Article

COVID-19 in Pakistan: A national analysis of five pandemic waves

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Abstract: The COVID-19 pandemic showed distinct waves where cases continue to increase. This paper compares key characteristics from the five different COVID-19 waves in Pakistan. The data comes from the daily national situation reports (Sitreps) ptepared by the National Emergency Operations Centre (NEOC) in Islamabad. We use specific criteria to define COVID-19 waves. The beginning of each COVID-19 wave is marked by the day with the lowest number of daily cases preceding a sustained rise, while the end is the day with the lowest number of cases after a 7-day decline, which should be lower than the 7 days after. Key variables such as COVID-19 tests, cases and deaths with their rates of change to the peak and then to the trough are used to make descriptive comparisons. In addition, a linear regression model is used to estimate daily new COVID-19 deaths in Pakistan. There were five distinct waves in Pakistan, each of which had the typical topology of a full-blown infectious disease epidemic. The time from the beginning of the wave to the peak became shorter and shorter, and from the peak to the trough longer and longer. Each wave also appears to be getting shorter, with the exception of wave 4, which lasted longer than wave 3. A one percent increase in vaccinations reduced the number of deaths in wave 5 by 0.38% (95% CI: -0.67, -0.08) and the relationship is statistically significant.

Keywords: COVID-19; infectious disease; statistically significant

1. Introduction

The first case of COVID-19, a novel and poorly understood disease, was discovered in Pakistan on February 26, 2020. As a developing country with limited resources, crumbling healthcare infrastructure and low healthcare spending [1], Pakistan has no experience with pandemics and a high burden of communicable diseases [2]. As of February 23, 2022, the country had fully vaccinated 43% of its total population [3] and the Omicron variant of COVID-19 was the dominant strain [4]. These factors make Pakistan a high-risk country with a large pool of people at risk of infection.

The emergence of COVID-19 was arguably the biggest social and economic disruption in Pakistan in recent history. The pandemic has essentially manifested itself in five distinct waves, each with a spike, plateau and trough in cases, followed by a lull after which the number of COVID-19 infections begins to rise again. Thus, each individual wave follows a four-stage pattern followed by an endemic, as has been observed in many infectious disease epidemics [5]. Apart from anecdotal observations, there is evidence that this is also the case with COVID-19 [6]. What distinguishes COVID-19 from other epidemics is the fact that a new wave follows shortly after the end of a single wave and not only after a longer period of time, as is the case with annually recurring flu waves, for example. This pattern has been observed around the world [7–11], with the timing of COVID-19 waves largely coinciding in different countries [6].

In this context, the current literature on COVID-19 largely focuses on high-income countries during the first waves or at the regional level. Given the varying capacities of countries to cope with the pandemic, there is a need to examine the characteristics of subsequent waves of the pandemic in the context of developing countries, preferably with the granularity of a country-level analysis.

This paper aims to provide a comprehensive understanding of the impact of COVID-19 in Pakistan. To achieve this, we examine the five waves of the pandemic in Pakistan and analyze various key aspects and critical statistics. These include the total number of COVID-19 tests conducted, confirmed cases, hospitalizations, COVID-19 related deaths and vaccination progress during each wave. In addition, we use statistical models to identify the key factors contributing to COVID-19-related deaths. Our aim is to fill the existing gap in the literature by providing valuable insights specifically for a developing country like Pakistan, for which little data is currently available.

2. Materials and Methods

2.1. Criteria for COVID-19 waves

We start by retroactively defining different periods between 2020 and 2022 as different waves, based on the existing literature. In these five waves, there are a total of 628 observations (daily set of indicators). Based on our criteria, the starting point of each COVID-19 wave is defined as the day with the lowest number of daily new COVID-19 cases, preceded by a consistent rise in these cases before the peak of the respective COVID-19 wave. The end of the of each wave is defined as the day with the lowest number of daily new COVID-19 cases after a 7-day decline; this number also had to be lower than the cases on each of the 7 days that followed it (Table 2).

2.2. Data and variables

To estimate the pattern for COVID-19 during the five waves in Pakistan, we use time series data of various daily indicators from April 3, 2020 to February 23, 2022, which are divided into the following broad themes:

(i) time span of waves

ii) COVID-19 tests

iii) COVID-19 cases

iv) Test-to-case ratio

v) COVID-19 positivity

vi) Hospitalization and treatment

vii) COVID-19 deaths

viii) COVID-19 vaccination

ix) Political environment

Several variables in the above list were converted into ratios to describe all five COVID-19 waves in Pakistan (Table 1). The data for all but two of the above topics, COVID-19 vaccination and political environment, are compiled from the daily national situation reports (Sitreps). These sitreps are compiled by the National Emergency Operations Centre (NEOC) in Islamabad, Pakistan. The data in these sitreps served as the basis for all major policy decisions on COVID-19 in Pakistan. The data on COVID-19 vaccination comes directly from the National Command & Operation Centre (NCOC) in Islamabad, Pakistan, the government forum that brings together the Ministries of Health and Planning and the military to set pandemic policy and coordinate the response. The data for the policy environment comes from a publicly available dataset from the Blavatnik School of Governance at the University of Oxford. This dataset is compiled using qualitative information on the non-pharmaceutical interventions (NPIs) in a country and quantified into an index called the Oxford Containment and Health Index for COVID-19. A detailed method for calculating the index can be found in a working paper from the Blavatnik School.

