GIS-Based Solutions for Monitoring and Controlling COVID-19 in ASHGHAL Construction Projects: Improving Construction Sector Resilience

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Abstract

Early in 2020, doctors around the globe identified the virus responsible for Coronavirus disease 2019 (COVID-19). Rapidly spreading, the virus reached every continent. As part of its efforts to prepare for the FIFA World Cup in 2022 and Qatar National Vision 2030, the Public Works Authority (Ashghal), the State of Qatar, is on a fast-track mission to implement major infrastructure projects to revamp roads and sewer networks. Managing the human workforce on construction project sites becomes a significant challenge considering the pandemic. Large infrastructure projects are always characterized by many workers interacting in proximity at the work site. Immediately at the pandemic's beginning, management was instructed to leverage technology to empower decision-makers with COVID-19 monitoring tools across all the infrastructure construction projects. Thus, the Engineering Services Department created an ArcGIS Dashboard for engineers, contractors, and higher management to track the construction projects' COVID-19 status. Maps and data are combined in ArcGIS Dashboards to highlight significant patterns and measures. This paper explores the workflow established with direct communication and a submission system from the contractors and project managers to help collect and monitor critical health parameters of workers to prevent the propagation of COVID-19 infection. The study concluded that implementing a GIS safety dashboard for workers can help reduce the risk of project shutdowns due to novel Coronaviruses and provide an effective tool for organizations to improve occupational health and safety standards at worksites.

Keywords: Workforce; Occupational Health; Safety; Construction; COVID-19; Dashboard

1 Introduction

The worldwide impact of Coronavirus on the construction industry has led to a poor economic structure; countries are experiencing difficulties in developing their infrastructure (Majumder & Biswas, 2021). COVID-19 is the largest health and safety threat to the global construction industry. The COVID-19 crisis has decreased site productivity, increased regulatory costs, hindered project completion, and increased construction workers' risk and infection exposure (Olanrewaju et al., 2021). An outbreak of the novel Coronavirus disease of 2019 (COVID-19) poses a significant public health concern of international concern. This outbreak has serious economic and social implications ((WHO), 2022). The COVID-19 epidemic directly threatens the achievement of the above health

goals and affects their realization in terms of economic and social development.

A sufficient understanding of COVID-19's transmission characteristics has not been developed in light of global environmental changes ((CDC), 2022). In addition, the acceleration of global urbanization, the concentration of the population, the frequency and complexity of interactions, and the lack of medical protection in developing countries all contribute to the difficulty of preventing and controlling COVID-19 (Zhou et al., 2020).

COVID-19 has a wide-ranging, complicated, and sophisticated effect on the construction industry, just as it does on other major parts of the economy. Over 80% of construction workers on sites use hazardous materials and components, work in harsh weather conditions, carry or convey heavy materials and components, have poor health and safety practices, work in unhygienic conditions, and are exposed to harsh weather conditions (Olanrewaju et al., 2021).

In state of Qatar the Public Works Authority 'Ashghal' is responsible for majority of the infrastructure related to roads and drainage. Ashghal was established in 2004 to be responsible for the planning, design, procurement, construction, delivery, and asset management of all infrastructure projects and public buildings in Qatar ((ASHGHAL), 2022).

Following the announcement of awarding the FIFA 2022 World Cup hosting rights to the State of Qatar on December 02, 2010, the State was estimated to spend significantly on hundreds of new construction projects and the pressure started to build up for infrastructure projects. As of 2015, the construction sector contributed 10% to Qatar's gross domestic product (Al-Nuaimi, 2019). Then, on both the construction sites/offices and in the accommodation facilities, Ashghal took a series of measures to prevent the spread of Coronavirus disease (COVID-19); also policies and guidelines were reviewed and updated frequently as the pandemic evolved ((ASHGHAL), 2020).

Combined with large-scale population flow and other factors, the strong infectivity, long incubation period, and uncertain detection of COVID-19 made it imperative to provide scientific and technological support to prevent and control the spread of the epidemic. Ashghal aims to reduce the impact and spread of the COVID-19, hence, the pursue for monitoring tools was inevitable.

