

# GEOGRAPHICAL DISTRIBUTION OF COVID-19 INFECTION ACROSS SAUDI ARABIA



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**Abstract.** *Background.* Saudi Arabia, a large country in terms of population size and geographical area, is divided into administrative areas and governorates. It has metropolises, cities (large, medium sized, and small), towns, villages and rural neighborhoods, classifiable into well equipped, rapidly expanding, and others. The COVID-19 epidemics spread all over the country with differentials in infection rates, percentages, and affected persons, alongside daily increases. This analysis, focused on administrative areas, aimed to comprehend the spread and escalation of the epidemic, in addition to highlighting the distribution of the infected population with a special emphasis on geographical spread and seasonal variations. *Materials and methods.* This analysis of data compiled from COVID-19 daily reports published by the Saudi Arabian Ministry of Health considers into account administrative areas and localities (neighborhoods) to demonstrate the distribution of spread, increase in infection, and the proportion of population infected between March 21, 2020 and May 4, 2023. *Results.* A large majority of the infected cases were reported in three major administrative areas including Riyadh, Makkah, and the Eastern Region. Other regions had a smaller number of infected cases. However, some locations, especially medium-sized upcoming towns and neighborhoods experienced greater number of people seriously affected at a rapid pace, with seasonal differentials, in medium sized upcoming cities — the governorate headquarters and promising future cities, apart from the major cities. *Conclusions.* COVID-19 spread in the country followed a certain regional pattern. Beyond the populous administrative areas, upcoming cities in fast changing areas had a high impact. Thus, having a categorization of major, medium or low spread is necessary. Such detailing of COVID-19 infection would be useful not only to develop combating strategies but also to create epidemic and emergency preparedness.

**Key words:** spread and increase, affected locations, contamination per 1000 persons, major cities, governorates and localities, seasonal variation.

## ГЕОГРАФИЧЕСКОЕ РАСПРОСТРАНЕНИЕ ИНФЕКЦИИ COVID-19 В САУДОВСКОЙ АРАВИИ

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**Резюме.** *Введение.* Саудовская Аравия, крупная по численности населения и территории страна, разделена на административные районы и провинции, в состав которых входят мегаполисы, города (большие, средние и малые), поселки, деревни и сельские кварталы с разным уровнем развития инфраструктуры, темпом экономического роста и пр. Эпидемия COVID-19 распространилась по всей стране, но с региональными различиями в уровнях заражения, процентах и количестве пострадавших, показателях ежедневного прироста числа забо-

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левших. Настоящий анализ ситуации с COVID-19 на разных административных территориях страны был проведен с целью выявления факторов распространения эпидемии и распределения инфицированного населения в зависимости от географического положения региона и присущих ему сезонных климатических колебаний. *Материалы и методы.* Были проанализированы данные о распределении заболеваемости, росте заражения и доле населения, инфицированного в период с 21 марта 2020 г. по 4 мая 2023 г., на различных административных территориях и населенных пунктах (районах) страны, полученные из ежедневных отчетов о COVID-19, опубликованных Министерством здравоохранения Саудовской Аравии. *Результаты.* Подавляющее большинство случаев заражения было зарегистрировано в трех основных административных районах, включая Эр-Рияд, Мекку и Восточный регион. В других регионах число зараженных было меньше. Тем не менее большое количество людей серьезно пострадало от быстрого темпа распространения заболевания, особенно в крупных и развивающихся городах, в крупных жилых и коммерческих районах, кварталах среднего размера. *Выводы.* Распространение COVID-19 в стране имело определенную региональную закономерность. Помимо густонаселенных административных районов, большое влияние на этот показатель оказали города в быстроразвивающихся регионах. Были выделены административные районы с большим, средним и низким уровнем распространения COVID-19. Такая классификация будет полезной не только для разработки стратегий борьбы, но и для обеспечения готовности к эпидемиям и чрезвычайным ситуациям в будущем.

*Ключевые слова:* распространение и рост, затронутые территории, инфицированность на 1000 человек, крупные города, провинции и населенные пункты, сезонные колебания.

## Introduction

Saudi Arabia is a large country in terms of geographical area and is divided into 13 administrative areas and 151 governorates. The country borders five Arabian Gulf countries and a few other Arab nations, boasting a wide coastal area to the east and west. Despite accommodating a vast population, both native and foreign, the country maintains a low population density, mainly because of uninhabited desert areas. Developmental efforts focused on constructing infrastructure — residential, commercial, educational, and medical — in various parts of the country have created many urban areas. Consequently, populations have migrated to these areas seeking improved lifestyles, livelihoods, and professional opportunities [23]. In summary, many cities and towns in Saudi Arabia have high population concentrations. This situation expedites the potential for faster infection rates in the country [6, 21, 22].

Saudi Arabia has grappled with a rapid spread of COVID-19 in various overpopulated areas characterized by a transient population, despite efforts to contain, isolate, enforce social distancing, and impose lockdowns. In addition, the country implemented several strategies, such as the suspension of religious, entertainment, and sporting mass gatherings; temporary closure of educational establishments; and the postponement of all non-essential gatherings by imposing a complete curfew implemented even before confirming the first case [4, 5, 8, 11, 16, 20, 23]. COVID-19, recognized as a new strain of the Middle East Respiratory Syndrome Coronavirus, plagued the Middle East, with the majority of cases reported in Saudi Arabia. The country also experienced a higher case fatality rate [12, 20].

The global pandemic reported its first case on March 2, 2020, in Saudi Arabia and has been resisted through various strategic interventions. Saudi

Arabia has been appraised for its mitigation measures (a combination of Chinese and German technologies) characterized by swift community action and hospital preparedness. These efforts have been made in the absence of experimental studies on treatment options, economic impact assessments, and epidemiological studies [3, 6, 7, 9, 13, 15, 20]. This endeavor could be aligned with the 2030 Vision, which aims to position the country as a business and tourism hub, aiming for well-developed herd immunity [2, 23].

Considering the diverse geography of the country and the heterogeneity of its population in terms of living arrangements, population density, and livelihoods reflected in varying sex ratios, child population, geographical condition, environmental situation, and the availability of resources, such as hospitals and medical facilities [14], this study aimed to conduct a spatial analysis of COVID-19. Hence, disparities across cities and neighborhoods, in addition to the administrative areas of the country, were important in understanding risk factors, immune responses, treatment effectiveness, and mortality rate. This spatial analysis, focused on administrative areas, aimed to comprehend the spread and escalation of the epidemic, in addition to highlighting the distribution of the infected population with a special emphasis on geographical spread and seasonal variations.

## Materials and methods

This analysis was based solely on daily reports of COVID-19 cases published by the Ministry of Health of Saudi Arabia (<https://sehhty.com>), which is referred to by Alanezi et al. (2020) as the most reliable source of information. Reports from March 21, 2020, to May 4, 2023, were compiled on an Excel worksheet for consolidated illustrations and analyses.

A trend of daily infections across administrative areas was plotted.

Majorly affected locations within each administrative area were plotted.

An increase in infection rates was calculated for each administrative area, specifically focusing on the major affected locations.

The number of infected cases per 1000 individuals based on available population data in 2020, 2021, and 2022 for administrative areas was determined.

Population sizes for administrative areas in 2020, 2021, and 2022 were used to calculate the infection rate per 1000 individuals. However, population data for localities within each administrative area was only available for 2022.

## Results

Saudi Arabia has been substantially impacted by COVID-19 (SARS-CoV-2). The infection initially spread through travelers from Iran to the Eastern Region via neighboring Bahrain and Kuwait. A few cases in Al-Qatif City disseminated to other parts of the province and thereafter extended to additional provinces and neighborhoods, such as Makkah, Jeddah, Al-Madina, and Riyadh. On March 21, 2020, the Ministry of Health commenced daily online data uploads, recording a total of 392 infected individuals. The infection rate swiftly escalated to 1453 by March 31, 2020, and reached 840 435 by May 4, 2023. This indicates a rapid spread, especially during June–July 2020, reporting approximately 5000 new cases per day, and later during January–February 2022. The spread during June–July is referred to as the first wave, while that during January–February is referred to as the second wave, with random surges in the second quarter of 2021.

### Spread in the administrative areas

Several governorates in Saudi Arabia were affected with varying intensities. Metropolises with a large transient population, emerging cities with a dense population, and areas with a high-proportion of expatriates, were more affected than others (Fig. 1). For example, by May 4, 2023, Riyadh, Makkah, and the Eastern Region administrative areas were affected more than the others with 231 547, 206 004, and 164 006 affected individuals, respectively, accounting for approximately 71% of the total cases. Al-Jouf and the Northern Borders had 3974 and 7038 infected individuals, respectively, marking the two administrative areas with the lowest infection rates (Fig. 1). Another region exhibiting lower spread was Al-Baha, with 11 143 reported cases.

