OR): 1.349, $P=0.004$) after adjustment for possible confounders [92]. In Iran, a recent meta-analysis on ten studies revealed that patients with DM had significantly higher mortality rates (OR: 0.549, $P\leq 0.001$) compared with healthy ones [21]. Strikingly, two studies have indicated that DM might increase the risk of contracting COVID-19 [95]. In line with this notion, Chun et al. [95] demonstrated a higher risk of COVID-19 among diabetic insulin users compared with the healthy group (OR: 1.25, $P=0.0278$). Besides, Mirjalili and colleagues [21] indicated the highest proportion of COVID-19 among patients with hypertension and DM.

As a matter of concern in patients with DM, the course of the glycemic control and the disease is adversely affected by alterations in lifestyle during the COVID-19 pandemic [96]. The pandemic has led to changes in dietary habits as well as reduced amounts of physical activity, which may be driven by social distancing and lockdown strategies [96]. In addition, fear of contracting the infection could decrease receiving healthcare services among patients with DM [97]. In support of this issue, a recent study indicated a significant weight gain as well as an insignificant increase in glycemic parameters among patients with type 2 DM during the COVID-19 lockdown [96]. Comparing the implemented strategies between Turkey and Iran illustrates that mortality rates among in-patients with DM are lower in Turkey than corresponding rates in Iran (13.6% vs. 23.5%) [21, 91]. Potential explanations related to lower mortality rates in Turkey might be efficient prevention of overloading the healthcare system and universal coverage of the national insurance system [91]. Taken together, the integration of the two critical pandemics of DM and COVID-19 could cause a double burden of disease, especially in countries with a scarcity of healthcare resources [21]. Hence, effective strategies should be implemented for those with DM and COVID-19, given that these groups are more susceptible to developing COVID-19 poor outcomes compared with those without DM.

Conclusion

In this study, we have dissected the entangled packages of implemented strategies and compared the interventions applied by three countries to flatten the curve of the COVID-19 pandemic. We found that there might be several decisive NPIs that remarkably could bring the epidemic under control. Although, no strategy can act as a silver bullet to overcome the disease. Analysis of previous efforts put in place in Turkey and South Korea demonstrated that along with smart social distancing measures, smart contact tracing, and increasing the capacity to perform PCR tests are among the important keys to mitigate the COVID-19 propagation [13, 98]. Our findings provide insights into five domains including prevention, screening, in-patient and out-patient facilities, governance, and management of DM, which call policymakers for the development of new strategies to combat this epidemic.

First, the social distancing methods utilized in the mentioned countries encompass a spectrum, ranging from small gathering cancellation to the whole country lockdown legislations [4]. Interpretation of the strategies implanted by these three countries reveals that Iran has experienced a decline in COVID-19 new cases after the establishment of national social distancing commands [11]. However, lack of supervision strategies, as well as discounting the social distancing measures has led to the recurrence trend in the disease incidence [11, 26]. Furthermore, by applying several indicators of social distancing measures such as mobility index, we found that even during the lockdown performance, the rate of population interaction was higher in Iran compared with the other two countries. Indeed, lockdown implementations are considered as the last resort measures, representing a country's failure to overcome a threat. Furthermore, premature and sudden lifting of the stringent interventions can contribute to an earlier second peak [7]. Hence, these findings call policymakers to develop and adjust infrastructures to effectively cope with the COVID-19 pandemic.

Second, the most critical step prior to developing an action plan for a pandemic propagation is recognizing the suspected or infected patients [61]. According to the Worldometer results, total tests per 1 million population in Turkey are reported to be threefold higher than in Iran [3]. Meanwhile, the low preparation time of the PCR test and smart contact tracing performed in South Korea has led to a remarkably lower confirmed cased per test compared to the other two countries [13]. As a result, providing additional kits for PCR testing as well as the collaboration of the test providers in a national COVID-19 consortium could ensure adequate and prompt testing for the population.

Third, contact tracing is of utmost importance both in the early phases of the epidemic and later on, when the incidence trend has declined through other means [18]. By integration of technologies and design innovations, these methods empowered South Korea to quickly recognize, track, and quarantine the suspected cases. Indeed, with the combination of tracing, prompt test performing, and smart tracking, South Korea has adopted a cluster-based screening approach, which has led to successful containment of the pandemic even with lower PCR tests than Iran [13, 18]. Hence, these approaches hold important lessons for other countries in order to improve their infrastructures.

Fourth, governments should protect health care providers for coping with the COVID-19 epidemic. Along with PPE scarcity, lack of hospital beds has imposed a paramount burden on health care staff in Iran [11, 81]. Therefore, providing adequate protective equipment and urgent financial support should be placed at the forefront. Besides, a comprehensive economic package for deprived groups and applicants affected by the COVID-19 pandemic is demanded to relieve the gravity of the epidemic.

Last but not least, it could be concluded that the need for recognizing the barriers and implementing timely strategies for patients with COVID-19 and DM has never been timelier [21]. According to a previous effort, the potential challenges in the management of DM in Iran could be categorized into a weak care delivery system and defective diabetes self-care [99]. One essential solution for effectively controlling the imposed burden of DM during the COVID-19 pandemic could be applying telemedicine and telehealth services [100]. Policymakers should pave the wave to ensure that patients with DM could still access essential care during the ongoing waves of the pandemic [101]. In addition, intensified glycemic control is recommended in those with both COVID-19 and DM [102]. Thus, clinicians should be informed accurately about the latest updates in the glycemic management of patients with DM during the ongoing waves of the COVID-19 pandemic.

To the best of our knowledge, this is the first study that addressed diverse NPIs developed and implemented by Iran, Turkey, and South Korea. The share of achievements and failures in the strategies developed to combat the COVID-19 pandemic has precious policymaking implications. In addition, comparing these interventions based on their achievements toward aspirational goals enables a better understanding of priorities and provides an in-depth context in applying them to overcome the COVID-19 epidemic. In this paper, we did not discuss the ethical considerations of the governments' approach to contact tracing. Moreover, ongoing privacy concerns might increase regarding the development of tracing and tracking technologies, necessitating the development of effective security strategies.

Taken together, we reviewed the untapped potential of different communities to refine the COVID-19 propagation. Our findings suggest a closer inspection of the effectiveness of implanted strategies against COVID-19. We categorized and compared developed interventions to combat the COVID-19 pandemic between Iran, Turkey, and South Korea. We can infer that fostering an effective strategy necessitates social distancing methods implementation, prompt test performing, smart contact tracing, and adequate PPE supplying. Hence, policymakers should be noticed that a suitable combination of NPIs is necessary to stem the propagation of the disease.

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