2 Role of Location Intelligence

At the 2020 Esri User Conference, the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University won the Making a Difference Award for creating the Johns Hopkins COVID-19 Dashboard. The iconic dashboard visualization created by Ensheng Dong, a doctoral student at Johns Hopkins University, is used around the globe to assess the spread of the Coronavirus disease 2019 (COVID-19) pandemic (Milner, 2020).

This dashboard is intended to provide researchers, public health authorities, and the general public with an easy-to-use tool for tracking outbreaks. By providing data based on the date of report rather than the date of event, the dashboard functions as a snapshot of the cumulative data reported as of the date of report (Dong et al., 2022).

The use of location intelligence has changed the process of fighting Coronavirus (COVID-19). An organization's ability to respond to crises, maintain continuity of operations, and support the process of reopening can be significantly enhanced through the use of maps and geographical information systems (GIS). There are variety of utilizations of the GIS and its technology at early adoption of the spatial solutions; these are captured as part of the published studies which are summarized in Table 1.

Table 1: Summary of Studies Grouped by the Geospatial Solutions Theme

(Franch-Pardo et al., 2020)

Spatial Subject	Number of studies
Spatial Temporal Analysis	23
Health and Social Geography	17
Environmental Variables	15
Data Mining	11
Web-based Mapping	5

A wide range of GIS tools are being used to control the pandemic, particularly in relation to spatiotemporal analysis and web-based mapping (Fatima et al., 2021; Franch-Pardo et al., 2020). COVID-19 prevention and control were enhanced through the use of GIS data for decision-making, measure formulation, and effectiveness assessment. As a technology, GIS provides a complete solution for preparing data, building platforms, creating models, and producing maps. In a number of recent studies, spatial solutions provided by GIS has been found to have much potential for preventing and controlling COVID-19, with the most significant aspects being enhanced prevention measurements and the evaluation of controls (Karabegovic et al., 2021; Sarwar et al., 2020).

Different Web-based GIS services have been launched by governments, public health agencies, and academic institutions. ArcGIS is a commercial technology developed by Esri that is well-known and widely used throughout the world. All ArcGIS dashboard implementations have the same user interface, which makes them easy to identify. Despite the modular interface, each dashboard can be assembled in a different manner, although most organizations use either the same or a very similar interface.

The purpose of this study is to explore the implementation of geographical and geospatial analysis in Ashghal. A key objective of the study is to highlight current geospatial analytical methods that can be used to collect, process, analyze, and visualize COVID-19 cases in infrastructure construction projects.

3 Methods

Since the start of the pandemic, the Public Works Authority 'Ashghal' has continued to take all necessary precautions to protect the health and safety of its employees and stakeholders and ensure the continuity and on-time delivery of its projects. As information is of utmost importance today, particularly in times of post-pandemic crisis, it is imperative that Ashghal Infrastructure Projects share data promptly and confidentially.

Before implementing this transformation, all information related to COVID-19 was collected manually for each site in each project, then it was transferred to Excel sheets by email to be reviewed and finally checked to proceed through a certain analysis and reporting cycle. GIS technology allows for rapid construction of an information system for a relevant subject, especially in terms of database management, spatial analysis tools, and mapping (Zhou et al., 2020). An instrumental aspect of large-scale epidemic prevention and control is the use of data to support decisions and actions, particularly in the case of Asghal infrastructure projects.

Ashghal has unfurled a robust health and wellness initiative. As soon as the pandemic hit us, a core committee comprising of Projects Affairs Health Advisor, Information Technology Team Engineers, Engineering services GIS experts, Planning and Quality experts, and Safety Experts worked together

to create an online Covid reporting dashboard. Through ArcGIS Dashboards, users are able to convey information by using intuitive and interactive data visualizations that present location-based analytics. Data dashboards provide a visual representation of geographic information and data that can be used for monitoring events, making decisions, communicating with others, and identifying trends. A dashboard is a display that consists of multiple visualizations grouped together on a single screen. With them, you can obtain a comprehensive view of your data as well as key insights for making quick decisions based on the data.