### Affected locations in each administrative area

Certain governorates and cities, recognized as major commercial, educational, residential, and developmental zones hosting migrants, reported a higher number of cases. Figure 2 (see color plate) illustrates these geographical clusters by percentage

for each quarter annually. For example, in the Riyadh administrative area, Al-Kharj, Riyadh, and Wadi Ad Dawasir emerged as major affected areas: key economic, commercial, and educational centers. These locations exhibited higher infection rates, but with seasonal variations. The overall infection rate displayed peak periods in the second quarter (Q2 2020; April–June) and Q1 2022 (January–March). Riyadh City recorded peak infections in Q1 2022, followed by Q2 2020. Al-Kharj had the highest infection rate in Q1 2022, followed by Q2 2020 and Q3 2020. Wadi Ad Dawasir followed a different trend, with its highest infection rate in Q3 2020, followed by Q2 2021. The overall infection rate in this administrative area largely depended on Riyadh City. In contrast, the Makkah administrative area had high infection rates in Jeddah, Makkah City, and Taif. Makkah City experienced a substantial surge during Q2 2020, followed by Q1 2022, and Q3 2020. Jeddah showed a different pattern, with its highest infection rate was in Q2 2020 and Q1 2022, while Taif recorded peak infections during Q2 2020 and Q3 2020. Other locations in this region recorded elevated infection rates in Q1 2022. In contrast, the Al-Madina administrative area experienced a gradual spread: Al-Madina City showed substantial spread during Q2 2020; Al-Ula initially had a lower spread but reached its highest during Q1 2022; and Yanbu had a gradual spread, with the highest in Q3 2020 and Q3 2021.

The three majorly affected localities in the Eastern Region were Ad Dammam, Al-Hufuf, and Al-Khubar, with heavy infections occurring during Q2 2020 (very high in Al-Khubar) and Q1 2022. Al-Qasim showed a different pattern: Q2 2020 was less serious, but Q3 had a wider spread, especially in Buraydah and its smaller localities. Q1 2022 also recorded higher levels, particularly in Ar Rass, whereas Unayzah recorded a smaller spread. Hail administrative areas recorded heavy infections in Ash Shinan, Baqa, and Hail City. None exhibited high levels in Q2 2020 but Ash Shinan reported high levels in Q2 2021, while Baqa and Hail City experienced elevated infections in Q3 2020. Additionally, smaller geographic clusters indicated significant infection rates in Q3 2020, Q2 2021, Q3 2021, and Q1 2022. Aseer had a more limited spread, except in Q3 2020 in Khamis Mushayt, Muhayil, and other smaller locations. However, Q1 2022 saw a serious spread in Muhayil and Abha, but not in Khamis Mushayt. In the Jazan administrative area, a comparatively uniform spread was recorded in Abu Arish, Baysh, Jazan City, and other smaller locations, with high infection rates during Q3 2020 and Q1 2022. Baysh experienced serious infections only in Q2 2020.

Hubuna, Najran City, and Sharorah were the most affected localities in the Najran administrative area. None of them had a high spread during Q2 2020. Hubuna recorded a high spread in Q2 2021 and Q3 2021, and Najran City and Sharorah recorded a high

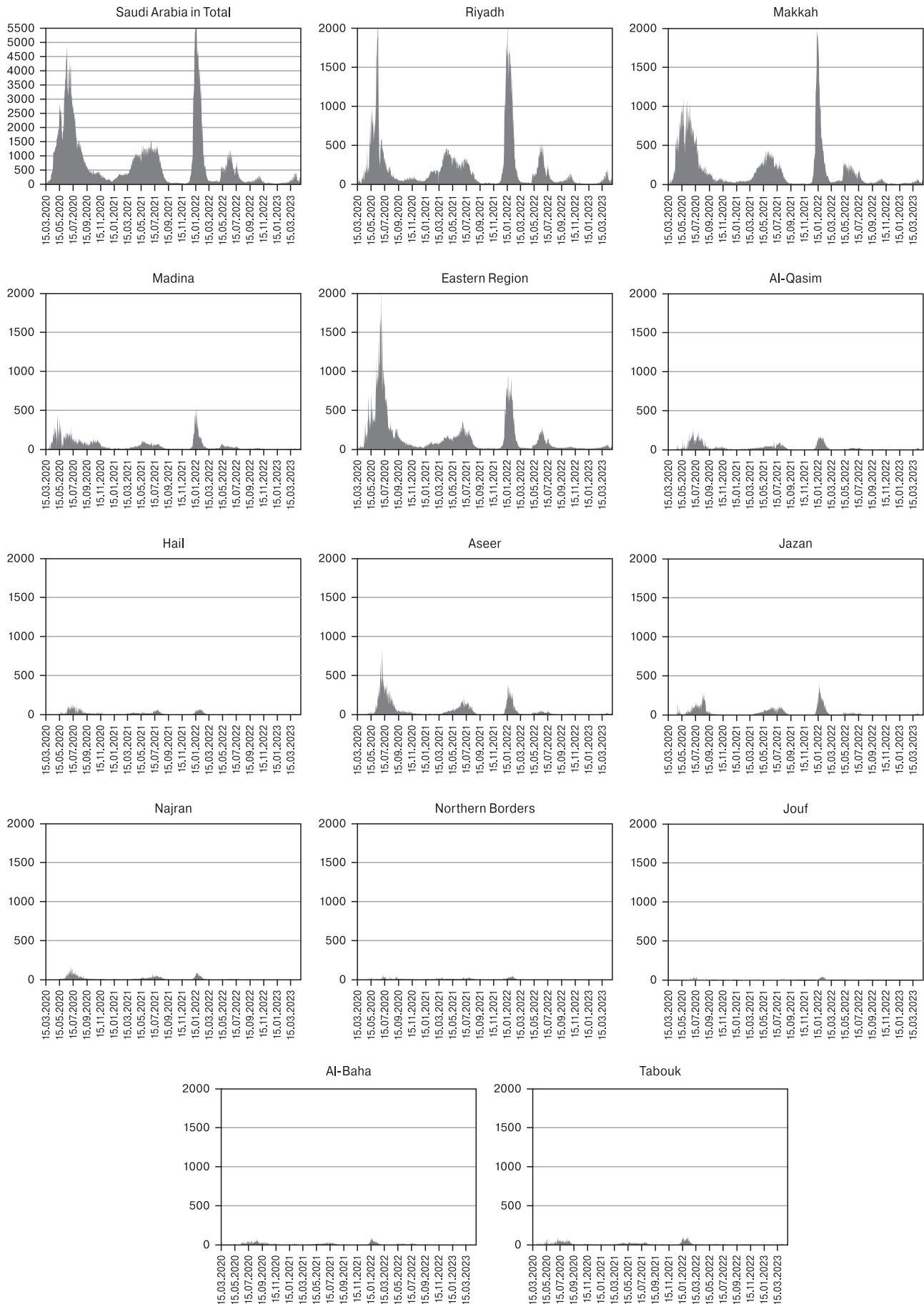


Figure 1. COVID-19 daily infections in Saudi Arabia and its 13 administrative areas

spread in Q3 2020. Other smaller geographic divisions/townships recorded a gradual spread. In the Northern Borders administrative area, Arar, Rafha, Turayf, and other smaller townships recorded a spread. Arar experienced high spread during Q3 2020, Q2 2021, and Q1 2022; Rafha followed a similar pattern but in Q3 2021 instead of Q2 2021; Turayf showed high spread during Q1 2021 and Q1 2022. In the Al-Jouf administrative area, Al-Qurayyat, Sakaka, Tubarjal, and other smaller townships were affected. The highest spread occurred during Q3 2020 and Q1 2022 in Al-Qurayyat and Sakaka, Q3 2021 and Q2 2022 in Tubarjal, and Q1 2022 in other smaller units. In the Al-Baha administrative area, Al-Baha City experienced serious impact in Q1 2022, Al-Mukhwah in Q3 2020 and Q1 2022, and Biljurashi in Q3 2020 and Q2 2021. Other smaller locations, exhibited the widest spread during Q3 2020 and Q1 2022. Within the Tabouk administrative area, Duba (Q1 2022), Tabouk City (Q3 2020), and Umluj (Q2 2021 and Q3 2021) were the most affected areas, showing seasonal variations. Other smaller locations in the area experienced major infections in Q1 2022.

The number of locations affected in each administrative area varied: Riyadh (33), Makkah (29), Al-Madina (11), the Eastern Region (27), Al-Qasim (14), Hail (9), Aseer (25), Jazan (17), Najran (7), the Northern Borders (8), Al-Jouf (8), Al-Baha (9), and Tabouk (8), constituting a total of 205 localities.

### Increase in infection

This section aims to explain the pattern of COVID-19 spread, highlighting the major affected localities. It was found that cases of infection increased significantly, from a mere 392 cases on March 21 (193 899 in Q2 2020, including 10 days in March) to 847 219 in Q2 2023 (April and 4 days in May). This represented a 4.4 times increase with seasonal, monthly, and quarterly variations (Table 1). This increase on a daily basis was traced across quarters-seasons: cases increased by 1.7 (334 690), 1.9 (362 652), 2.0 (390 325), 2.5 (488 499), 2.8 (546 599), 2.9 (556 868), 3.9 (750 564), 4.1 (795 593), 4.2 (816 373), 4.3 (826 686), and 4.3 (833 527) times, quarter-wise, recording the highest increases during Q1 2022 (1.0 points from 2.9 to 3.9), followed by Q2 2021 (0.5 points from 2.0 to 2.5), and recording a fractional increase except in Q3 2021 (0.3 point increase).