Table 2. Key indicators and characteristics of each COVID-19 wave.

Variables		Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Dates		April 3, 2020 to August 31, 2020	October 12, 2020 to February 16, 2021	February 23, 2021 to June 22, 2021	July 6, 2021 to November 29, 2021	December 7, 2021 to February 23, 2022
Main variants of concern(VOCs)		B.1	B.1.36	(Alpha/B.1.1.7)/ (Delta/B.1.617.2)	Delta/B.1.617.2	Omicron/B.1.1.529
Wave timespan						
Duration of wave (days)		150	128	120	147	83
Wave start till peak (days)		72	57	55	31	52
Wave peak till trough (days)		78	71	65	116	31
COVID-19 tests						
Total tests (n)		2,571,244	4,638,219	5,458,041	7,148,130	4,120,909
Avg. Daily new tests (n)		17,142 (7,931)	36,236 (5,363)	45,484 (8,623)	48,627 (8,341)	49,650 (7,494)
Δ Daily new tests	Till peak	380.9	216.5	701.1	836.6	540.4
Δ Daily new tests	After peak	-147.8	-101.0	-504.9	-286.4	-1137.6
COVID-19 cases						
Total cases (n)		293,752	246,188	377,668	320,333	221,825
Avg. Daily new cases (n)		1,958 (1,687)	1,923 (815)	3,147 (1,547)	2,179 (1,548)	2,673 (2,519)
Δ Daily new cases	Till peak	93.9	60.9	94.0	161.0	155.9
Δ Daily new cases	After peak	-84.8	-40.0	-84.1	-48.0	-236.4
Test-to-case ratio						
Avg. Test-to-case ratio (%)		15 (15)	23 (11)	19 (11)	44 (38)	57 (56)
Δ Test-to-case	Till peak	4.1	-1.1	-0.4	-1.13	-3.31
Δ Test-to-case	After peak	84.5	0.3	0.7	1.36	0.99
COVID-19 positivity rate						
Avg. Daily positivity rate (%)		11.3 (6.4)	5.2 (1.8)	6.8 (2.9)	4.2 (2.6)	4.9 (4.1)
Δ Positivity rate	Till peak	0.23	0.15	0.10	0.23	0.22
Δ Positivity rate	After peak	-0.28	-0.10	-0.11	-0.07	-0.30
Hospitalization and treatment						
Avg. hospital admissions at anygiven time (n)		3,817 (2,479)	2,187 (818)	3,970 (1,366)	3,396 (1,776)	1125 (423)
Avg. Length of hospital stay(days)[a]		-	13	11	9	5
Avg. Daily new hospitalization-to-cases (%)		-	8.8 (2.4)	12.4 (3.5)	22.7 (10.7)	15.7 (10.8)
Avg. Daily recoveries (n)		1,870 (2,587)	1,746 (1,608)	2,990 (1,454)	2,272 (2,329)	2,371 (3,797)
Δ Daily recoveries	Till peak	23.4	14.3	69.9	202.4	28.76
Δ Daily recoveries	After peak	-19.8	-6.6	-51.1	-57.7	-0.97
Avg. Stable-admitted (%)		67 (27)	20 (6)	14 (5)	7 (4)	9 (4)
Avg. Patients on oxygen-admitted		27 (23)	68 (5)	75 (5)	83 (2)	81 (3)

(%)						
Avg. Oxygen beds in use at anygiven time (n)		865 (828)	1,521 (608)	2,995 (1,080)	2,803 (1,470)	918 (361)
Avg. Oxygen beds utilization (%)		18 (11)	15 (6)	24 (8)	20 (10)	7 (3)
Avg. Ventilators in use at anygiven time (n)		214 (163)	249 (90)	429 (145)	336 (153)	109 (36)
Avg. Ventilator-admission (%)		7 (4)	11 (1)	11 (0.6)	10 (2)	10 (1)
Avg. Ventilators utilization (%)		17 (10)	13 (5)	20 (7)	15 (7)	5 (2)
COVID-19 deaths						
Total deaths (n)		6,204	5,537	9,423	6,287	1,401
Avg. Daily new deaths (n)		41.4 (35.3)	43.3 (23.0)	78.5 (37.4)	42.8 (30.6)	16.9 (14.3)

(*Continued*)

Table 2. (Continued)