3.1 Ashghal COVID-19 Dashboard

As part of various initiatives implemented by the Authority, Ashghal has created a unique GIS-based live COVID-19 Dashboard that helps Ashghal generate daily COVID reports that include the number of positive cases, number of suspected cases, and the number of recovered cases across Ashghal's projects and offices. One of the biggest challenges during the pandemic has been the flow of information and the sharing of knowledge and how the information will contribute to the organization's ability to contain the outbreak. As part of Ashghal's effort to make information sharing spontaneous, live, and practical, it launched a live COVID Dashboard, an online platform accessible from anywhere within the organization, allowing members of the organization to view information regarding the number of COVID cases. With the latest Geographical Information Systems for location intelligence, Ashghal could map all its work sites and thousands of employees across Qatar in real time to reflect where the cases were distributed, how many were positive, and how many were suspect.

Engineering services experts and engineers undertook an exercise to determine the cost saved and number of hours spent before using the manual entry and analysis and after implementing the online automation Table 2. The amount of time spent on online applications is small in comparison to the amount of time spent on manual applications. More than 219,000 QAR as total cost savings from reporting and tracking COVID-19 cases in Ashghal's Affairs and departments and with more than 168 contractors as sources of information, Table 2.

Table 2: Cost Saved Monthly in Using the Online Application

Affairs & Departments	Activity	Monthly Man-Hours Spent Before	Monthly Cost Saved QR (NOW)
Asset Affairs including **60** Contractors	Data Entry	180*	27,000
	COVID Tracking	300	45,000
Project Affairs Including **108** Contractors	Data Entry	324	48,600
	COVID Tracking	540	81,000
GSD Including All Towers	Data Entry	44	6,600
PQD	Data Entry	66	9,900
President Office	Data Entry	11	1,650
Total		**1,465**	**219,750**

An average hourly rate of 150 /hour.

Engineering services experts at Ashghal explore a two stages method to enhance the production of data for the COVID-19 Dashboard. Stage One: Enhance the workflow of data, Second Stage: Create and reflecting the information in meaningful manner including maps and ensure the sharing in the organization.

3.1.1 Stage One: COVID-19 Reporting – Workflow

The Dashboard provides the mechanism to enter COVID cases data through secured data entry form to restricted, responsible persons for each project and Ashghal office spaces. The contractor shall enter COVID related data on daily basis (if no cases to be reported, the contractor shall enter 0 as a value). Cut of time is 5 PM daily, however the system is open for reporting till midnight. The system will be sending notifications to PMs in case the contractor didn't enter any data before 5 PM daily.
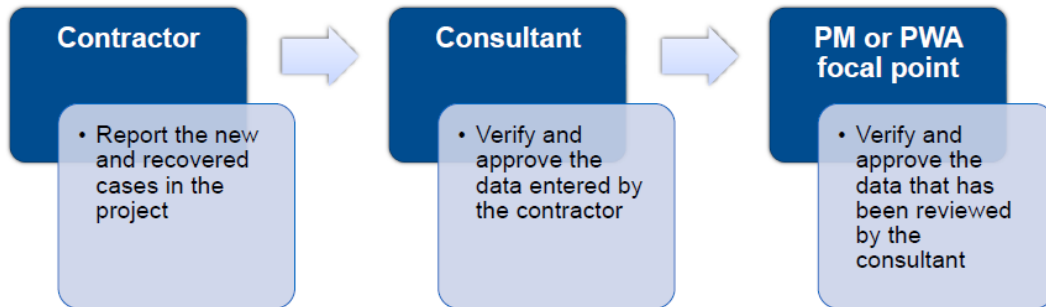
Fig. 1: COVID-19 Reporting – Workflow

Any case reported before 5 PM shall be closed by the consultant and project manager on the same day, otherwise a notification will be sent to the defined focal point in Ashghal and any case reported after 5 PM will be considered the next day, Figure 1. The development of the workflow was essential to control and streamline the data from all contractors and engineers work on projects. As first step the contractor is required to fill the COVID-19 form online on a daily basis as illustrated in Figure 2.