The Riyadh administrative area, housing the national capital, initially recorded 52 909 cases (Q2 2020), which saw a gradual increase until Q1 2021, followed by a rise of 0.6 points. Subsequently, in Q1 2022, it surged by 1.3 points, displaying a slow but consistent upward trend. By Q2 2023, this administrative area reported a total of 231 547 cases. Numerous localities within this area were affected, notably Ad Duwadimi (77–2079; 27 times), Ad Dilam (956–5387; 19.2 times), and Afif (1371–1979; 17.0 times). While these increases followed a different pattern, Ad Duwadimi witnessed the fastest rise, particularly during Q1 2022

(an increase from 1705 to 1880; 175 cases) and Q2 2021 (from 1572 to 1656; 84 cases). However, the number of cases in Ad Dilam rapidly increased during Q1 2021 and Q2 2021 (from 2040 to 2528, an increase of 488; and to 3072, an increase of 544), marking rises of 4.5 and 4.4 points, respectively. In Afif, the increase was less rapid (from 1371 to 1979 cases), with the most rapid rise observed during Q2 2021 (from 1572 to 1656 cases), marking an increase of 3.4 points. All other localities, including Riyadh, recorded nominal increases except during Q1 2021 and Q2 2021.

In the Makkah administrative area, there were 57 389 cases in Q2 2020, which increased rapidly in the next quarter (0.5 points) and thereafter progressed slowly until Q1 2021. It saw a rise of 0.5 points in Q1 2021 and 0.9 points in Q1 2022, with a gradual but consistent increase to 206 004 by Q2 2023. The majorly affected localities include Al-Kamil (31–1768; 57 times), Al-Lith (100–3869; 38.7 times), and Rabigh (5537–23 032; 18.8 times). While these increases showed different patterns, Al-Kamil's rise was considered the fastest, particularly during Q3 2020 (an increase from 31 to 261; 230 cases), Q2 2021, and Q3 2021 (362–840, an increase of 478 cases, and to 1170 cases, an increase of 330 cases, respectively), and Q1 2022 (1180–1741; 561 cases). In contrast, cases in Rabigh recorded rapid increases only in Q1 2022 (16 956–20 408; 3452 cases), registering a 13.9-point surge. All other localities, including Jeddah and Makkah, recorded nominal increases, except in Q1 2022, although Makkah and Al-Qunfudhah did not.

In the Al-Madina administrative area, there were 15 106 cases in the beginning quarter (Q2 2020), which increased quickly over the next two quarters (0.6 and 0.4 points), and thereafter proceeded slowly until Q4 2021, raised by 0.7 points. In Q1 2022, it reporting slow but steady increases, reaching 56 872 by Q2 2023. Localities notably affected at a rapid pace include Al-Ula (35–1699; 48.5 times), Khaybar (24–1384; 57.7 times), Al-Mahd (95–1125; 11.8 times), and Yanbu (947–11 305; 11.9 times). While these increases showed different patterns, Khaybar witnessed the fastest rise. Initially low in Q2 2020, it surged notably in Q3 2020 and Q4 2020 (from 24 to 275, an increase of 251 cases; and to 398, an increase of 123 cases, respectively), followed by Q2 2021 and Q3 2021 (from 434 to 640, an increase of 206 cases; and to 850, an increase of 210 cases, respectively), and Q1 2022 (from 852 to 1339, an increase of 487 cases). However, the number of cases at Al-Mahd (most rapid in Q1 2022) and Yanbu increased slowly (from 95 to 1125 and from 947 to 11 305, respectively). Al-Madina recorded a gradual increase, whereas other localities experienced swift spreading, especially in Q2 2021 and Q1 2022.

In the Al-Qasim administrative area, there were 3759 cases in the first quarter, which rapidly increased in the next quarter (2.2 points) and continued to rise in Q1 2021 and Q2 2021 (0.9 points each) and Q1 2022 (1.7 points), reporting slow but steady increases.

Table 1. Increase of COVID-19 reported cases from the base as unity by administrative areas

Region/Location	2020			2021				2022				2023	
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
<b>Riyadh</b>													
Ad Diriyah	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.4	1.4	1.4	1.4	1.4	1.4
Afif	1.0	4.8	5.8	6.7	10.1	12.3	12.4	15.2	16.0	16.4	16.8	16.8	17.0
Ad Duwadimi	1.0	5.5	6.5	8.3	12.8	14.5	14.8	22.4	24.2	25.2	25.8	26.3	27.0
Ad Dilam	1.0	3.1	4.7	9.2	13.6	15.0	15.0	18.2	18.8	18.9	19.1	19.1	19.2
Al-Kharj	1.0	1.9	2.1	2.6	3.2	3.4	3.5	4.9	5.3	5.5	5.5	5.6	5.6
Al-Majmaah	1.0	2.3	3.3	4.0	5.0	5.5	5.6	6.8	7.0	7.1	7.2	7.2	7.2
Hawtat Bani Tamim	1.0	2.3	2.6	3.4	4.7	5.1	5.1	6.2	6.5	6.6	6.6	6.6	6.6
Riyadh	1.0	1.2	1.3	1.5	2.0	2.2	2.3	3.6	3.9	4.0	4.1	4.1	4.2
Wadi Ad Dawasir	1.0	2.5	3.0	3.5	4.5	5.2	5.2	5.7	5.9	6.0	6.1	6.2	6.2
Rest of Riyadh	1.0	2.2	2.5	3.1	3.8	4.4	4.5	5.7	5.9	6.0	6.1	6.1	6.1
<b>Total</b>	1.0	1.3	1.4	1.6	2.2	2.5	2.5	3.8	4.1	4.2	4.3	4.3	4.4
<b>Makkah</b>													
Al-Kamil	1.0	8.4	10.4	11.7	27.1	37.7	38.1	56.2	57.0	57.0	57.0	57.0	57.0
Al-Lith	1.0	6.2	6.8	9	21.2	23.3	23.6	38.3	38.6	38.7	38.7	38.7	38.7
Jeddah	1.0	1.3	1.4	1.5	1.9	2.1	2.2	3.2	3.5	3.6	3.7	3.8	3.8
Khulays	1.0	2.6	2.9	3.0	3.5	3.6	3.7	8.6	8.7	8.7	8.7	8.7	8.7
Makkah	1.0	1.3	1.4	1.5	1.7	1.8	1.9	2.3	2.5	2.5	2.5	2.5	2.5
Al-Qunfudhah	1.0	4.4	4.7	5.0	7.2	8.3	8.4	9.7	9.9	9.9	10.0	10.0	10.0
Rabigh	1.0	2.0	2.0	2.2	3.0	3.6	4.0	18.1	18.7	18.8	18.8	18.8	18.8
Taif	1.0	2.0	2.0	2.1	2.6	3.0	3.1	3.7	3.9	4.0	4.1	4.1	4.2
Rest of Makkah	1.0	3.0	3.3	3.5	5.2	6.0	6.1	9.0	9.3	9.4	9.4	9.4	9.4
<b>Total</b>	1.0	1.5	1.5	1.6	2.1	2.3	2.3	3.2	3.4	3.5	3.5	3.6	3.6
<b>Al-Madina</b>													
Al-Ula	1.0	6.9	8.7	9.3	12.7	21.6	22.4	45.1	47.1	48	48.3	48.4	48.5
Khaybar	1.0	11.5	16.6	18.1	26.7	35.4	35.5	55.8	57.2	57.5	57.6	57.6	57.7
Al-Mahd	1.0	3.9	5.2	5.9	6.7	7.0	7.2	11.6	11.7	11.8	11.8	11.8	11.8
Yanbu	1.0	3.6	5.4	5.8	8.4	9.4	9.5	11.5	11.7	11.8	11.9	11.9	11.9
Al-Madina	1.0	1.4	1.6	1.7	1.8	1.9	1.9	2.4	2.5	2.6	2.7	2.7	2.7
Rest of Al-Madina	1.0	3.9	6.2	6.7	12.5	17.4	18.4	26.6	27.2	27.6	27.7	27.7	27.7
<b>Total</b>	1.0	1.6	2.0	2.0	2.4	2.6	2.7	3.4	3.6	3.7	3.7	3.7	3.8
<b>Al-Qasim</b>													
Al-Badai	1.0	5.0	5.9	6.3	8.4	11.1	11.2	14.9	15.2	15.3	15.3	15.3	15.4
Al-Midhnab	1.0	5.0	5.9	6.3	7.5	9.2	9.2	11.0	11.1	11.1	11.1	11.1	11.2
Ar Rass	1.0	3.2	3.3	3.4	3.6	3.8	3.9	7.2	7.6	8.0	8.2	8.3	8.5
Buraydah	1.0	2.5	2.8	2.9	3.3	3.8	3.9	4.8	5.0	5.2	5.3	5.3	5.4
Riyadh Al-Khabra	1.0	6.5	8.5	8.9	12.3	15.6	15.7	19.3	19.3	19.3	19.3	19.3	19.3
Unayzah	1.0	3.6	4.2	4.5	5.6	6.8	6.9	8.8	9.2	9.5	9.6	9.7	9.9
Rest of Al-Qasim	1.0	4.3	5.3	5.7	7.5	9.3	9.4	11.3	11.5	11.6	11.6	11.6	11.6
<b>Total</b>	1.0	3.2	3.7	3.9	4.8	5.7	5.7	7.4	7.6	7.8	7.8	7.9	8.0
<b>Eastern Region</b>													
Al-Jubayl	1.0	1.3	1.4	1.5	1.7	2.0	2.0	2.4	2.4	2.5	2.5	2.5	2.5
Al-Khafji	1.0	3.5	4.1	5.2	9.1	12.1	12.2	15.7	16.1	16.3	16.4	16.5	16.6
Al-Mubarraz	1.0	2.9	3.0	3.2	3.8	4.1	4.1	4.7	4.7	4.8	4.8	4.8	4.8
Al-Nuayriyah	1.0	4.0	4.8	5.2	9.0	10.4	10.4	12.1	12.2	12.2	12.2	12.2	12.2
Buqayq	1.0	2.8	3.0	3.6	4.7	5.3	5.3	6.1	6.2	6.2	6.2	6.2	6.2
Ad Dammam	1.0	1.5	1.6	1.7	1.9	2.0	2.1	2.7	3.1	3.2	3.2	3.3	3.3
Adh Dhahran	1.0	1.8	2.0	2.2	2.7	3.1	3.1	3.8	4.1	4.3	4.3	4.4	4.5
Hafar Al-Batin	1.0	3.5	3.6	3.6	4.0	4.6	4.6	5.7	5.7	5.8	5.8	5.8	5.9
Al-Hufuf	1.0	1.7	1.8	1.9	2.1	2.2	2.2	2.8	3.0	3.0	3.0	3.0	3.1
Al-Khubar	1.0	1.3	1.4	1.4	1.6	1.8	1.8	2.4	2.5	2.5	2.5	2.6	2.6
Al-Qatif	1.0	1.5	1.6	1.7	1.7	1.8	1.9	2.3	2.3	2.3	2.3	2.3	2.4