Variables		**Wave 1**	**Wave 2**	**Wave 3**	**Wave 4**	**Wave 5**
Δ Daily new deaths	Till peak	1.1	0.5	2.0	1.17	0.45
Δ Daily new deaths	After peak	-1.0	0.1	-1.9	-0.44	-0.81
Avg. Daily new deaths-daily newhospitalization (%)		11 (5)	27 (13)	23 (8)	10 (4)	7 (4)
Avg. Daily new deaths-ventilatorin use (%)		23 (17)	17 (6)	18 (5)	12 (5)	13 (8)
Avg. Death-to-case ratio (%)		2.2 (0.8)	2.3 (1.1)	2.8 (1.2)	2.2 (0.8)	1.1 (1.0)
COVID-19 vaccination[b]						
Total administered 2nd doses ofvaccine		-	-	3,136,386	45,294,948	45,667,572
Avg. Daily new 2nd doses ofvaccine		-	-	26,356 (25,980)	308,129 (172,896)	550,212 (186,287)
Policy environment						
Oxford containment and healthindex		58.8 (7.6)	62.4 (4.0)	65.7 (6.3)	58.1 (9.4)	58.6 (5.5)

Note: Standard deviations are reported in parentheses. Δ refers to rate of change. [a]Data for daily new COVID-19 hospitalizations was not available during wave 1. [b]COVID-19 vaccines were not being administered during waves 1 and 2.

4. Results

Newey-West standard errors are used to account for autocorrelation and potential heteroscedasticity in the error terms. Statistical tests are performed to ensure that the required assumptions for the regression model are met: for heteroscedasticity the Breusch-Pagan test is applied, while for serial correlation the Durbin-Watson test is used. The variance inflation factor (VIF) is calculated for multicollinearity. The presence of unit roots is tested using extended Dicky-Fuller tests for each independent variable in our regression model. All variables are found to be stationary and thus fulfil an important condition for our analysis (Table 3). The statistical analysis is performed using STATA 17 software.

Table 3. Augmented Dicky-Fuller tests for unit roots.

Variable	Test Statistics	P-Value	H_0: Random Walk
Daily New COVID-19 Deaths	-6.96	0.000	Stationary
Daily New COVID-19 Cases	-3.23	0.018	Stationary
Daily New COVID-19 Tests	-3.94	0.001	Stationary
Oxford Containment and Health Index	-3.30	0.015	Stationary
Ventilator-admitted Ratio	-5.69	0.000	Stationary
Oxygen-Admitted Ratio	-3.00	0.034	Stationary
Fully Vaccinated People	-2.77	0.003	Stationary

Pakistan experienced five different waves from April 3, 2020 to February 23, 2022 (Fig. 1). Wave 1 lasted the longest (150 days), while wave 5 was the shortest (83 days). Wave 4 was characterised by a relatively rapid rise and a long tail, while wave 5 showed a reverse development pattern. The duration of each wave of COVID-19 in Pakistan was shorter than the previous one, except for wave 4. After wave 1, each wave took less time to reach its peak and more time to reach its trough, except for wave 5.

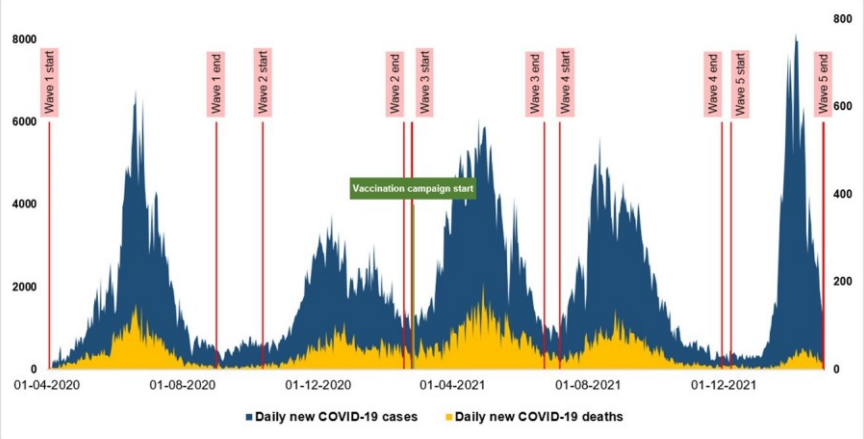

Fig 1. COVID-19 waves, daily new cases, and daily new deaths.

5. Conclusions

On We describe how the COVID-19 waves have differed in terms of cases, hospitalizations and deaths in Pakistan and analyze the possible reasons for these differences. Pakistan experienced its first COVID-19 wave earlier than other South Asian countries, with wave 1 lasting the longest. As testing increased and restrictions were enforced, subsequent waves became shorter, but wave 3 stood out for lax implementation and resulted in the highest number of cases and deaths. The higher daily case counts in waves 3, 4 and 5 were also attributed to the highly infectious Delta and Omicron variants. Wave 3 recorded the most COVID-19 deaths with 9,423 deaths, the highest daily death rate and the sharpest increase in daily deaths. Finally, vaccination began in wave 2, with full vaccination achieved in wave 3 and the highest second vaccination dose in wave 5.

At the beginning of the pandemic, Pakistan's lack of experience posed a challenge. Nevertheless, a national action plan for COVID-19 was established in March 2020. COVID-19 management in Pakistan kept pace with the spread of the disease in five different waves and successfully implemented the COVID-19 vaccination campaign across the country. The experiences and limitations offer valuable lessons for future pandemic management in a developing country like Pakistan.

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