Fig. 2: Data Entry COVID Form UI

As per the suggested workflow, and once the contractor submits the daily entry COVID-19 form, the Consultant must approve the data to be processed, Figure 3.

Fig. 3: COVID Form – Approval by the Consultant

A data approval must be obtained from Ashghal PM after the consultant has approved the daily COVID form as shown in Figure 4.

Fig. 4: COVID Form – Approval by Ashghal PM

As final step, user chooses reports option from the menu to generate reports for all reported cases and customized the outputs, Figure 5.
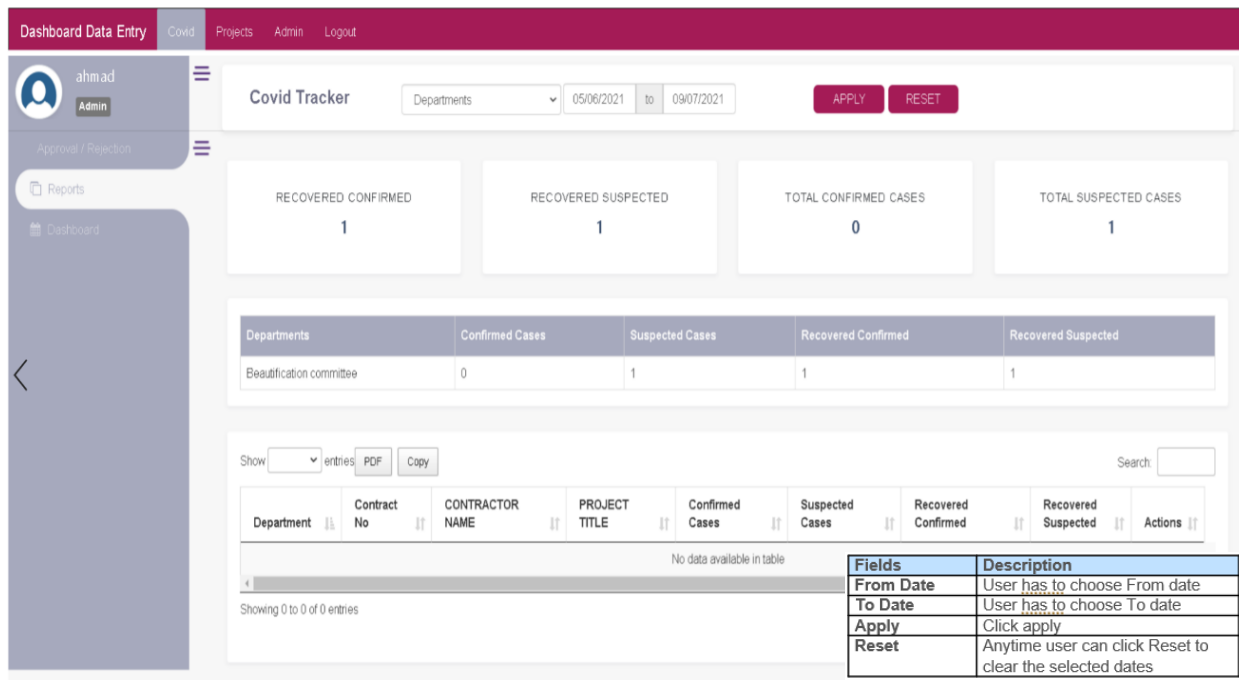
Fig. 5: COVID - Report Generation

Once the report is displayed, the users can generate the report in various formats including PDF and MS Word.