Region/Location	2020			2021				2022				2023	
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
<b>Eastern Region</b>													
Ras Tannurah	1.0	1.9	2.0	2.1	2.2	2.4	2.4	3.4	3.4	3.4	3.4	3.4	3.4
Safwa	1.0	1.5	1.5	1.5	1.7	1.9	1.9	2.4	2.4	2.4	2.4	2.4	2.4
Rest of Eastern Region	1.0	2.7	3.0	3.4	4.6	5.4	5.4	6.9	7.0	7.0	7.1	7.1	7.1
<b>Total</b>	1.0	1.7	1.8	1.9	2.2	2.4	2.5	3.1	3.3	3.3	3.4	3.4	3.4
<b>Aseer</b>													
Abha	1.0	2.6	2.8	2.9	3.6	4.5	4.5	6.3	6.9	7.1	7.2	7.3	7.3
Ahad Rufaydah	1.0	3.3	3.5	3.5	3.9	4.3	4.3	5.6	5.8	5.8	5.9	5.9	6.0
Ballasmar	1.0	10.5	13.3	14	21.7	31.2	31.3	33.5	34.1	34.7	34.7	34.7	34.9
Bishah	1.0	2.5	2.6	2.7	3.3	3.7	3.7	4.2	4.3	4.4	4.5	4.6	4.6
Zahran Al-Janub	1.0	5.5	6.6	7.0	11.5	13.8	13.9	16.5	16.8	16.9	16.9	17	17.1
Khamis Mushayt	1.0	2.6	2.8	2.9	3.4	3.8	3.8	4.3	4.4	4.4	4.5	4.5	4.5
Muhayil	1.0	2.5	2.7	2.7	3.2	3.6	3.6	5.1	5.3	5.3	5.4	5.4	5.5
Rijal Al-Ma	1.0	8.5	10.0	10.2	12.7	15.4	15.5	18.9	19.1	19.2	19.2	19.2	19.2
Sarat Abidah	1.0	6.2	6.9	7.0	7.4	7.6	7.6	15.3	16.3	16.9	17.5	18.2	19.0
Rest of Aseer	1.0	5.5	5.7	5.8	6.9	7.8	7.8	9.3	9.4	9.5	9.5	9.5	9.5
<b>Total</b>	1.0	3.3	3.5	3.6	4.4	5.2	5.2	6.5	6.7	6.8	6.9	6.9	7.0
<b>Tabouk</b>													
Tabouk	1.0	2.8	3.0	3.2	4.0	4.4	4.5	5.7	5.9	6.0	6.2	6.3	6.4
Rest of Tabouk	1.0	4.4	5.1	5.5	8.7	11.8	12.3	19.9	20.6	20.8	20.9	20.9	21.0
<b>Total</b>	1.0	3.0	3.3	3.5	4.6	5.4	5.5	7.5	7.8	7.9	8.1	8.2	8.3
<b>Hai</b>													
Hail	1.0	2.6	4.2	4.5	4.8	6.0	6.1	7.1	7.3	7.4	7.5	7.5	7.6
Rest of Hail	1.0	6.9	8.8	10.1	14.9	20.9	21	27.2	27.3	27.4	27.4	27.4	27.4
<b>Total</b>	1.0	2.9	4.5	4.9	5.7	7.2	7.3	8.8	8.9	9.1	9.1	9.1	9.2
<b>Northern Borders</b>													
Arar	1.0	5.8	7.2	9.3	12.9	15.8	16.1	20.1	20.5	21.0	21.0	21.1	21.3
Rafha	1.0	6.5	7.8	9.4	10.6	16.3	16.5	20.9	21.0	21.1	21.1	21.1	21.1
Rest of Northern Borders	1.0	2.6	3.3	4.9	5.5	6.2	6.3	8.4	8.4	8.5	8.5	8.5	8.5
<b>Total</b>	1.0	4.7	5.8	7.6	9.7	12.2	12.4	15.7	15.9	16.2	16.2	16.2	16.3
<b>Jazan</b>													
Abu Arish	1.0	10.2	10.4	10.8	16.8	22.3	22.4	30.2	31.3	31.7	32	32.4	32.9
Baysh	1.0	2.2	2.2	2.2	2.5	2.7	2.7	3.9	4.0	4.0	4.1	4.1	4.1
Jazan	1.0	7.5	8.2	8.4	10.5	12.8	13	20.3	21.6	22.4	22.9	23.4	23.8
Sabya	1.0	5.3	5.4	5.5	7.2	8.3	8.4	13.0	13.8	14.0	14.0	14	14.1
Samtah	1.0	6.5	6.6	6.8	8.5	9.8	9.9	13.6	14.1	14.4	14.6	14.7	15.0
Rest of Jazan	1.0	6.5	6.7	7.0	11.8	15.9	16	21.4	21.8	22.1	22.1	22.2	22.3
<b>Total</b>	1.0	4.9	5.1	5.2	7.1	8.8	8.9	12.7	13.2	13.5	13.6	13.7	13.9
<b>Najran</b>													
Najran	1.0	3.3	3.7	3.9	4.7	5.6	5.7	6.7	6.9	7.1	7.2	7.2	7.3
Sharorah	1.0	3.8	3.9	4.1	4.6	5.3	5.3	6.6	6.7	6.8	6.8	6.8	6.8
Rest of Najran	1.0	5.8	6.7	7.3	11.8	18.8	18.9	25.2	25.3	25.5	25.6	25.6	25.7
<b>Total</b>	1.0	3.6	3.9	4.2	5.1	6.5	6.5	8.0	8.1	8.3	8.4	8.4	8.5
<b>Al-Baha</b>													
Al-Baha	1.0	2.1	2.4	2.7	3.3	4.8	8.1	8.1	9.7	11.3	11.8	12.3	12.6
Al-Mukhwah	1.0	4.5	6.2	6.4	7.6	8.3	10.8	10.8	11.3	11.5	11.5	11.6	11.6
Biljurashi	1.0	9.5	11.6	12.8	19.7	23.6	27.0	27.0	28.3	29.3	29.5	29.7	30.1
Rest of Al-Baha	1.0	7.5	9.2	9.9	10.6	11.7	15.3	15.3	15.8	16.3	16.3	16.3	16.5
<b>Total</b>	1.0	5.3	6.6	7.1	8.9	10.5	13.7	13.7	14.7	15.7	15.9	16.1	16.3
<b>Al-Jouf</b>													
Sakaka	1.0	5.6	6.1	7.5	11.1	11.1	11.1	15.5	15.8	16.2	16.3	16.4	16.7
Rest of Al-Jouf	1.0	3.4	4.5	6.1	10.8	10.8	10.8	15.1	15.2	15.4	15.4	15.4	15.4
<b>Total</b>	1.0	4.4	5.2	6.8	10.9	10.9	10.9	15.3	15.5	15.8	15.8	15.9	16.0
<b>Country Total</b>	1.0	1.7	1.9	2.0	2.5	2.8	2.9	3.9	4.1	4.2	4.3	4.3	4.4

This number reached 29 347 by Q2 2023. Affected localities included Al-Badai (98–1507; 15.4 times), Al-Midhnab (161–1801; 11.2 times), Riyadh Al-Khabra (77–1489; 19.3 times), and others (507–5904; 11.6 times). Although these increases followed different patterns, neither Al-Badai nor Al-Midhnab showed rapid seasonal increases, while Riyadh Al-Khabra did experience such rises in Q3 2021 and Q1 2022. While Buraydah recorded a slow increase, other localities witnessed a rapid spread, especially in Q1 2022.

In the Eastern Region, where this epidemic first emerged in the country, there were 48 305 cases initially. It swiftly spread, expanding to a large population in the next quarter (83 999 with a gap of 35 694, resulting in a 0.7 points increase), followed by another rise in Q1 2022 (0.6 points). A gradual but consistent increase was reported, reaching 164 006 by Q2 2023. Localities substantially and rapidly affected included Al-Khafji (208–3456; 16.6 times) and Al-Mubarraz (2728–13 068; 4.8 times). Despite following a similar pattern, a rapid increase was recorded during Q2 2021 and Al-Khafji had a second season of rapid increase during Q3 2021 (3.9 and 3.8 points, respectively). Major cities, such as Ad Dammam, Al-Khubar, and Al-Jubayl, recorded slow increases.

The Aseer administrative area initially recorded a reasonably high spread of 7972 in Q2 2020, which gradually increased to 55 573 by Q2 2023. The widely affected localities were Ballasmar (86–2999; 34.9 times), Zahran Al-Janub (102–1740; 17.1 times), Rijal Al-Ma (91–1751; 19.2 times), and Sarat Abidah (102–1934; 19.0 times). While these increases followed different patterns, Ballasmar's and Rijal Al-Ma's increases were comparable to those of Zahran Al-Janub and Sarat Abidah.

The Tabouk administrative area was a less affected geographical area, with a smaller spread of 1537 cases in Q2 2020, which slowly increased to 12 751 by Q2 2023. Localities in this administrative area were less widely affected, except Tabouk (1338–8568; 6.4 times). While the increase was slow, there was a relatively high spread during Q2 2020. Other localities in the area had a relatively low spread in the first quarter, notably expanding from 199 to 4183, marking a 21-time increase.

Similarly, the Hail administrative area followed a comparable pattern, recording a smaller spread of 1615 cases in Q2 2020, which gradually increased to 143 949 by May 4, 2023. Localities in this administrative area were less widely affected, except for Hail (1484–11 293; 7.6 times). While this increase was slow, there was a relatively high spread in Q2 2020, which recorded a slow but steady increase. Other localities witnessed a low spread in the first quarter but a rapid spread in the next one (Q3 2020), and thereafter in Q2 2021, Q3 2021, and Q1 2022. This was relatively widespread.

The Northern Borders administrative area followed a pattern very similar to that of Tabouk and

Hail areas, recording a smaller spread: 431 cases in Q2 2020, which increased slowly to 7038 by Q2 2023. Localities in this administrative area were less widely affected except the headquarters Arar (208–4422; 21.3 times) and Rafha (57–1201; 21.1 times), where the initial slow spread expanded in Q3 2020, Q2/Q3 2021, and Q1 2022. Other localities in the area witnessed a low spread in the first quarter that was maintained throughout by containment measures.

Jazan had a different pattern of spread, and most of the major locations were widely affected: 2393 cases in Q2 2020 increased rapidly to 33 286 by Q2 2023, marking Q3 2020 (to 11 651; 4.9 points) and Q1 2022 (from 21 188 to 30 318; 3.8 points) as the rapid increase seasons. Widely affected localities in this administrative area were the headquarters Jazan (437–10 399; 23.8 points) and others, such as Abu Arish (142–4674; 32.9 points), Baysh (1056–4364; 4.9 points), Sabya (232–3268; 14.1 points), and Samtah (155–2324; 15.0 points). Out of these, the largest city/governorate, Jazan, had the smallest spread, with a rapid spread at two points, in Q3 2020 (to 3294; 7.5 points) and Q1 2022 (from 5695 to 8858; 7.0 points), whereas the other specified towns had different patterns. The rest of Jazan, comprising small towns, witnessed a rapid and wide increase in COVID-19, by 22.3 times, with Q3 2020, Q2 2021, and Q1 2022 as the seasons of rapid increase.

The Najran administrative area had a lesser spread, unlike Jazan: 1651 cases in Q2 2020 increased slowly to 13 957 by Q2 2023, indicating no sharp increase or seasonal spread. Najran (1208–8799; 7.3 times) and Sharorah (329–2231; 6.8 times) were the two widely affected localities, with no widespread, not even seasonal variations. The rest of Najran, comprising small towns and neighborhoods, recorded a rapid spread from a mere 114 to 2927 cases, increasing by 25.7 times.

A smaller administrative area, Al-Baha, had a smaller spread: 684 cases in Q2 2020 increased slowly to 11 143 by Q2 2023, marking an increase in Q3 2020. The three major towns/governorates having high spread included Al-Baha (244–3066; 12.6 times), Al-Mukhwah (118–1369; 11.6 times), and Biljurashi (103–3097; 30.1 times). Out of these, Biljurashi Town's spread could be considered wider than the other two, whereas the headquarters had a smaller spread. In addition, there were no periodic (seasonal) increases noted in Al-Baha and Al-Mukhwah, but there were seasonal increases noted in Biljurashi (Q3 2020, Q2 2021 and Q3 2021, and Q1 2022). The remaining Al-Baha recorded a rapid increase from 219 to 3611 cases, indicating an increase of 16.5 times.

Another smaller administrative area was Al-Jouf, which had a comparatively smaller spread: 248 cases in Q2 2020, which increased to 35 318 by Q2 2023, marking an increase in Q3 2020 (to 1350; 4.4 times) and Q1 2022 (11 935–15 738; 4.4 times). The only major town with a high spread was Sakaka, the head-



quarter (117–1952; 16.7 times) with the same seasonal hikes of Q3 2020 (to 656; 5.6 times) and Q1 2022 (1300–1819; 3.4 times). The rest of Al-Jouf recorded an almost equal spread, from a mere 131 to 2022 cases, increasing by 15.4 time.

### Infections per population (1000 persons)

Absolute numbers, percentages, and proportions explain the spread of COVID-19 in a population, especially in Saudi Arabia, which has an unevenly distributed population. More than half of the population is concentrated in Riyadh, Makkah, and the Eastern Region administrative areas, where major administrative, educational, health, and developmental infrastructure are concentrated; 71 percent of COVID-19 infections occurred in areas that comprised 67.6% of the total population.

As the total infection rate in the country was 26.3 per 1000 persons, as per Q2 2023, administrative areas could be divided into three categories: more or less than the national average (25–30), lower than the national average (less than 25), and higher than the national average (more than 30), as shown in Table 2. The first group comprised Riyadh (27), Makkah (26), Al-Madina (27), Aseer (27), Jazan (24), and Najran (24). There were many seriously affected locations in the Riyadh Administrative area, including Wadi Ad Dawasir (11–65), followed by Hawtat Bani Tamim (9–61), Ad Dilam (2–47), and Afif (2–36). While Al-Kharj (3–14), the rest of Riyadh (3–16), and Ad Duwadimi (1–24) had low levels of spread, Riyadh City had a spread close to the total (7–28). In the Makkah administrative area, infection was widespread in Al-Lith (5–186), Khulays (18–154), and Al-Kamil (1–77). Makkah and Jeddah cities/governorates were less infected (10–26 and 7–26, respectively) than Al-Qunfudhah (5–51), Rabigh (2–36), and Taif (10–41). The remaining area was infected at a slower rate. The Al-Madina administrative area experienced a slow spread with an infection rate of seven in the beginning, which increased to 27 towards the end, with some towns/governorates having higher infections per 1000 persons, such as Khaybar (2–87), Yanbu (4–44), and Al-Ula (1–42). Al-Mahd (2–23) and Al-Madina City (10–26) showed a low spread. The Aseer administrative area had many locations affected by the widest spread, including Ballasmar (8–278), Sarat Abidah (5–97), and Zahran Al-Janub (4–72). Other localities/towns were less affected but had varying intensities, including Bishah (5–24) and Khamis Mushayt (5–24), followed by the rest of Aseer (2–16). Other locations, such as Abha, Ahad Rufaydah, Muhayil, and Rijal Al-Ma, were moderately affected. In the case of the Jazan administrative area, Baysh was the worst-affected town/governorate (32–134) from the beginning, followed by Abu Arish (2–67), Jazan City (3–60), Samtah (4–54), and Sabya (3–45). The other localities in the rest of the Jazan administrative area

were generally less affected. The last one in the group was the Najran administrative area, with two major affected locations: Najran City (3–23) and Sharorah Town (4–25). While this area was less widely affected (3–24), Sharorah was more affected than Najran City, the headquarters.