3.1.2   Stage Two: COVID-19 Map Dashboard – Visualization

The Dashboard provides a visual data representation with maps reflecting all approved collected data from stage one. The COVID-19 data is analysed in real-time and presented through meaningful graphs to understand the patterns of cases. The data is also presented on the GIS Map to display the impact on Ashghal's construction or maintenance projects across Qatar. The map depicts the risk factor as – high, medium, or low in red, blue and green colour, Figure 6.
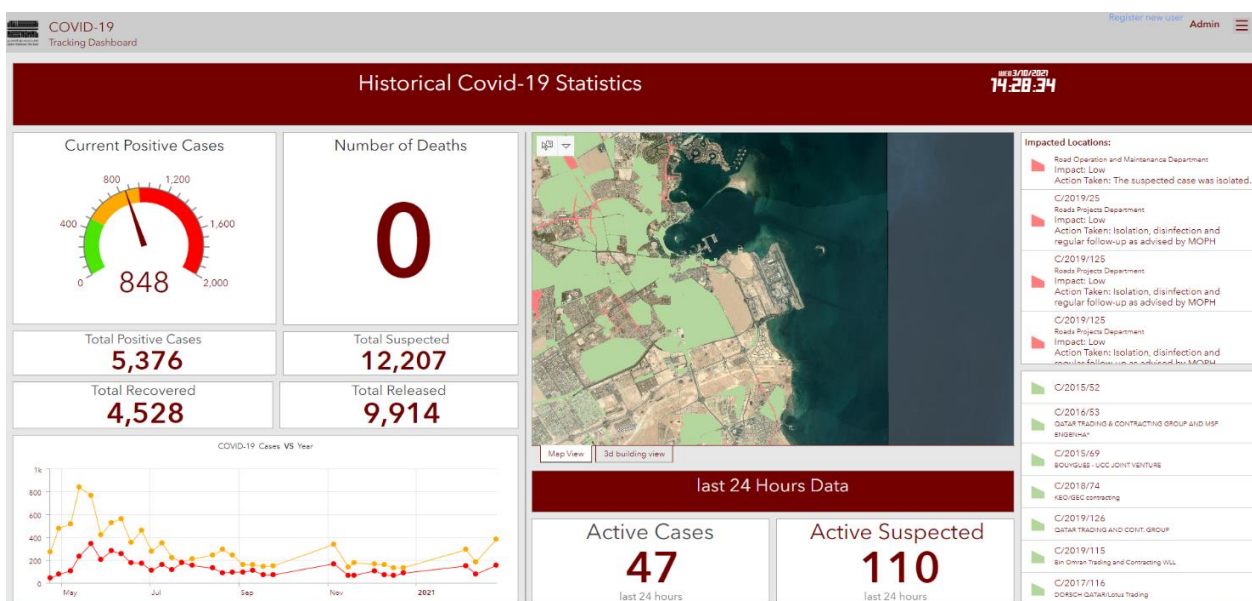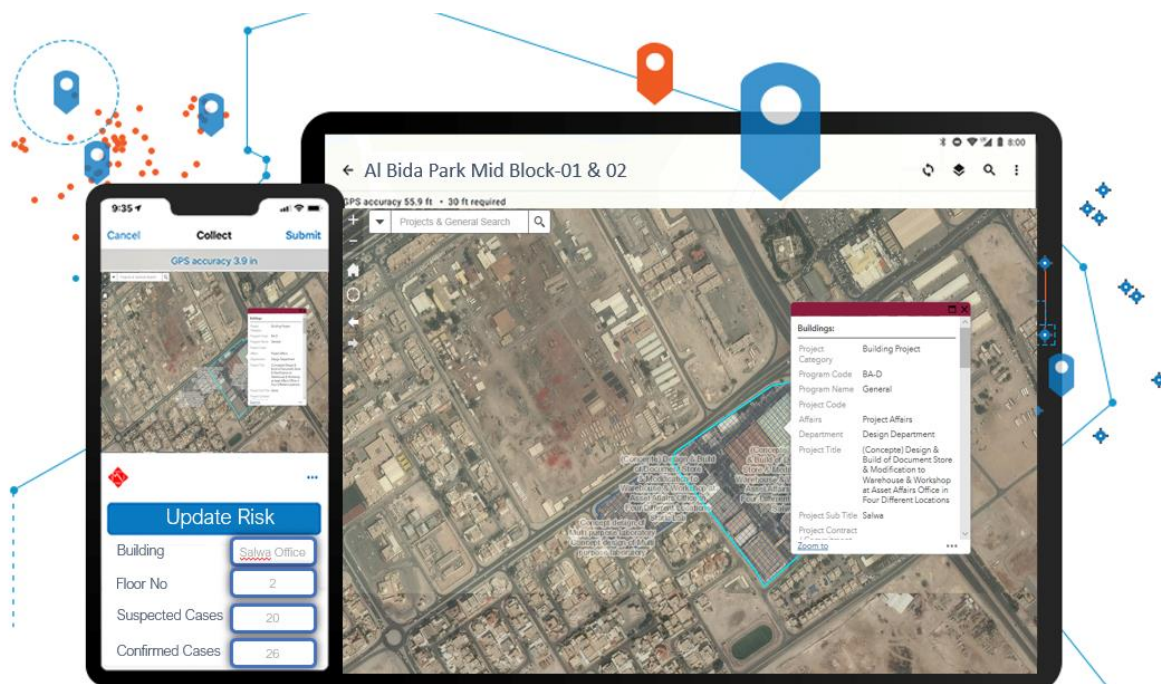