The second category comprises Al-Jouf, Hail, Tabouk, the Northern Borders, and Al-Qasim administrative areas, with less serious threats that were less widespread. Among these, the first three indicated a smaller spread, whereas the fourth indicated a major spread. As expected, the rural Al-Jouf was not seriously affected except for the headquarters of Sakaka, where the spread was slightly slower and less threatening. However, in the Hail administrative area, there was a reasonably serious threat to the headquarters, Hail City, with 3–25 infections per 1000 persons; other parts had a smaller spread (0–12). In contrast, the Tabouk administrative area was less widely affected (2–14), with Tabouk City (2–14) and the rest (1–14) showing mild attacks. In the Northern Borders administrative area, this epidemic spread very sparsely; the two affected locations were Arar (1–22) and Rafha (1–19), which showed lesser spread than that in other cities and towns. Other localities also had a similar pattern of spread, albeit less than what was previously mentioned, with Al-Qasim being a major administrative area that managed to largely contain the epidemic. Its spread was contained within 3–22 per 1000 individuals but with less geographical spread. Riyadh Al-Khabra was the most widely affected location (3–58), followed by Al-Midhnab (5–54), Al-Badai (2–31), and Unayzah (3–30), whereas the least affected locations were Buraydah and the rest of Al-Qasim.

The administrative areas, namely Al-Baha, the Northern Borders, and the Eastern Region, were negatively affected considering the share of the population. Although small, the Al-Baha administrative area had a large infection attack rate, not in its headquarters (3–34), Al-Baha City, but in Biljurashi (3–86) and Al-Mukhwah (4–52), whereas other locations had a smaller spread (1–19). The Eastern Region has received wide attention in the context of COVID-19, where the spread began, creating huge emergencies. Several cities, towns, and governorates were widely infected, giving rise to higher-than-national average scenarios of emergencies. Out of all the locations, the worst affected were Safwa (25–173) and Al-Qatif (61–143), followed by Al-Nuayriyah (6–77), Adh Dhahran (16–71), Buqayq (11–70), and Al-Jubayl (23–60). The least affected locations in this administrative area were Ad Dammam (9–30), Ras Tannurah (10–33), and Al Khubar (13–34).

In addition to the pattern of spread based on population size, per 1000 individuals, there were seasonal patterns as well, which might be similar to those mentioned in the previous section regarding the increase in COVID-19 spread.

**Table 2. Patterns of COVID-19 spread per 1000 persons for various locations in each administrative area by quarters of 2020, 2021, 2022, and 2023**

Administrative area/ Location	2020			2021				2022				2023	
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
<b>Riyadh</b>													
Ad Diriyah	22	24	25	26	27	28	28	31	31	31	32	32	32
Afif	2	10	12	14	21	26	26	32	34	35	35	35	36
Ad Duwadimi	1	5	6	7	11	13	13	20	21	22	23	23	24
Ad Dilam	2	8	12	23	34	37	37	45	47	47	47	47	47
Al-Kharj	3	5	5	7	8	9	9	12	14	14	14	14	14
Al-Majmaah	4	10	15	18	22	25	25	30	31	32	32	32	32
Hawtat Bani Tamim	9	21	24	31	43	47	47	57	60	60	61	61	61
Riyadh	7	8	9	10	14	15	16	24	26	27	28	28	28
Wadi Ad Dawasir	11	26	32	36	48	54	55	60	62	63	64	65	65
Rest of Riyadh	3	6	6	8	10	11	11	15	15	15	16	16	16
<b>Total</b>	<b>6</b>	<b>8</b>	<b>9</b>	<b>11</b>	<b>14</b>	<b>16</b>	<b>16</b>	<b>23</b>	<b>25</b>	<b>26</b>	<b>26</b>	<b>27</b>	<b>27</b>
<b>Makkah</b>													
Al-Kamil	1	11	14	16	37	51	51	76	77	77	77	77	77
Al-Lith	5	30	33	43	102	112	113	184	186	186	186	186	186
Jeddah	7	9	9	10	13	14	15	21	24	25	25	26	26
Khulays	18	46	52	53	62	65	66	152	154	154	154	154	154
Makkah	10	14	15	15	18	19	20	24	26	26	26	26	26
Al-Qunfudhah	5	23	24	26	37	43	43	50	51	51	51	51	51
Rabigh	2	4	4	4	6	7	8	34	35	36	36	36	36
Taif	10	19	20	21	26	30	30	36	38	39	40	40	41
Rest of Makkah	0	1	1	1	2	2	2	3	3	3	3	3	3
<b>Total</b>	<b>7</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>15</b>	<b>17</b>	<b>17</b>	<b>23</b>	<b>24</b>	<b>25</b>	<b>25</b>	<b>26</b>	<b>26</b>
<b>Al-Madina</b>													
Al-Ula	1	6	7	8	11	19	19	39	40	41	41	42	42
Khaybar	2	17	25	27	40	53	54	84	86	87	87	87	87
Al-Mahd	2	8	10	12	13	14	14	23	23	23	23	23	23
Yanbu	4	13	20	21	31	34	35	42	43	43	43	44	44
Al-Madina	10	14	16	16	18	18	18	23	25	26	26	26	26
Rest of Al-Madina	0	2	3	3	5	7	7	11	11	11	11	11	11
<b>Total</b>	<b>7</b>	<b>12</b>	<b>14</b>	<b>15</b>	<b>18</b>	<b>19</b>	<b>20</b>	<b>24</b>	<b>26</b>	<b>26</b>	<b>26</b>	<b>26</b>	<b>27</b>
<b>Al-Qasim</b>													
Al-Qasim	2	10	12	13	17	22	23	30	31	31	31	31	31
Al-Badai	5	24	29	30	36	45	45	53	54	54	54	54	54
Al-Midhnab	3	10	10	11	11	12	12	22	24	25	25	26	26
Ar Rass	4	9	10	10	12	13	14	17	18	18	19	19	19
Buraydah	3	19	26	27	37	47	47	58	58	58	58	58	58
Riyadh Al-Khabra Unayzah	3	11	13	14	17	21	21	27	28	29	30	30	30
Rest of Al-Qasim	1	6	7	8	10	13	13	16	16	16	16	16	16
<b>Total</b>	<b>3</b>	<b>9</b>	<b>11</b>	<b>11</b>	<b>14</b>	<b>17</b>	<b>17</b>	<b>21</b>	<b>21</b>	<b>21</b>	<b>22</b>	<b>22</b>	<b>22</b>
<b>Eastern Region</b>													
Al-Jubayl	23	31	33	35	40	46	47	56	57	58	59	59	60
Al-Khafji	3	9	11	14	24	32	32	41	42	43	43	43	44
Al-Mubarraz	9	26	28	29	35	37	38	43	43	43	43	44	44
Al-Nuayriyah	6	26	30	33	57	66	66	76	77	77	77	77	77
Buqayq	11	31	34	40	53	59	60	69	69	70	70	70	70
Ad Dammam	9	14	14	15	17	18	18	25	28	29	29	29	30
Adh Dhahran	16	29	31	35	43	48	49	60	65	67	68	70	71
Hafar Al-Batin	3	11	11	11	12	14	14	17	18	18	18	18	18
Al-Hufuf	26	45	47	49	54	56	57	73	76	77	78	78	79
Al-Khubar	13	18	18	19	21	24	24	31	32	33	33	33	34
Al-Qatif	61	93	96	101	106	112	113	138	140	141	142	143	143

Administrative area/ Location	2020			2021				2022				2023	
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
<b>Eastern Region</b>													
Ras Tannurah	10	19	20	21	22	24	24	33	33	33	33	33	33
Safwa	25	65	73	82	113	131	131	167	170	172	172	172	173
Rest of the Eastern Region	1	2	2	2	3	4	4	5	5	5	5	5	5
<b>Total</b>	<b>10</b>	<b>17</b>	<b>18</b>	<b>19</b>	<b>22</b>	<b>24</b>	<b>24</b>	<b>29</b>	<b>31</b>	<b>31</b>	<b>32</b>	<b>32</b>	<b>32</b>
<b>Aseer</b>													
Abha	6	15	16	16	21	25	26	36	39	41	41	41	42
Ahad Rufaydah	5	16	17	17	19	21	21	28	28	29	29	29	29
Ballasmar	8	84	106	112	173	249	249	267	272	277	277	277	278
Bishah	5	13	14	14	17	19	19	22	23	23	23	24	24
Zahrn Al-Janub	4	23	28	30	49	59	59	70	71	71	71	72	72
Khamis Mushayt	5	14	15	15	18	20	20	23	23	24	24	24	24
Muhayil	6	16	17	17	20	22	22	32	32	33	33	34	34
Rijal Al-Ma	2	15	18	18	23	28	28	34	34	34	34	34	34
Sarat Abidah	5	32	36	36	38	39	39	78	84	87	90	93	97
Rest of Aseer	2	9	9	9	11	13	13	15	15	16	16	16	16
<b>Total</b>	<b>4</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>18</b>	<b>21</b>	<b>21</b>	<b>25</b>	<b>26</b>	<b>27</b>	<b>27</b>	<b>27</b>	<b>27</b>
<b>Tabouk</b>													
Tabouk	2	6	7	7	9	10	10	13	13	14	14	14	14
Rest of Tabouk	1	3	3	4	6	8	8	14	14	14	14	14	14
<b>Total</b>	<b>2</b>	<b>5</b>	<b>6</b>	<b>6</b>	<b>8</b>	<b>10</b>	<b>10</b>	<b>13</b>	<b>13</b>	<b>14</b>	<b>14</b>	<b>14</b>	<b>14</b>
<b>Hail</b>													
Hail	3	12	14	15	17	20	20	24	24	25	25	25	25
Rest of Hail	0	3	4	4	7	9	9	12	12	12	12	12	12
<b>Total</b>	<b>2</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>14</b>	<b>16</b>	<b>16</b>	<b>19</b>	<b>19</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>21</b>
<b>Northern Borders</b>													
Arar	1	6	7	10	13	16	17	21	21	22	22	22	22
Rafha	1	6	7	8	9	15	15	19	19	19	19	19	19
Rest of Northern Borders	2	4	5	7	8	9	10	13	13	13	13	13	13
<b>Total</b>	<b>1</b>	<b>6</b>	<b>7</b>	<b>9</b>	<b>12</b>	<b>15</b>	<b>15</b>	<b>18</b>	<b>18</b>	<b>19</b>	<b>19</b>	<b>19</b>	<b>19</b>
<b>Jazan</b>													
Abu Arish	2	21	21	22	34	45	46	62	64	65	65	66	67
Baysh	32	70	70	71	81	88	89	126	129	130	132	132	134
Jazan	3	19	21	21	26	32	33	51	54	56	58	59	60
Sabya	3	17	17	18	23	27	27	42	44	45	45	45	45
Samtah	4	23	24	24	30	35	35	49	50	51	52	53	54
Rest of Jazan	0	2	2	3	4	6	6	8	8	8	8	8	8
<b>Total</b>	<b>2</b>	<b>9</b>	<b>9</b>	<b>9</b>	<b>13</b>	<b>16</b>	<b>16</b>	<b>22</b>	<b>22</b>	<b>23</b>	<b>23</b>	<b>23</b>	<b>24</b>
<b>Najran</b>													
Najran	3	11	12	12	15	18	18	21	22	22	23	23	23
Sharorah	4	14	14	15	17	19	19	24	25	25	25	25	25
Rest of Najran	1	5	6	7	11	18	18	24	24	24	24	24	24
<b>Total</b>	<b>3</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>15</b>	<b>19</b>	<b>19</b>	<b>22</b>	<b>23</b>	<b>23</b>	<b>23</b>	<b>23</b>	<b>24</b>
<b>Al-Baha</b>													
Al-Baha	3	6	6	7	9	13	13	22	26	31	32	33	34
Al-Mukhwah	4	20	28	29	34	37	38	49	51	52	52	52	52
Biljurashi	3	27	33	37	56	67	68	77	81	84	84	85	86
Rest of Al-Baha	1	9	11	12	12	14	14	18	19	19	19	19	19
<b>Total</b>	<b>2</b>	<b>11</b>	<b>14</b>	<b>15</b>	<b>19</b>	<b>22</b>	<b>22</b>	<b>28</b>	<b>30</b>	<b>32</b>	<b>32</b>	<b>32</b>	<b>33</b>
<b>Al-Jouf</b>													
Sakaka	1	3	3	4	5	6	6	9	9	9	9	9	10
Rest of Al-Jouf	0	1	1	2	3	4	4	5	5	5	5	5	5
<b>Total</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>6</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>
<b>Country Total</b>	<b>6.1</b>	<b>10.6</b>	<b>11.5</b>	<b>12.7</b>	<b>15.9</b>	<b>17.8</b>	<b>18.1</b>	<b>23.3</b>	<b>24.7</b>	<b>25.4</b>	<b>25.7</b>	<b>25.9</b>	<b>26.3</b>

## Discussion

Saudi Arabia witnessed the COVID-19 pandemic across the country in administrative areas and almost all governorates with varying numbers of cases, speed, intensity, and share of the population. From the beginning of the infection, Saudi Arabia experienced highs and lows based on population size, urban growth, infrastructure, and economic sectors. For example, a high spread of the disease was reported in Riyadh, Makkah, and administrative areas of the Eastern Region. The second set of regions included Al-Madina, Aseer, Al-Qasim, and Jazan. Other regions had fewer infections. These could directly relate to urbanization, social and religious gatherings, commercial activities, and workplaces, despite the effective implementation of various containment measures all over the country, with seasonal variations [5, 6, 18, 21, 22, 23].

Almost all administrative areas passed the peak stage of infection, and thereby marked declines with substantial public health measures in place to confront political, monetary, and social difficulties [2, 15, 20]. Moreover, most of the cases constituted of travelers from other countries in the Eastern Region and contacts in the Riyadh, Makkah, and Al-Madina administrative areas, apart from medical professionals [17]. In addition, metropolitan cities, such as Makkah, Riyadh, Jeddah, and Al-Madina, had been seriously affected by overcrowding in residences, workplaces, religious places, commercial outlets, and social entertainment sites [17]. This regional disparity may be attributed to population size, population density, and professions that require travel. While the former administrative areas were urban centers, the others were hill stations with agricultural professions. It could be presumed that regions with more interpersonal contacts and dealings had more infections than other regions. This relates to the epidemic etiology and seasonal variations explained by scientists and medical professionals.

Apart from major metropolitan cities, administrative headquarters and smaller cities were infected in large numbers. In urban areas, owing to frequent movements and interpersonal contacts characterized by tertiary-level professions, there was a risk of asymptomatic transmission between travelers and their immediate contacts, which drove the growth of the pandemic, where frequent testing and social distancing, as countermeasures, were impractical, especially during peak seasons [1, 10]. Such frequent incidences occurred in urban centers in Riyadh (Ad Diriyah, Al-Kharj, and Wadi Ad Dawasir), Makkah (Taif), Al-Madina (Yanbu), Al-Qasim (Al-Badai, Ar Rass, and Buraydah), the Eastern Region (Al-Jubayl, Al-Mubarraz, Al-Nuayriyah, etc.), Aseer (Abha, etc.), Tabouk (Tabouk), Hail (Hail), the Northern Borders (Arar), Jazan (Abu

Arish etc.), Najran (Najran, Sharorah), Al-Baha (Biljurashi), and Al-Jouf (Sakaka). These were either administrative headquarters or major cities and townships with augmented population growth and economic infrastructure. The first case was detected in Al-Qatif, a medium-sized city (Khoshaim et al., 2020). Cities differ in demographic attributes, such as sex ratio, child population, geographical conditions, environmental situation, and availability of resources, such as hospitals and medical facilities [14].

This causes differences in monthly infected cases, increase in infection, and share of individuals infected, with differences across administrative areas and locations. In addition, there were differences in the spread across administrative areas and governorates depending on population, infrastructure, and professions. Fewer prospective administrative areas had lesser spread, confirming the effects of crowding, interpersonal contact, commercial establishments, and professions. This highlights the importance of emergency preparedness during epidemics. However, infections in such prominent administrative areas cannot be higher in terms of ratios and proportions based on population size, and are often higher in major urban pockets, locations, and townships. That is, the second-order administrative areas, cities, and neighborhoods were found to be at risk in terms of rapid growth and wider infections, such as Ballasmar, Safwa, Adh Dhahran, Wadi Ad Dawasir, Baysh, and Jazan.

## Conclusion

Despite strenuous efforts by the Saudi Arabian Ministry of Health in coordination with other governmental and non-governmental agencies, COVID-19 spread rapidly in the country, with spatial and seasonal differences across administrative areas, major cities, and major residential and commercial locations. Out of the 13 administrative areas, Riyadh, Makkah, and the Eastern Region reported disease widespread; Al-Madina, Al-Qasim, Aseer, and Jazan had a medium level of spread; and Tabouk, Hail, the Northern Borders, Najran, Al-Baha, and Al-Jouf had a low level of spread. This classification could be related to the distribution of population and infrastructure in the country. Major cities, such as Riyadh, Jeddah, Makkah, Al-Madina, Buraydah, and Ad Dammam, faced a high level of spread, both in terms of the number of infected individuals and its increase, as there were certain locations, such as headquarters of governorates (Taif, Khamis Mushayt, Samtah, Biljurashi, Wadi Ad Dawasir, Yanbu, Ar Rass, etc.) and other major residential and commercial locations (Al-Mubarraz, Al-Hufuf, Safwa, Ballasmar, etc.), that were reported to have a high rate of COVID-19 infection.

The increase in COVID-19 infection in the country during the peak seasons of Q3 2020, Q2 2021, and Q1 2022 threatened human lives, causing anxiety and apprehension. A significant increase was reported in the major administrative areas of Riyadh, Makkah, Al-Madina, Al-Qasim, and the Eastern Region. In addition, the increases in Wadi Ad Dawasir, Taif, Ar Rass, Al-Jubayl, Al-Hufuf, Safwa, Khamis Mushayt, Samtah, and Biljurashi were faster. In other words, the number of upcoming townships and promising future cities were impacted by the rapid increase. In these specified locations, the infection spread to a major share of the population.