Fig. 6: Automated Online Dashboard – with Key Indicators and Summary of Cases

As part of additional enhancements, the Live Data Entry of COVID cases with visibility of site, which can be seen in mobile or laptops to take instant decisions, Figure 7.

Fig. 7: COVID - Mobile Data Entry for Risk Updates

In the monitoring process, interactive maps and control panels are used between participants to communicate quickly about the current situation and to anticipate its development. In addition to displaying key indicators and providing critical information summaries, interactive dashboards, such as those shown in Figure 6, are remarkable tools. Ultimately, the GIS dashboard is to support the exchange of epidemiological and other data between internal departments, relevant agencies, and the public during the pandemic crisis.

The dashboard reported all positive and suspected cases in the last 24 hours. In addition, cumulative number (total number) of positive cases/suspected cases were reported. The recovered cases were also reported. Thus, GIS based software is an online dashboard that enabled the users to see the map of Qatar and identify the location where the positive and suspected cases were located.

4 Discussion and Conclusion

This system includes interfaces that facilitate the implementation of geospatial processes to meet the requirements of each research area, which vary from one to another. This way, an expert in their field can use GIS functionality, geo-information, and related processes in one web environment.

The spatial solution achieved the objective set by Ashghal team by providing 1) Early identification of positive cases through PCR Test result, 2) Identifying potential contacts as per Ministry of Public Health, Qatar Guidelines, 3) To report this information to doctors/nurses/ HSE managers and project directors confidentially and quickly to avoid spread, 4) To use the information to ensure immediate isolation and treatment of COVID positive workers and suspected cases, 5) To control and reduce COVID spread into workers accommodations and projects sites, 6) To use this online COVID dashboard to develop statistics and analyse trends to see projects reporting increasing number of cases and projects reporting decline in number of cases.

The identification and isolation of suspected COVID positive cases in the earliest possible time period. These two vital pieces of information were captured by the online dashboard. The medical team of doctors and nurses and managers were able to track all COVID cases and order effective isolation, testing, rehabilitation and monitor recovery of these cases on a daily basis.

As Ashghal works in bringing to life multi-billion-dollar infrastructure projects, the most important factor in this journey is the health and wellbeing of the human capital involved. This project enabled Ashghal to block only infected zones where non infected zones were able to continue with adhering to other constrains and the policy. The transformation enabled Ashghal to monitor the health of its employees on daily basis comparing to monthly basis before this project.

This transformation reduces the cost of monitoring and reporting by a monthly sum of 219,750 QAR equal to US $60.000. The online health and wellness dashboard helped us to save costs, save lives and provide timely and effective medical management of COVID cases.

The live COVID dashboard gives an immediate real-time update on the number of COVID cases in any Ashghal project and the link of the dashboard to the GIS system so the end user can see all projects, zoom in on any project, and detect the number of active and suspected cases. Historical data (from last year), including cumulative overall total in all projects, are also available. According to the statistics, Ashghal appears to be taking all necessary preventative measures to control the pandemic. Ashghal has always adapted innovative technology and human skills to work together to produce effective results. Despite enormous challenges, Ashghal continues to provide the best services for Qatar and its communities with passion, care, and promise. The Government of Qatar has implemented improvement measures that will set the benchmark for regional performance in the areas of Health, Safety, and Welfare. As part of this objective, Ashghal is continuously designing, building, operating, and managing infrastructure with the highest priority being given to the health, safety, and welfare of its employees, contractors, and customers.

References

Al-Nuaimi, B., & Al-Ghamdi. (2019). Environmental and Economic Life Cycle Analysis of Primary Construction Materials Sourcing Under Geopolitical Uncertainties: A Case Study of Qatar. *In Sustainability*, *11*(21). https://doi.org/https://doi.org/10.3390/su11216000

(ASHGHAL), T. P. W. A. (2020, 07 September 2020). *Roads and Subdivision Projects on Track while Maintaining Precautionary Measures*. ASHGHAL. Retrieved December 31, 2022 from https://www.ashghal.gov.qa/en/MediaHub/News/Pages/Roads-and-Subdivision-Projects-on-Track-while-Maintaining-Precautionary-Measures.aspx#.Y7BjZXbMKUk

(ASHGHAL), T. P. W. A. (2022). *The Public Works Authority 'Ashghal' - An Overview*. ASHGHAL. Retrieved December 31, 2022 from https://www.ashghal.gov.qa/en/AboutUS/Pages/default.aspx

(CDC), C. f. D. C. a. P. (2022). *Clinical Questions about COVID-19: Questions and Answers*. https://www.cdc.gov/coronavirus/2019-ncov/hcp/faq.html/

Dong, E., Ratcliff, J., Goyea, T. D., Katz, A., Lau, R., Ng, T. K., Garcia, B., Bolt, E., Prata, S., & Zhang, D. (2022). The Johns Hopkins University Center for Systems Science and Engineering COVID-19 Dashboard: data collection process, challenges faced, and lessons learned. *The Lancet Infectious Diseases*.

Fatima, M., O'Keefe, K. J., Wei, W., Arshad, S., & Gruebner, O. (2021). Geospatial Analysis of COVID-19: A Scoping Review. *Int J Environ Res Public Health*, *18*(5). https://doi.org/10.3390/ijerph18052336

Franch-Pardo, I., Napoletano, B. M., Rosete-Verges, F., & Billa, L. (2020). Spatial analysis and GIS in the study of COVID-19. A review. *Science of The Total Environment*, *739*, 140033. https://doi.org/https://doi.org/10.1016/j.scitotenv.2020.140033

Karabegovic, A., Ponjavic, M., & Hukic, M. (2021). Epidemic Location Intelligence System as Response to the COVID-19 Outbreak in Bosnia and Herzegovina. *Applied System Innovation*, *4*(4), 79.

Milner, G. (2020). Creating the Dashboard for the Pandemic. *ArcUser: The Magazine for Esri Software Users*, *23*(3), 56-59. https://www.esri.com/content/dam/esrisites/en-us/newsroom/arcuser/arcuser-summer-2020.pdf

Olanrewaju, A., AbdulAziz, A., Preece, C. N., & Shobowale, K. (2021). Evaluation of measures to prevent the spread of COVID-19 on the construction sites. *Cleaner engineering and technology*, *5*, 100277.

Sarwar, S., Waheed, R., Sarwar, S., & Khan, A. (2020). COVID-19 challenges to Pakistan: Is GIS analysis useful to draw solutions? *Sci Total Environ*, *730*, 139089. https://doi.org/10.1016/j.scitotenv.2020.139089

(WHO), W. H. O. (2022). *Coronavirus disease (COVID-19) Weekly Epidemiological Updates and Monthly Operational Updates*. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/

Zhou, C., Su, F., Pei, T., Zhang, A., Du, Y., Luo, B., Cao, Z., Wang, J., Yuan, W., & Zhu, Y. (2020). COVID-19: challenges to GIS with big data. *Geography and sustainability*, *1*(1), 77-87.