Based on the statistics of the spread of COVID-19, administrative areas were divided into three categories: major spread (Al-Baha, the Northern Borders, and the Eastern Region), medium spread (Riyadh, Makkah, Al-Madina, Aseer, Najran, and Jazan), and low spread (Al-Qasim, Al-Jouf, Hail, and Tabouk). This classification provides insights into emergency preparedness, strategies for controlling and combating infectious diseases, and future considerations. It also highlights the need to concentrate on medium-sized and upcoming neighborhoods that are fast-growing in terms of population and infrastructure.

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## Additional information

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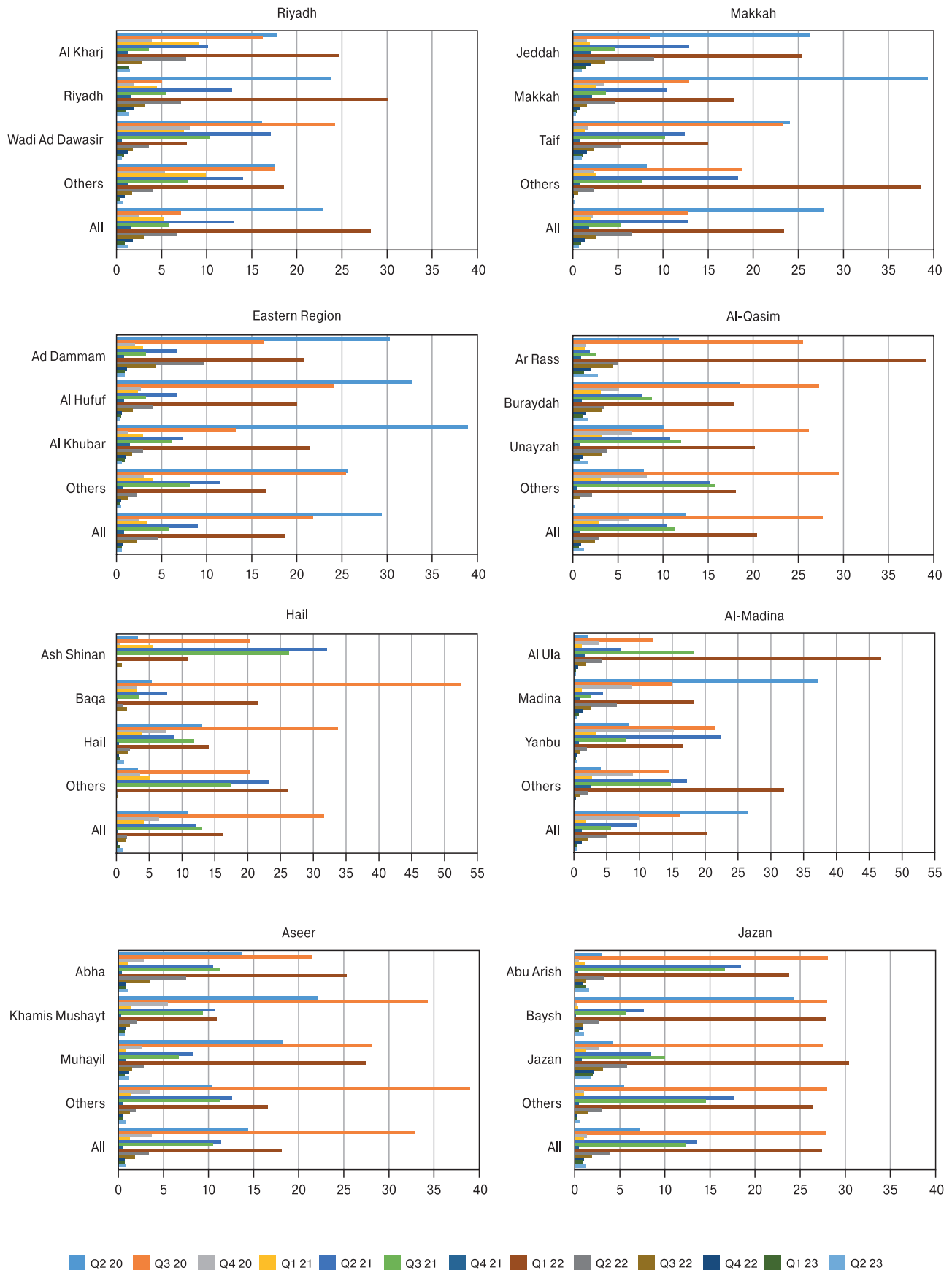
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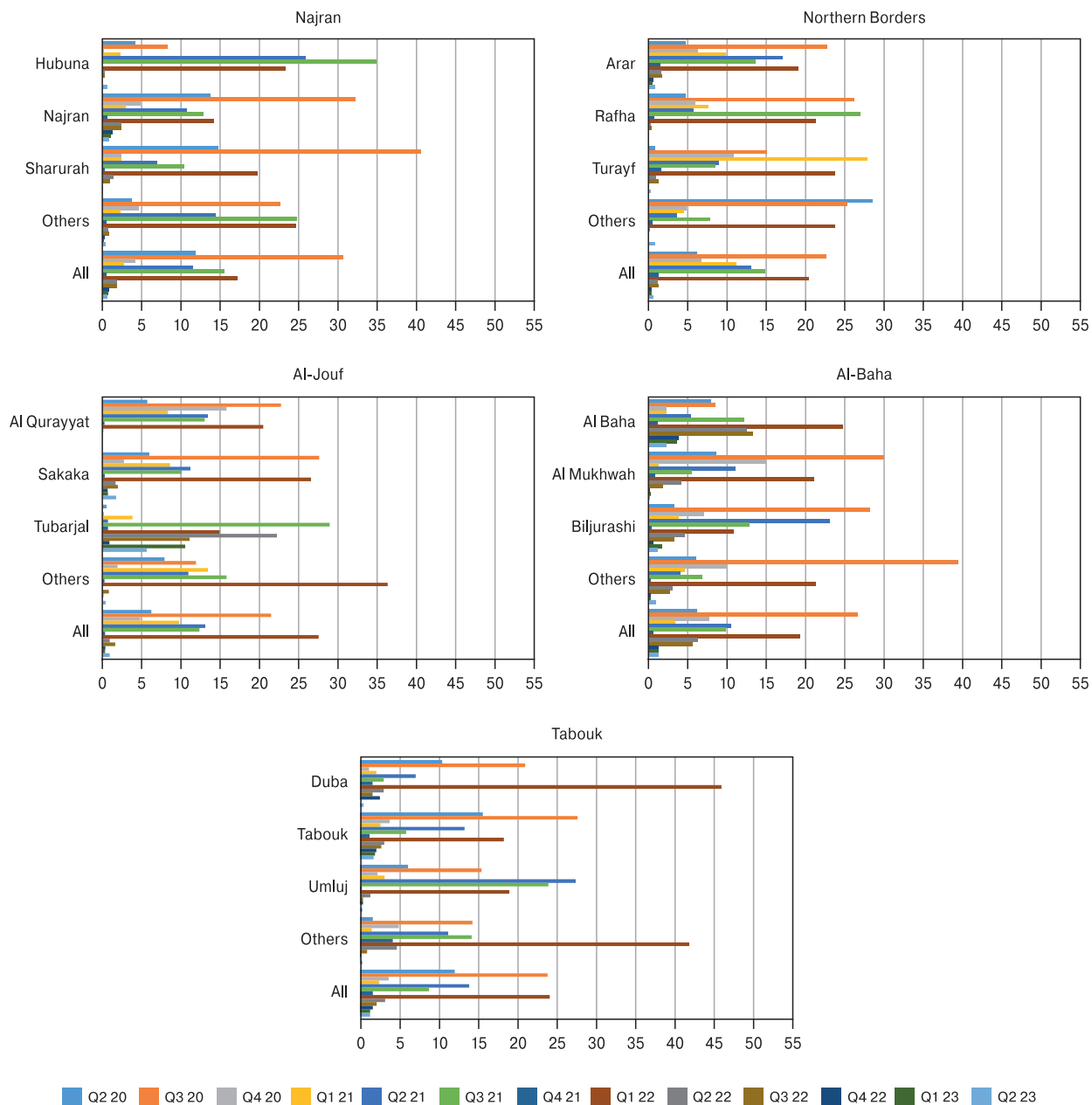
**Иллюстрации к статье «Географическое распространение инфекции COVID-19 в Саудовской Аравии» (авторы: Х.М. Альдоссари, А. Абдул Салам) (с. 141–154) (1-й фрагмент; продолжение см. на с. II)**  
 Illustrations for the article “Geographical distribution of COVID-19 infection across Saudi Arabia” (authors: Aldossari H.M., Abdul Salam A.) (pp. 141–154) (1st fragment; continued on p. II)



**Figure 2. Percentage distribution of COVID-19 spread at various locations by administrative areas**

**Иллюстрации к статье «Географическое распространение инфекции COVID-19 в Саудовской Аравии» (авторы: Х.М. Альдоссари, А. Абдул Салам) (с. 141–154) (2-й фрагмент; начало см. на с. I)**

Illustrations for the article “Geographical distribution of COVID-19 infection across Saudi Arabia” (authors: Aldossari H.M., Abdul Salam A.) (pp. 141–154) (2nd fragment; start on p. I)



**Figure 2. Percentage distribution of COVID-19 spread at various locations by administrative areas**